LPG System Description and Operation (LWR)

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

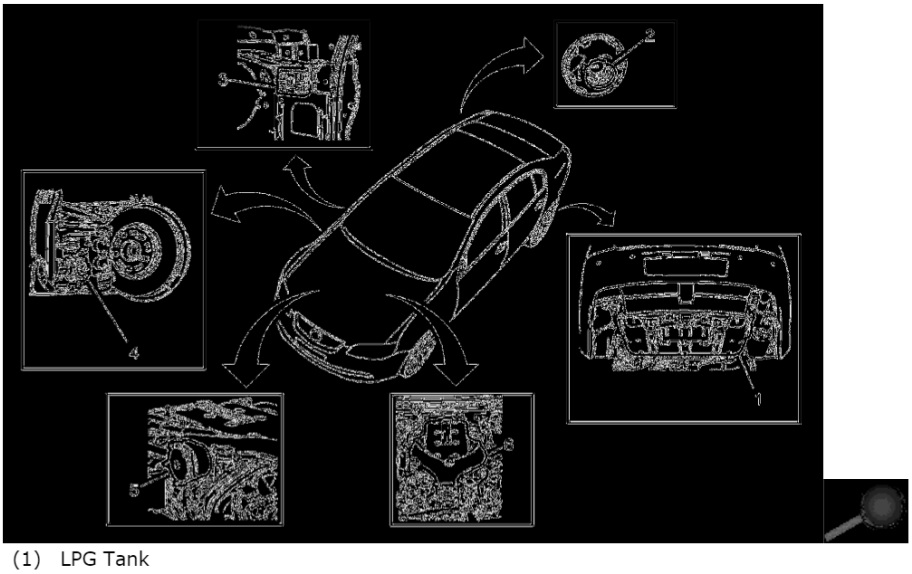
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

The LPG system comprises of an LPG tank located underbody in the rear of the vehicle, an LPG filler located in the filler compartment on the rear quarter panel, an LPG manual service valve located on the pump which controls the service lines. An LPG vaporizer located behind the right front wheelhouse liner, an fuel injector control module located in hinge pillar panel, an LPG fuel filter located on the right side of the engine, six LPG injectors located on top of the engine, LPG diagnostic connector and fuses located on the left of the radiator.

The system performance has been optimized for operating as a dedicated LPG fuel vehicle.

Liquefied Petroleum System Component View

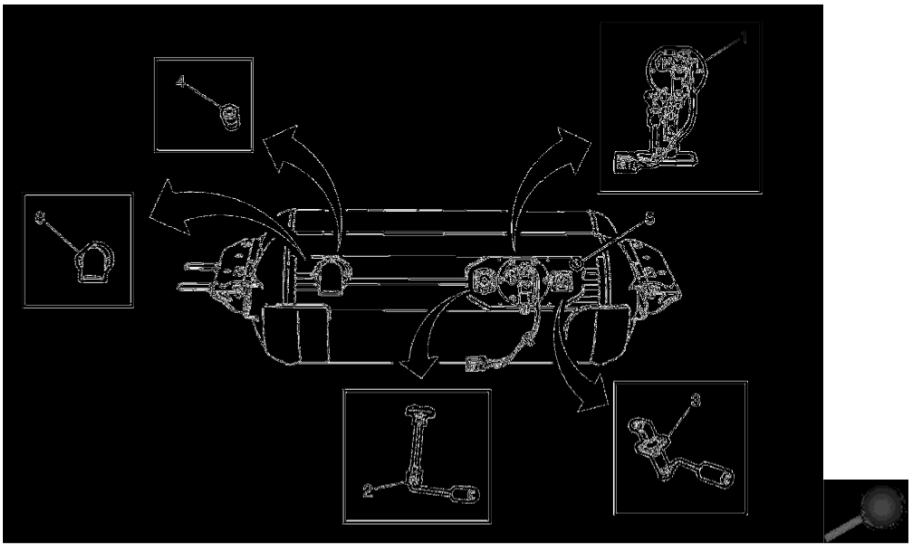


(1) LPG Tank
(2) LPG Fill Valve
(3) LPG Fuel Injector Control Module
(4) LPG Vaporizer
(5) LPG Fuel Filter
(6) LPG Manifold and Injectors

LPG Tank

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(1) Pump with a Manual Service Valve, Automatic Fuel Shutoff Device (Solenoid Valve), Excess Flow Valve and a Tank Pressure Sensor
(2) Tank Fuel Gauge Assembly
(3) Automatic Fill Limiter (AFL)
(4) Pressure Relief Valve (PRV)
(5) Temperature Safety Device (Non Serviceable)
(6) Pressure Relief Valve Cover

The LPG Tank is made of aluminum and is manufactured to stringent safety standards. The vapor pressure inside the LPG tank will vary with ambient temperature – as the ambient temperature rises, so does the vapor pressure. The LPG tank is heat treated during manufacture and MUST NOT be heated or welded in any way.

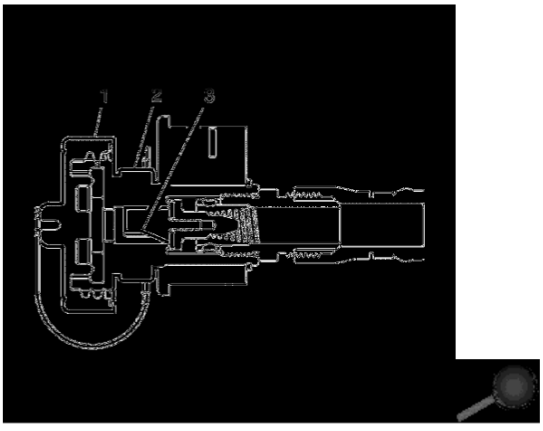
The LPG tank is bolted to the longitudinal rails under the rear floor. The tank is fitted with two safety devices:

- Pressure relief valve - That protects the tank under over pressure situations.
- A temperature safety device fuse that protects the tank under extreme temperature events by venting LPG gas to the atmosphere in a controlled manner. The temperature fuse in not serviceable and must not be tampered with at service or in normal use.

The tank is provided with a shield to protect against impact and abrasion damage.

Filler Valve

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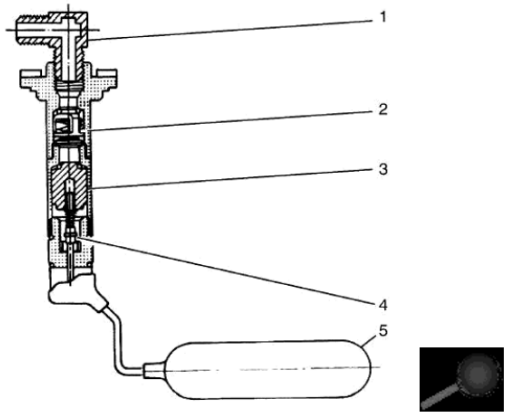
The filler valve is located in the normal fuel filler pocket, adjacent to the petrol filler.

The valve incorporates a spring-loaded non-return valve (3) and a sealed cap (1) fitted to the filling connection (2).

The filler valve is connected to the LPG tank AFL inlet elbow by a filler line, which is routed through a steel encased tube, along the rail under the wheelhouse then into the feed and fill bundle.

The connection is designed to shear off in the event of the vehicle being driven away with the filler hose inadvertently attached. In this situation, the non return valve of the automatic fill limiter (AFL) prevents discharge of LPG from the tank. A small amount of LPG from the hose will be discharged.

Automatic Fill Limiter



The Automatic Fill Limiter (AFL) is fitted into the LPG tank. The inlet elbow (1) connects the to the LPG filler line.

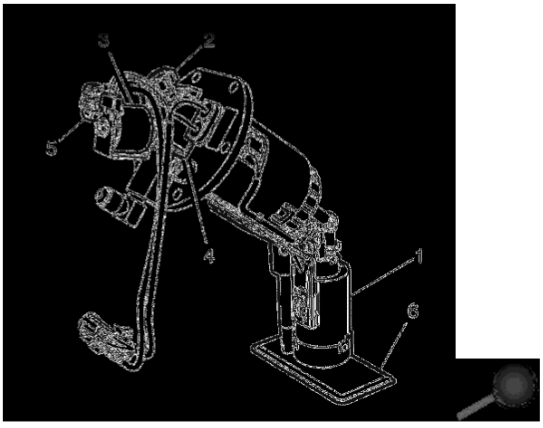
When the tank is being filled with liquid LPG, the AFL float (5) rises with the liquid within the LPG tank. The float arm is connected to an actuator (4) that operates a shut-off piston (3). When the level reaches approximately 80% full, the piston (3) is in the closed position, effectively shutting off the flow of LPG into the tank.

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The remaining 20% of the tank volume is necessary vapor space to allow for the expansion of the liquid that occurs as the temperature of the liquid increases.

The AFL is also fitted with a non-return valve (2) to prevent the gas escaping.

LPG Fuel Pump



The pump module contains the following components:

1. Fuel Pump
2. Manual Service Valve
3. Automatic Fuel Shutoff Device (solenoid valve)
4. Excess Flow Valve (the EFV is internal to pump housing)
5. Tank Pressure Sensor
6. Fuel Filter

Manual Shut-Off Valve

The manual service valve (2) allows the supply of LPG to be manually shut off for servicing, a leak in the system develops or in the event of a vehicle accident by turning the knob off.

Automatic Fuel Shutoff

The automatic fuel shutoff (3) is an electrically operated valve, which allows the flow of LPG from the tank into the service line. LPG will only flow to the service line when the solenoid is energized. The solenoid valve is only energized when the engine is cranking/running.

Excess Flow Valve

The excess flow valve (4) will close automatically if the flow of liquid LPG is excessive, thereby restricting the supply of liquid LPG. The valve will automatically reopen a short period after the excess flow condition has ceased.

The excess flow valve is designed to shut off if the flow exceeds a specified amount, as would occur if the service line was severed or opened.

Tank Pressure Sensor

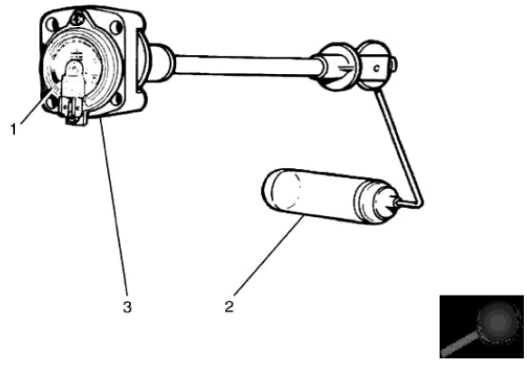
The tank pressure sensor measures the vapor pressure in the tank. This is used for determining when the pump should operate and optimizing the vehicles cold start mode.

Fuel Pump

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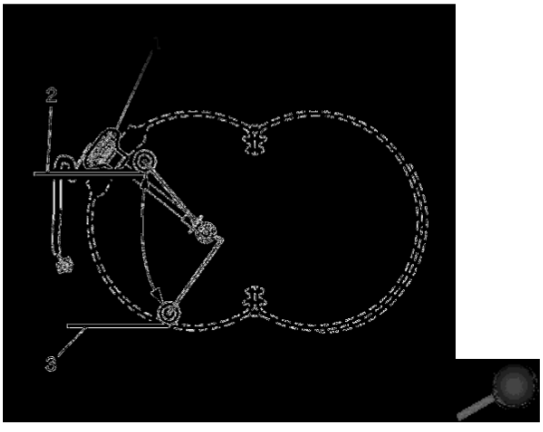
When the LPG tank pressure is below 500 kPa (i.e. when the fuel temperature is below 0–15°C depending on fuel composition) the FPCM commands pump operation in order to provide additional service line pressure. When the tank pressure rises above 500 kPa the FPCM switches the pump off. The pump provides up to 300 kPa of additional pressure. The pump is a DC brush motor.

LPG Tank Fuel Gauge Assembly



The tank fuel gauge assembly (3) has a float (2) similar to a petrol gauge sender unit, and a fuel sender card (1).

As the liquid level in the LPG tank rises, so too does the float. The float is connected to magnets within the assembly. There are corresponding magnets in the sender card (1) and any change in the position of the liquid level is transmitted to the fuel contents gauge via this magnetic coupling. There is no mechanical connection between the rotating components inside and outside the tank.



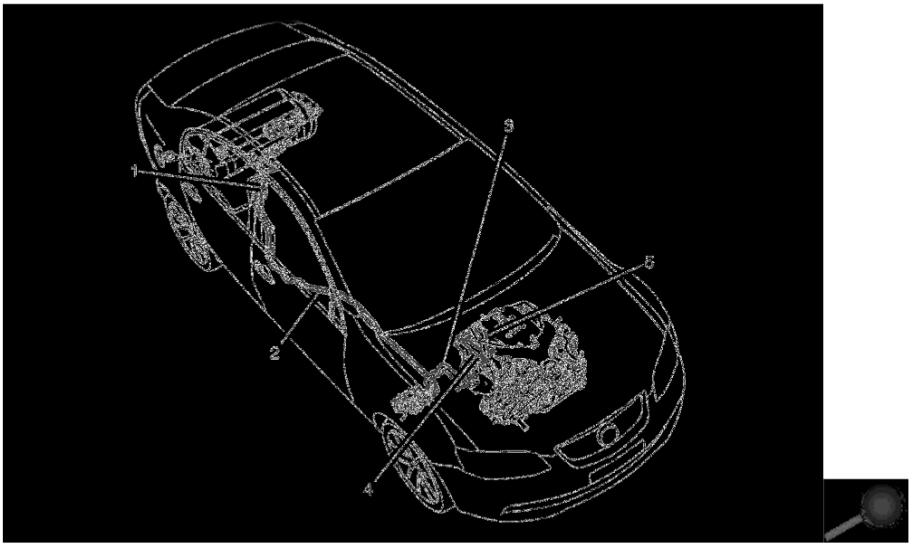
The fuel contents gauge (1) will show full when the liquid level in the tank is at 80% (2). It will show empty when the tank contents falls to approximately 8.5 liters (3).

The fuel gauge sender unit within the fuel contents gauge, incorporates a variable resistor that will vary its resistance from approximately 250 ohms when the tank is empty to approximately 49.4 ohms at the 80% shutoff point.

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The sender resistance is read by the ECM. The ECM sends this information to the instrument cluster via GMLAN.

Service Line



(1) LPG Rear Pipe
(2) LPG Feed Pipe to Vaporizer
(3) LPG Feed Front Pipe
(4) LPG Feed Hose to Filter
(5) LPG Feed Hose to Engine Fuel Rail

The service line carries the liquid LPG from the manual service valve at the LPG storage tank to the vaporizer. The service line consists of five major components:

Vaporizer

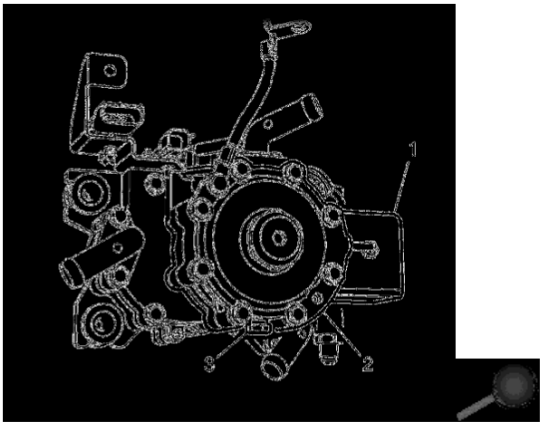
Construction

The vaporizer (also known as a converter) functions are to:

- Heat incoming LPG before vaporizing the LPG from liquid LPG to gaseous LPG. To prevent icing because of the temperature drop with the phase change of the LPG.
- Regulate the output pressure to suit engine requirements.

The vaporizer is a multiple plate design which consists of 4 main sections.

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Vaporizer Lock Off Solenoid

The vaporizer lock-off solenoid is an electrically operated solenoid valve (1), which allows or prevents the flow of liquid LPG to the reducer when energized or de-energized by the LPG control module.

The vaporizer lock-off is energized for three seconds when the ignition is turned on, or constantly while the engine is being cranked or is running.

A filter is incorporated into the design. It does not require servicing.

When the engine stops running, or the ignition is turned off, the vaporizer lock-off is closed and the supply of LPG is shut off.

Control of the solenoid is by the FICM and ECU.

Vaporizer Water Heating Section

The LPG is heated using a series of heat exchanger plates. The heating coolant is from the engine heater circuit. Flow through the vaporizer is prior to coolant flowing through the HVAC heater core.

Electrical Heating Section

During cold starts (low coolant temperature), LPG is heated with a electrical heater (2). This heater (3 elements) is a ceramic heater (PTD heater). The heaters self regulate temperature. The PTC heater will draw a high current start up, and drop quickly as heater reaches operating temperature.

Pressure Regulator

The pressure regulator is a vacuum referenced single stage regulator. There is an oil/tar separation stage inside the pressure regulator, with a drain plug (3) fitted on the vehicle.

Operation

The conversion of the high pressure liquid LPG coming from the LPG tank to a low pressure, vapor is controlled by the primary valve inside the pressure regulator.

In the process of rapidly reducing the pressure from approximately 1,260 kPa in the tank to atmospheric (101.3 kPa), the liquid LPG changes state to become a vapor and this causes a rapid reduction in temperature. To compensate for this and to assist in vaporization, engine coolant circulates through the heat exchanger channels in the lower chambers prior to the main valve. If coolant temperature is low, the fuel injection control module will turn on the vaporizer electric heater to supplement the coolant heat exchangers.

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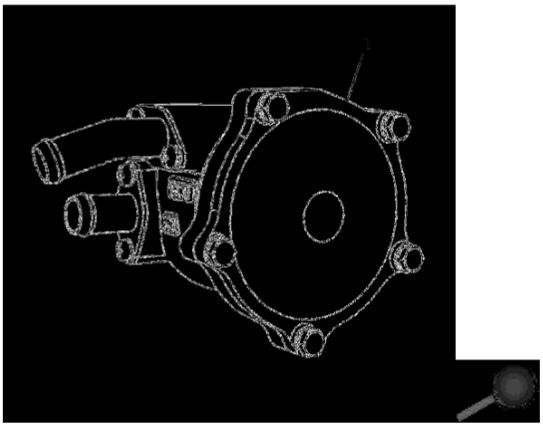
The reducer seals off LPG flow when the engine is stopped.

The pressure regulating spring, acting on the upper side of the diaphragm, pushes the diaphragm down. This opens the primary valve, allowing LPG to enter the pressure regulator at this point the LPG changes state from liquid to a vapor.

When the engine is cranked or running, a vacuum is created in the engine intake manifold that is transmitted to the reference chamber of the pressure regulator. The effect of this vacuum is to work against the regulating spring force, together with the pressure of the LPG acting on the underneath side of the primary diaphragm. This combined action achieves a balance on each side of the diaphragm.

LPG released from the reducer flows through to the Tar filter, before being delivered to each LPG injectors.

Tar Filter

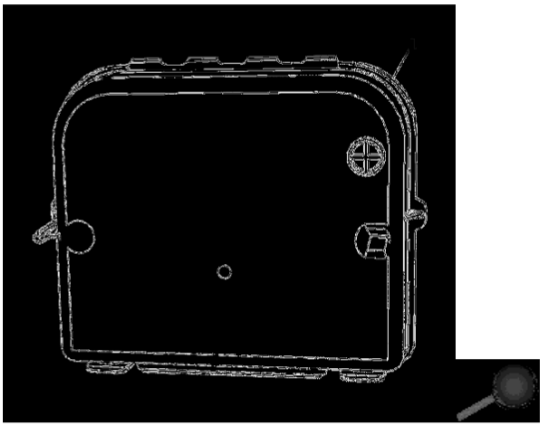


The Tar filter (1) is mounted to a bracket and secured to the mounting bracket by 3 bolts.

Exiting LPG vapor from the vaporizer passes through the Tar filter and vapor lines and then to the LPG injector manifolds.

Servicing of the vapor filter is by replacing the cartridge as per the service booklet.

Fuel Injector Control Module



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The fuel injection control module (FICM) controls the operation of the LPG Vaporizer Heater Elements, the Fuel Shutoff Solenoid Valves, the Warm Up Mode Indicator in the instruments and the Torque reduction signal to the engine control module (ECM). The FICM will also transmits and diagnostics trouble codes (DTC) it sets to the engine control module, the FICM does not store and DTC's.

To control these functions the FICM receives the following GMLAN information; Outside Air Temperature, Engine Coolant Temperature, Transmission Oil Temperature, Mass air Flow, Engine Crank status, Engine Run status, Engine Run Time and Fuel Tank Pressure.

The FICM is permanently connected to battery voltage and remains in standby mode as long as its Comm Enable input is inactive (low). The Comm Enable signal is low, when the ignition key is in the OFF position and will become active (+12) shortly after the ignition key is turned to the accessory position. The Comm Enable signal stays active during system power modes Accessory, Run and Crank Requests. When the Comm Enable becomes active the FICM will transition out of standby mode.

LPG Vaporizer Heater Elements

The LPG Vaporizer has the three heater elements, the FICM controls the operation of the heater elements via three relays. The FICM uses the outside air temperature, engine coolant temperature and the transmission temperature to estimate the temperature of the LPG in the fuel tank. The FICM will activate its heater relay outputs to control the operation of the heater elements. The number and the length the of time that the heater elements are commanded on, will vary depending on the Estimated LPG Temperature, Engine Coolant Temperature, Mass Air Flow, Engine Run Status and Engine Run time. If any of the GMLAN signals used to control the operation of the LPG Vaporizer are not received, then all heater relays will be turned off.

Fuel Shutoff Solenoid Valves

The FICM controls the operation of fuel shutoff solenoid valves, based on the status of the engine run and engine cranking GMLAN signals from the engine control module. When the FICM is in standby mode the fuel shutoff output will be switched off. When the engine is cranking or running then the shutoff solenoids will be energized.

Warm Up Mode Indicator

When starting the vehicle from cold, LPG warm up mode may be activate. When the warm up mode is activated the FICM will send a GMLAN message to the instrument and it will display "Warm Up Mode Engine Power Reduced" and a chime will sound.

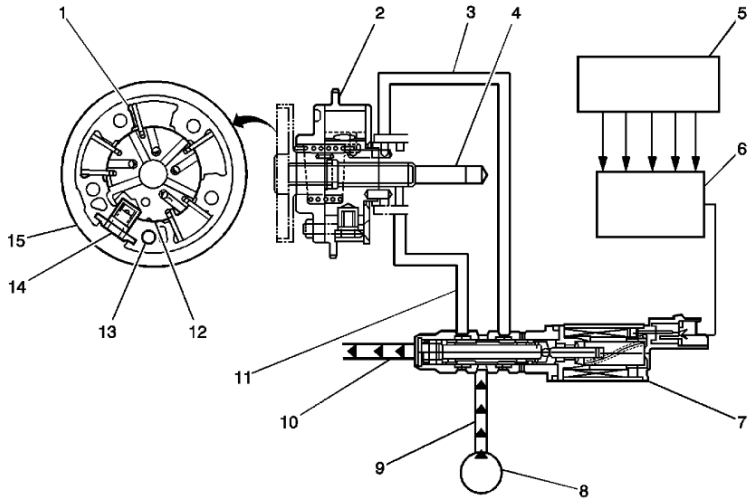
Requested Torque Signal

When Warm Up Mode is activated the FICM will vary the requested torque signal sent to the Engine Control Module (ECM), requesting a reduction engine torque. This signal has a square wave 50% duty cycle, the frequency of the signal will vary in the range of 50 Hz to 150 Hz. The frequency of this signal is calculated by the FICM based on the LPG fuel temperature and the fuel tank pressure. The ECM will reduce the engine torque during the engine warm-up phase depending on the frequency of its signal.

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Camshaft Actuator System Description

Camshaft Actuator System Overview



(1) Camshaft Actuator Vane
(2) Timing Chain Sprocket
(3) Engine Oil Pressure-For retarding the camshaft
(4) Camshaft
(5) Input Signals from Engine Sensors
(6) Engine Control Module (ECM)
(7) Camshaft Actuator Solenoid
(8) Engine Oil Pump
(9) Engine Oil Pressure Supply
(10) Engine Oil Drain
(11) Engine Oil Pressure-For advancing the camshaft
(12) Camshaft Actuator Rotor
(13) Camshaft Position Sensor Reluctor
(14) Camshaft Actuator Lock Pin
(15) Camshaft Actuator Housing

The camshaft actuator system enables the engine control module (ECM) to change camshaft timing of all 4 camshafts while the engine is operating. The camshaft position (CMP) actuator assembly (15) varies the camshaft position in response to directional changes in oil pressure. The CMP actuator solenoid valve controls the oil pressure that is applied to advance or retard a camshaft. Modifying camshaft timing under changing engine demand provides better balance between the following performance concerns:

- Engine power output
- Fuel economy

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- Tailpipe emissions

The CMP actuator solenoid valve (7) is controlled by the ECM. The crankshaft position (CKP) sensor and the CMP sensors are used to monitor changes in camshaft positions. The ECM uses the following information in order to calculate the desired camshaft positions:

- Engine coolant temperature
- Calculated engine oil temperature (EOT)
- Mass air flow (MAF)
- Throttle position (TP)
- Vehicle speed
- Volumetric efficiency

Operation

The CMP actuator assembly has an outer housing that is driven by an engine timing chain. Inside the assembly is a rotor with fixed vanes that is attached to the camshaft. Oil pressure that is applied to the fixed vanes will rotate a specific camshaft in relationship to the crankshaft. The movement of the intake camshafts will advance the intake valve timing. The movement of the exhaust camshafts will retard the exhaust valve timing. When oil pressure is applied to the return side of the vanes, the camshafts will return to 0 crankshaft degrees, or top dead center (TDC). The CMP actuator solenoid valve directs the oil flow that controls the camshaft movement. The ECM commands the CMP solenoid to move the solenoid plunger and spool valve until oil flows from the advance passage (11). Oil flowing thru the CMP actuator assembly from the CMP solenoid advance passage applies pressure to the advance side of the vanes in the CMP actuator assembly. When the camshaft position is retarded, the CMP actuator solenoid valve directs oil to flow into the CMP actuator assembly from the retard passage (3). The ECM can also command the CMP actuator solenoid valve to stop oil flow from both passages in order to hold the current camshaft position.

The ECM operates the CMP actuator solenoid valve by pulse width modulation (PWM) of the solenoid coil. The higher the PWM duty cycle, the larger the change in camshaft timing. The CMP actuator assembly also contains a lock pin (14) that prevents movement between the outer housing and the rotor vane assembly. The lock pin is released by oil pressure before any movement in the CMP actuator assembly takes place. The ECM is continuously comparing CMP sensor inputs with CKP sensor input in order to monitor camshaft position and detect any system malfunctions. If a condition exists in either the intake or exhaust camshaft actuator system, the opposite bank, intake or exhaust, camshaft actuator will default to 0 crankshaft degrees.

CMP Actuator System Operation

Driving Condition	Change in Camshaft Position	Objective	Result
Idle	No Change	Minimize Valve Overlap	Stabilized Idle Speed
Light Engine Load	Retarded Valve Timing	Decrease Valve Overlap	Stabled Engine Output
Medium Engine Load	Advanced Valve Timing	Increase Valve Overlap	Better Fuel Economy with Lower Emissions
Low to Medium RPM with Heavy Load	Advanced Valve Timing	Advance Intake Valve Closing	Improved Low to Mid-range Torque
High RPM with Heavy Load	Retarded Valve Timing	Retard Intake Valve Closing	Improved Engine Output

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Driving Condition	Change in Camshaft Position	Objective	Result

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Electronic Ignition System Description

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

Crankshaft Position Sensor

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

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

Camshaft Position Sensor

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

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

Knock Sensor

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

The control module learns a minimum noise level, or background noise, at idle from the knock sensor and uses calibrated values for the rest of the RPM range. The control module uses the minimum noise level to calculate a noise channel. A normal knock sensor signal will ride within the noise channel. As engine speed and load change, the noise channel upper and lower

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parameters will change to accommodate the normal knock sensor signal, keeping the signal within the channel. In order to determine which cylinders are knocking, the control module only uses knock sensor signal information when each cylinder is near top dead center (TDC) of the firing stroke. If knock is present, the signal will range outside of the noise channel.

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

Ignition Coils

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

Engine Control Module (ECM)

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

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

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Engine Control Module Description

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

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

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

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

ECM Function

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

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

EEPROM

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

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

Data Link Connector (DLC)

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

Malfunction Indicator Lamp (MIL)

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

ECM Service Precautions

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

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Emissions Diagnosis For State I/M Programs

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

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

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

Aftermarket (Add-On) Electrical And Vacuum Equipment

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

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

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

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

Electrostatic Discharge (ESD) Damage

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

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

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

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

Emissions Control Information Label

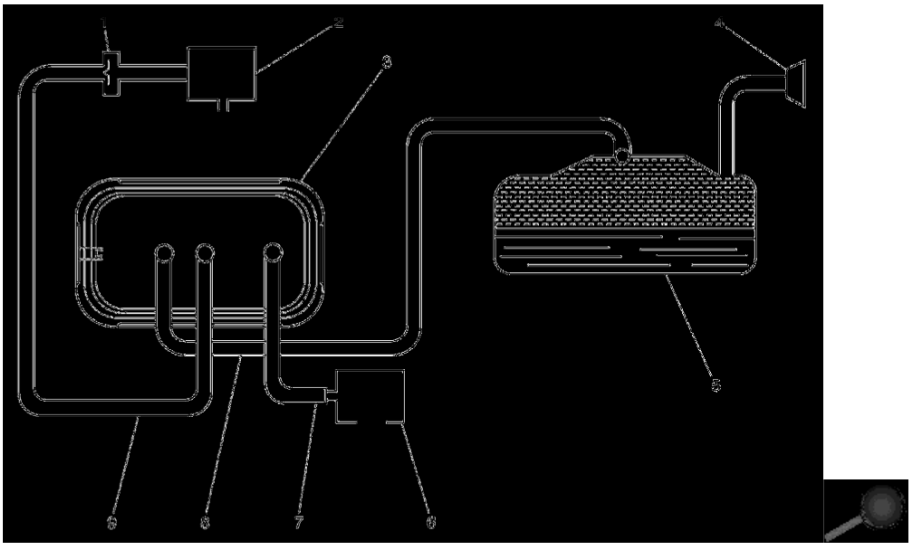
The underhood Vehicle Emissions Control Information Label contains important emission specifications. This identifies the year, the displacement of the engine in liters, and the class of the vehicle.

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

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Evaporative Emission Control System Description

EVAP System Operation



(1) Purge Tube Check Valve, Turbo-Charged Applications Only
(2) EVAP Canister Purge Solenoid Valve
(3) EVAP Canister
(4) Fuel Fill Cap/Fill Neck
(5) Fuel Tank
(6) EVAP Air Inlet
(7) EVAP Vent Pipe
(8) EVAP Vapor Pipe
(9) EVAP Purge Pipe

The evaporative emission (EVAP) control system limits fuel vapors from escaping into the atmosphere. Fuel tank vapors are allowed to move from the fuel tank, due to pressure in the tank, through the vapor pipe, into the EVAP canister. Carbon in the canister absorbs and stores the fuel vapors. Excess pressure is vented through the vent pipe and EVAP air inlet to atmosphere. The EVAP canisters store the fuel vapors until the engine is able to use them. At an appropriate time, the control module will command the EVAP purge solenoid valve open, allowing engine vacuum to be applied to the EVAP canister. Fresh air will be drawn through the EVAP air inlet and vent pipe to the EVAP canisters. Fresh air is drawn through the EVAP canister, pulling fuel vapors from the carbon. The air/fuel vapor mixture continues through the EVAP purge pipe and EVAP purge solenoid valve into the intake manifold to be consumed during normal combustion.

EVAP System Components

The EVAP system is made up of the following components:

- The purge tube check valve, turbo-charged applications only

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- The EVAP canister purge solenoid valve
- The EVAP canister
- The fuel fill cap/fill neck
- The fuel tank
- The EVAP air inlet
- The EVAP vent pipe
- The EVAP vapor pipe
- The EVAP purge pipe

EVAP Canister

The EVAP canister is a sealed unit with 3 ports.

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

EVAP Purge Solenoid Valve

The EVAP purge solenoid valve controls the flow of vapors from the EVAP system to the intake manifold. This normally closed valve is pulse width modulated (PWM) by the control module to precisely control the flow of fuel vapor to the engine.

EVAP Air Inlet

The EVAP air inlet filters air entering the EVAP canister.

Purge Tube Check Valve

Turbocharged vehicles have a check valve in the purge tube, between the EVAP purge solenoid valve and the EVAP canister, to prevent pressurization of the EVAP system under boost conditions.

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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 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 module also contains a primary jet pump and a secondary jet pump. 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 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 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 flow control module via a GMLAN serial data message. A liquid fuel pressure sensor provides the feedback the fuel pump flow control module requires for Closed Loop fuel pressure control.

Fuel Pump Flow Control Module

The fuel pump flow control module is a serviceable GMLAN module. The fuel pump flow control module receives the desired fuel pressure message from the engine control module (ECM) and controls the fuel pump located within the fuel tank to achieve the desired fuel pressure. The fuel pump flow control module sends a 25 kHz PWM signal to the fuel pump, and pump speed is changed by varying the duty cycle of this signal. Maximum current supplied to the fuel pump is 15 A. A liquid fuel pressure sensor provides fuel pressure feedback to the fuel pump flow control module.

Fuel Pressure Sensor

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

Flex Fuel Sensor

The flex fuel sensor measures the ethanol-gasoline ratio of the fuel being used in a flexible fuel vehicle. Flexible fuel vehicles can be operated with a blend of ethanol and gasoline, up to 85 percent ethanol. In order to adjust the ignition timing and the fuel quantity to be injected, the engine management system requires information about the percentage of ethanol in the fuel.

The flex fuel sensor uses quick-connect style fuel connections, an incoming fuel connection, and an outgoing fuel connection. All fuel passes through the flex fuel sensor before continuing

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on to the fuel rail. The flex fuel sensor measures two different fuel related parameters, and sends an electrical signal to the engine control module (ECM) to indicate ethanol percentage, and fuel temperature.

The flex fuel sensor has a three-wire electrical harness connector. The three wires provide a ground circuit, a power source, and a signal output to the ECM. The power source is battery positive voltage and the ground circuit connects to an engine ground. The signal circuit carries both the ethanol percentage and fuel temperature within the same signal, on the same wire.

The flex fuel sensor uses a microprocessor inside the sensor to measure the ethanol percentage and fuel temperature, and changes the output signal accordingly. The electrical characteristic of the flex fuel sensor signal is a square-wave digital signal. The signal is both variable frequency and variable pulse width. The frequency of the signal indicates the ethanol percentage, and the pulse width indicates the fuel temperature. The ECM provides an internal pull-up to 5 V on the signal circuit, and the flex fuel sensor pulls the 5 V to ground in pulses. The output frequency is linear to the percentage of ethanol content in the fuel. The normal range of operating frequency is between 50 and 150 Hz, with 50 Hz representing 0 percent ethanol, and 150 Hz representing 100 percent ethanol. The normal pulse width range of the digital pulses is between 1 and 5 ms, with 1 ms representing −40°C (−40°F), and 5 ms representing 151.25°C (304.25°F).

The microprocessor inside the sensor is capable of a certain amount of self-diagnosis. An output frequency of 180 Hz indicates either that the fuel is contaminated, or that an internal sensor electrical fault has been detected. Certain substances dissolved in the fuel can cause the fuel to be contaminated, raising the output frequency higher than the actual ethanol percentage should indicate. Examples of these substances include water, sodium chloride (salt), and methanol.

It should be noted that it is likely that the flex fuel sensor will indicate a slightly lower ethanol percentage than what is advertised at the fueling station. This is not a fault of the sensor. The reason has to do with government requirements for alcohol-based motor fuels. Government regulations require that alcohol intended for use as motor fuel be denatured. This means that 100 percent pure ethanol is first denatured with approximately 4½ percent gasoline, before being mixed with anything else. When an ethanol gasoline mixture is advertised as E85, the 85 percent ethanol was denatured before being blended with gasoline, meaning an advertised E85 fuel contains only about 81 percent ethanol. The flex fuel sensor measures the actual percentage of ethanol in the fuel.

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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 modules are required.

Fuel Fill Pipe

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

Fuel Filler Cap

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

Primary Fuel Tank Module

The primary fuel tank module is located inside of the right side of the fuel tank. The primary fuel tank 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 Module

The secondary fuel tank module is located inside of the left side of the fuel tank. The secondary fuel tank 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 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.

Fuel Filter

The fuel filter is located in the primary fuel tank module. The paper filter element traps particles in the fuel that may damage the fuel injection system. The filter housing is made to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature.

Pressure Relief Regulator Valve

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

Fuel Strainer

The fuel strainer attaches to the lower end of the primary fuel tank module. The fuel strainer is made of woven plastic. The functions of the fuel strainer are to filter contaminants and to wick fuel. The fuel strainer normally requires no maintenance. Fuel stoppage a this point indicates that the fuel tank contains an abnormal amount of sediment or contamination.

Primary and Secondary Jet Pumps

The primary jet pump is located in the primary fuel tank 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 module.

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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 115°C (239°F) for more than one hour, or more than 90°C (194°F) for any extended period.
- Apply a few drops of clean engine oil to the male pipe ends before connecting fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. (During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.)

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

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

Nylon fuel pipes are somewhat flexible and can be formed around gradual turns under the vehicle. However, if nylon fuel pipes are forced into sharp bends, the pipes 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 2 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 Injectors

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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 Injection Fuel Rail Fuel Pressure Sensor

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

Fuel Metering Modes of Operation

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

Starting Mode

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

Clear Flood Mode

If the engine 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.

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- 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

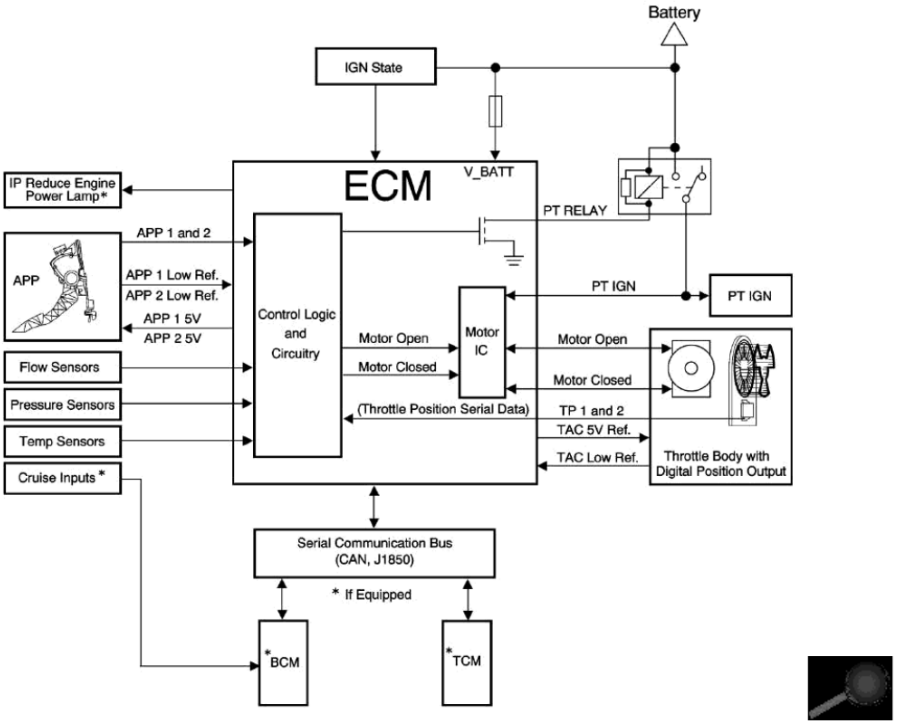
The ECM controls the air/fuel metering system in order to provide the best possible combination of driveability, fuel economy, and emission control. The ECM monitors the heated oxygen sensor (HO2S) signal voltage while in Closed Loop and regulates the fuel delivery by adjusting the pulse width of the 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

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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).

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Throttle Actuator Control (TAC) System Description



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

Modes Of Operation

Normal Mode

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

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

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

Reduced Engine Power Mode

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

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

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DTC P0005 (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0005

High Pressure Fuel Shutoff Relay Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Relay 1 Switch B+	*	*	—	—
Fuel Shutoff Solenoid 1 Control	*	*	—	—
Relay 1 Coil Control	P0628, P069E	*	P0629, P069E	—
Relay 1 Coil Ground	—	P062B, P0513	P062B, P0513	—
Fuel Shutoff Solenoid 1 Ground	—	*	*	—
Relay 2 Switch B+	P0005	P0005	—	—
Relay 2 Solenoid Control	*	*	**	—
Relay 2 Coil Control	P0005	P0005	P0005	—
Fuel Shutoff Solenoid 2 Ground	—	*	*	—

*Engine cranks, no start.
**Fuel shutoff solenoids always ON.

Circuit/System Description

Fuel shutoff valve 1 is located on the fuel tank outlet and closes off the liquid side of the fuel system when not energized. Fuel shutoff valve 2 is located on the fuel vaporizer and closes off the vapor side of the fuel system when not energized. The fuel injector control module controls the operation of the fuel shutoff solenoids, based on the status of the engine run and engine cranking GMLAN signals from the engine control module. When the fuel injector control module is in standby mode the fuel shutoff output will be switched off. When the engine is cranking or running then the shutoff solenoids will be energized.

Conditions for Running the DTC

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- Ignition is ON or the engine is running
- DTC P15AE or P15AF is not set.
- The DTC runs continuously once the above conditions are met for greater than 3 s.

Conditions for Setting the DTC

- The fuel injector control module detects the fuel shutoff valve control circuit is open or shorted to ground for 2 s when the fuel shutoff valve is commanded OFF.
- The fuel injector control module detects the fuel shutoff valve control circuit is shorted to voltage for 2 s when the fuel shutoff valve is commanded ON.

Action Taken When the DTC Sets

DTC P0005 is a Type A DTC.

Conditions for Clearing the DTC

DTC P0005 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG 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 that fuel shutoff valve relay 1 clicks when commanding the Fuel Pump Enable ON and OFF with a scan tool.

⇒ **If the fuel shutoff valve relay 1 does not click**

Refer to Circuit/System Testing.

⇓ **If the fuel shutoff valve relay 1 clicks**

3. Verify that fuel shutoff valve relay 2 clicks when commanding the Fuel Shutoff Solenoid Valves ON and OFF with a scan tool.

⇒ **If the fuel shutoff valve relay 2 does not click**

Refer to Circuit/System Testing.

⇓ **If the fuel shutoff valve relay 2 clicks**

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4. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the fuel shutoff valve relay 1. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 2 Ω between the ground circuit terminal 86 and ground.

⇒ **If 2 Ω or greater**

2.1. Ignition OFF.

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

⇒ If 1 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 a test lamp illuminates between the B+ circuit terminal 87 and ground.

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

4.1. Ignition OFF.

4.2. Test for less than 2 Ω in the B+ circuit end to end.

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

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

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

4.1. Ignition OFF.

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

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

⇓ If infinite resistance

4.3. Test for infinite resistance between the control circuit terminal 30 and ground.

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

⇒ If infinite resistance, replace the fuel shutoff valve relay 1.

⇓ **If the test lamp illuminates**

5. Connect a test lamp between the control circuit terminal 85 and the ground circuit terminal 86.
6. Verify the test lamp turns ON and OFF when commanding the Fuel Pump Enable ON and OFF with a scan tool.

⇒ **If the test lamp is always OFF**

6.1. Ignition OFF, disconnect the X-1 harness connector at the engine control module.

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

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

⇓ If infinite resistance

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

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

⇒ If less than 2 Ω, replace the engine control module.

⇒ **If the test lamp is always ON**

6.1. Ignition OFF, disconnect the X-1 harness connector at the engine control module, ignition ON.

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

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

⇒ If less than 1 V, replace the engine control module.

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

7. Verify that a test lamp does not illuminate between the control circuit terminal 30 and ground.

⇒ **If the test lamp illuminates**

Repair the short to voltage on the control circuit

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

8. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the fuel shutoff valve 1. It may take up to 2 minutes for all vehicle systems to power down.
9. Test for less than 2 Ω between the fuel shutoff valve 1 ground circuit terminal 2 and ground.

⇒ **If 2 Ω or greater**

9.1. Ignition OFF.

9.2. 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**

10. Connect the harness connector at the fuel shutoff valve 1.
11. Ignition ON, connect a 15 A fused jumper wire between the B+ circuit terminal 87 and the control circuit terminal 30.
12. Command the Fuel Shutoff Solenoid Valves ON with a scan tool and verify the fuel shutoff valves are activated.

⇒ **If the fuel shutoff valves do not activate**

12.1. Ignition OFF, disconnect the harness connector at the fuel shutoff valve 1.

12.2. 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 fuel shutoff valve 1.

⇓ **If the fuel shutoff valves activate**

13. Test or replace the fuel shutoff valve relay 1.
14. Ignition OFF, disconnect the fuel shutoff valve relay 2, ignition ON.
15. Verify a test lamp illuminates between the B+ circuit terminal 85 and ground.

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

15.1. Ignition OFF.

15.2. 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**

15.1. Ignition OFF.

15.2. 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,

15.3. Test for greater than 1.8 kΩ between the control circuit terminal 86 and ground.

⇒ If less than 1.8 kΩ, repair the short to ground on the circuit.

⇒ If greater than 1.8 kΩ, test or replace the fuel shutoff valve relay 2.

⇓ **If the test lamp illuminates**

16. Command the Fuel Pump Enable ON with a scan tool and verify a test lamp illuminates between the B+ circuit terminal 30 and ground.

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

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16.1. Ignition OFF.

16.2. 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 the test lamp illuminates**

17. Connect a test lamp between the B+ circuit terminal 85 and the control circuit terminal 86.
18. Verify the test lamp turns ON and OFF when commanding the Fuel Shutoff Solenoid Valves ON and OFF with a scan tool.

⇒ **If the test lamp is always OFF**

18.1. Ignition OFF, disconnect the harness connector at the fuel injector control module, ignition ON.

18.2. 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

18.3. Ignition OFF.

18.4. 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 fuel injector control module.

⇒ **If the test lamp is always ON**

18.1. Ignition OFF, disconnect the harness connector at the fuel injector control module control module.

18.2. 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 fuel injector control module.

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

19. Verify a test lamp does not illuminate between the control circuit terminal 87A and ground.

⇒ **If the test lamp illuminates**

Repair the short to voltage on the circuit.

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

20. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the fuel shutoff valve 2. It may take up to 2 minutes for all vehicle systems to power down.
21. Test for less than 2 Ω between the fuel shutoff valve 2 ground circuit terminal 2 and ground.

⇒ **If 2 Ω or greater**

21.1. Ignition OFF.

21.2. 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**

22. Connect the harness connector at the fuel shutoff valve 2.
23. Command the Fuel Shutoff Solenoid Valves OFF with a scan tool and verify that the engine will not start.

⇒ **If the engine starts**

Test or replace the fuel shutoff valve relay 2.

Component Testing

Relay Test

1. Ignition OFF, disconnect the appropriate fuel shutoff valve relay.

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2. Test for 70–110 Ω between terminals 85 and 86.

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

Replace the relay.

⇓ **If between 70–110 Ω**

3. Test for infinite resistance between the terminals listed below:
   - 30 and 86
   - 30 and 87
   - 30 and 85
   - 85 and 87

⇒ **If less than infinite resistance**

Replace the relay.

⇓ **If infinite resistance**

4. Test for less than 0.5 Ω between terminals 30 and 87A.

⇒ **If 0.5 Ω or greater**

Replace the relay.

⇓ **If less than 0.5 Ω**

5. Install a 15 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.
6. Test for less than 2 Ω between terminals 30 and 87.

⇒ **If 2 Ω or greater**

Replace the relay.

⇓ **If less than 2 Ω**

7. All OK

Shutoff Valve 1 Static Test

1. Ignition OFF, disconnect the harness connector at the fuel shutoff valve 1.
2. Test for 12.5–14.5 Ω between the control terminal 1 and the ground terminal 2.

⇒ **If not between 12.5–14.5 Ω**

Replace the fuel shutoff valve 1.

⇓ **If between 12.5–14.5 Ω**

3. Test for infinite resistance between each terminal and the fuel shutoff valve 1 housing/case.

⇒ **If less than infinite resistance**

Replace the fuel shutoff valve 1.

⇓ **If infinite resistance**

4. All OK

Shutoff Valve 2 Static Test

1. Ignition OFF, disconnect the harness connector at the fuel shutoff valve 2.
2. Test for 6.5–8.5 Ω between the control terminal 1 and the ground terminal 2.

⇒ **If not between 6.5–8.5 Ω**

Replace the fuel shutoff valve 2.

⇓ **If between 6.5–8.5 Ω**

3. Test for infinite resistance between each terminal and the fuel shutoff valve 2 housing/case.

⇒ **If less than infinite resistance**

Replace the fuel shutoff valve 2.

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⇓ **If infinite resistance**

4. All OK

Shutoff Valve Dynamic Test

1. Ignition OFF, disconnect the harness connector at the appropriate fuel shutoff valve.
2. Install a 15 A fused jumper wire between the control terminal 1 and 12 V. Install a jumper wire between the ground terminal 2 and ground.
3. Verify the fuel shutoff valve turns on & off/clicks, etc.

⇒ **If the fuel shutoff valve does not turn on & off/clicks, etc.**

Replace the fuel shutoff valve.

⇓ **If the fuel shutoff valve does turn on & off/clicks, etc.**

4. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- LPG Shutoff Valve Replacement
- Control Module References for fuel injector control module replacement, programming, and setup.

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DTC P0010, P0013, P0020, P0023, P2088, P2089, P2090, P2091, P2092, P2093, P2094, or P2095

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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

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

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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.
- DTCs P0010, P0013, P0020, P0023 and P2088 - P2095 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 s.

Action Taken When the DTC Sets

DTCs P0010, P0013, P0020, P0023 and P2088 - P2095 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0010, P0013, P0020, P0023 and P2088 - P2095 are Type B DTCs.

Diagnostic Aids

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

Reference Information

Schematic Reference

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Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Component View Reference

Powertrain Component Views

Description and Operation

Camshaft Actuator System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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

1. Ignition On.
2. Verify DTC P0335, P0336, P0340, 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:
   - 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.

⇓ **If Malfunction is not displayed**

4. Engine idling at normal operating temperature.
5. Verify the scan tool parameters listed below do not display Malfunction when commanding the appropriate scan tool Camshaft Position Actuator from 0–25° and back to 0° 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

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- 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.

⇓ **If Malfunction is not displayed**

6. Raise the engine speed to 2,000 RPM for 10 s.
7. 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**

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 appropriate harness connector at the Q6 camshaft position actuator solenoid valve. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition Off, disconnect the harness connector at the K20 engine control module.

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

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

⇒ If less than 2 Ω, replace the K20 engine control module

⇓ **If less than 5 Ω**

3. Ignition On.

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

4. Verify that a test lamp does not illuminate between the control circuit terminal 1 and ground.

⇒ **If the test lamp illuminates**

4.1. Ignition Off, disconnect the harness connector at the K20 engine control module, ignition On.

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

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

⇒ If less than 1 V, replace the K20 engine control module

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

5. Remove the test lamp.
6. Connect the DMM black lead to the control circuit terminal 1. Connect the DMM red lead to B+. Command the Camshaft Position Actuator Solenoid On and Off with a scan tool. Verify the voltage changes.

⇒ **If the voltage does not change**

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

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

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⇒ 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 voltage changes**

7. 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 and the low reference terminal 2.

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

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DTC P0011, P0014, P0021, or P0024

Diagnostic Instructions

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

DTC Descriptors

DTC P0011

Intake Camshaft Position System Performance 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.

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- The desired camshaft position is not changing greater than 4.5° for at least 1 s.
- Both of the desired and actual camshaft position actuator values cannot be greater than 20° or less than 5°.
- 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 5° for greater 2.5 s.

P0014 and P0024

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

Action Taken When the DTC Sets

DTCs P0011, P0014, P0021, and P0024 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0011, P0014, P0021, and P0024 are Type B DTCs.

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

Connector End View Reference

Component Connector End Views

Component View Reference

Powertrain Component Views

Description and Operation

Camshaft Actuator System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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Note:

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

1. Ignition On.
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 2° in each of the commanded states when commanding the Camshaft Position Actuator from 0–20° and back to 0° with the scan tool.
   - Intake Camshaft Position Variance
   - Exhaust Camshaft Position Variance

⇒ **If 2° or greater**

Refer to Circuit/System Testing.

⇓ **If less than 2°**

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

⇒ **If any of the DTCs are set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

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

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

9. All OK.

Circuit/System Testing

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

⇒ **If 5 Ω or greater**

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

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

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

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

⇓ **If less than 5 Ω**

3. Ignition On.

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

4. Verify that a test lamp does not illuminate between the control circuit terminal 1 and ground.

⇒ **If the test lamp illuminates**

4.1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.

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

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

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

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

5. Remove the test lamp.

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

⇒ **If Malfunction is displayed**

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

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

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

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

⇓ **If Malfunction is not displayed**

7. Ignition Off, remove the Q6 Camshaft Position Actuator Solenoid Valve.

8. Verify the conditions listed below do not exist with the Q6 Camshaft Position Actuator Solenoid Valve:

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

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

8.3. Oil seepage at the solenoid connector.

⇒ **If a condition is found**

Replace the Q6 Camshaft Position Actuator Solenoid Valve.

⇓ **If a condition is not found**

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

9. Ignition Off, swap the Q6 Camshaft Position Actuator Solenoid Valve with the Q6 Camshaft Position Actuator Solenoid Valve that is operating correctly.

10. Engine idling.

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11. Verify the scan tool Camshaft Position Variance parameter is less than 2° in each of the commanded states when commanding the Camshaft Position Actuator from 0–20° and back to 0° with a scan tool.

⇒ **If 2° or greater**

Replace the mechanical camshaft position actuator.

⇓ **If less than 2°**

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

Component Testing

1. Ignition Off, disconnect the harness connector at the appropriate Q6 Camshaft Position Actuator Solenoid Valve.
2. Test for 5-12 Ω between the control terminal 1 and the low reference circuit terminal 2.

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

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DTC P0016, P0017, P0018, or P0019

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 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 9° advanced or 12° retarded in relationship to the crankshaft.
  - Bank 1 exhaust camshaft is greater than 10° advanced or 13° retarded in relationship to the crankshaft.
  - Bank 2 intake camshaft is greater than 11° advanced or 13° retarded in relationship to the crankshaft.
  - Bank 2 exhaust camshaft is greater than 9° advanced or 13° retarded in relationship to the crankshaft.

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- 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 9° advanced or 12° retarded in relationship to the crankshaft.
  - Bank 1 exhaust camshaft is greater than 10° advanced or 13° retarded in relationship to the crankshaft.
  - Bank 2 intake camshaft is greater than 6° advanced or 9° retarded in relationship to the crankshaft.
  - Bank 2 exhaust camshaft is greater than 7° advanced or 9° 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.
4. Verify DTC P0016, P0017, P0018, or P0019 is not set.

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

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DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, or P0161

Diagnostic Instructions

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

DTC Descriptors

DTC P0030

HO2S Heater Control Circuit 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

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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

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

Diagnostic Fault Information

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

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Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
	P0135, P0141, P0155, P0161	P0155, P0158, P0160, P0161	P0155, P0158, P0160, P0161	P0140, P0141, P0152, P0154, P0155, P0158, P0160, P0161	
* Opens Fuse					

Typical Scan Tool Data

HO2S Sensor 1 Current/HO2S Sensor 2 Current

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

Circuit/System Description

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

Conditions for Running the DTC

P0030-P0032, 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 +45°C (−22 to +113°F) at engine start-up.
- The ECT and the intake air temperature (IAT) are within 8°C (14°F) at engine start-up.
- The DTCs run once per drive cycle when the above conditions are met.

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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.

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.

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.

Action Taken When the DTC Sets

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

Conditions for Clearing the MIL/DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the HO2S Heater Bank 1 or 2 Sensor 1 or 2 ON and OFF with a scan tool .
   - 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
   - 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 sets**

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 C and ground.

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

2.1. Ignition OFF, remove the test lamp.

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

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

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

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

2.1. Ignition OFF.

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

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

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

⇓ **If the test lamp illuminates**

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

⇒ **If the test lamp illuminates**

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

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

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

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

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

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

   ⇒ **If the parameter is not OK**

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

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

⇓ **If the parameter is OK**

Note:

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

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

   Note: This test may only be performed once per key cycle. If test is repeated, ignition OFF, allow the engine control module to shut down completely, then ignition ON.
7. Verify the scan tool HO2S Heater Control Circuit High Voltage Test Status Bank 1 or 2 Sensor 1 or 2 parameter is Malfunction when commanding the HO2S Heater ON with a scan tool.

⇒ **If the parameter is not Malfunction**

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

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

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

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

⇓ **If the parameter is Malfunction**

8. Test or replace the B52 Heated Oxygen Sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Heated Oxygen Sensor Replacement - Bank 1 Sensor 1
- Heated Oxygen Sensor Replacement - Bank 1 Sensor 2
- Heated Oxygen Sensor Replacement - Bank 2 Sensor 1
- 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

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DTC P0068 or P1101

Diagnostic Instructions

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

DTC Descriptor

DTC P0068

Throttle Body Air Flow Performance

DTC P1101

Intake Air Flow System Performance

Circuit/System Description

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

Conditions for Running the DTC

DTC P0068

- The engine speed is greater than 800 RPM.
- The ignition voltage is greater than 6.5 V.
- The throttle actuator control system is not in reduced power mode.
- The DTC runs continuously when the above conditions are met.

DTC P1101

- DTCs P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0114**, P0116, P0117, P0118, P0128, P0335, or P0336 are not set. **Where used.
- The engine speed is between 600–6,800 RPM
- The engine coolant temperature (ECT) is between −7 and +125°C (+19 and +257°F).
- The intake air temperature (IAT) sensor 1 is between −20 and +125°C (−4 to +257°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

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

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

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Component Connector End Views

Electrical Information Reference

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- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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

⇒ **If any of the DTCs are set**

Refer to DTC P0641, P0651, P0697, or P06A3 for further diagnosis.

⇓ **If none of the DTCs are set**

3. 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 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.
   - 7.1. Engine idling
   - 7.2. Perform the scan tool snapshot function.
   - 7.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
   - 7.4. Exit from the scan tool snapshot and review the data.
   - 7.5. Observe the MAF Sensor parameter frame by frame with a scan tool.

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

Refer to DTC P0101 for further diagnosis.

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⇓ **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 for further diagnosis.

⇓ **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.

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

Diagnostic Instructions

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

DTC Descriptors

DTC P0089

Fuel Pressure Regulator Performance

DTC P00C6

Fuel Rail Pressure Low During Engine Cranking

DTC P228C

Fuel Pressure Regulator Control Performance - Low Pressure

DTC P228D

Fuel Pressure Regulator Control Performance - High Pressure

Circuit/System Description

The high fuel pressure necessary for direct injection is supplied by the high pressure fuel pump. The high pressure fuel pump is mounted on the rear of the engine and is driven by a three-lobe cam on the Bank 2 exhaust camshaft. This high pressure fuel 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 2,176 psi), depending on engine speed and load. Output drivers in the ECM provide the high pressure fuel pump actuator 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 high pressure fuel pump operates at maximum flow rate. In the event of high pressure fuel pump control failure, the high pressure system is protected by a relief valve in the high pressure fuel pump that prevents the pressure from exceeding 17.5 MPa (2,538 psi).

The fuel rail pressure sensor provides the feedback necessary to the ECM to control the high pressure fuel pump and the fuel injectors. This fuel rail pressure sensor is diagnosed separately from the fuel pressure control system.

The ECM monitors the fuel rail pressure sensor and the high pressure fuel pump actuator to determine if the commanded and actual pressures are within a predetermined range during engine cranking and at all times while the engine is running. The ECM also monitors the high pressure fuel pump actuator to make sure it is operating within expected limits.

Conditions for Running the DTC

P0089, P228C, or P228D

- DTC P0016, P0017, P0018, P0019, P0090, P0091, P0092, P00C8, P00C9, P00CA, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0178, P0179, P0191, P0192, P0193, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0627, P0628, P1682, or P2269 is not set.

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- The ignition voltage is greater than 11 V.
- The low side fuel pressure is greater than 275 kPa (40 psi).
- The engine is running.
- The barometric pressure (BARO) is greater than 70 kPa (10.2 psi).
- The intake air temperature (IAT) is greater than −10° C (14° F).
- The DTCs run continuously when the above conditions are met for 10 s.

P00C6

- DTC P0016, P0017, P0018, P0019, P0090, P0091, P0092, P00C8, P00C9, P00CA, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0178, P0179, P0191, P0192, P0193, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0627, P0628, P1682, or P2269 is not set.
- The ignition voltage is greater than 8 V.
- The engine coolant temperature is less than 65°C (149°F).
- The low side fuel pressure is greater than 0 kPa (0 psi).
- The barometric pressure (BARO) is greater than 70 kPa (10.2 psi).
- The intake air temperature (IAT) is greater than −10° C (14° F).
- The engine is not running.
- The diagnostic runs once for each engine start.

Conditions for Setting the DTC

P0089

The high pressure fuel pump has exceeded it's control limits. This condition exists when the high pressure fuel pump actuator command is 0 ° or greater than 240 °. The condition exists for greater than 10 s.

P00C6

The engine control module detects that the fuel rail pressure is not rising greater than 3 MPa (435 psi) or has fallen below 2 MPa (290 psi) during engine cranking, depending on initial pressure when cranking begins.

P228C

The actual fuel rail pressure is 3 MPa (435 psi) less than the desired fuel rail pressure. The condition exists for greater than 10 s.

P228D

The actual fuel rail pressure is 3 MPa (435 psi) greater than the desired fuel rail pressure. The condition exists for greater than 10 s.

Action Taken When the DTC Sets

- DTCs P0089 and P00C6 are Type B DTCs.
- DTCs P228C and P228D are Type A DTCs.
- A message center or an indicator displays Reduced Engine Power for P228C and P228D.

Conditions for Clearing the DTC

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

Diagnostic Aids

- A leak in the high pressure fuel system may set a DTC.

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- A faulty valve, plunger, or solenoid in the high pressure fuel pump may set a DTC. High pressure fuel pump damage will most likely be undetectable upon visual inspection.
- A restricted fuel feed pipe between the high pressure fuel pump and the fuel rail pressure sensor may set a DTC.
- Any problem with the Bank 2 exhaust cam may set fuel pressure DTCs due to the location and design of the high pressure fuel pump. If DTC P0019 or P0391 are current or in history, a cam control issue may be the root cause.
- A leaking or restricted fuel injector may set DTC P0089.
- For DTC P00C6, park the vehicle outdoors overnight and perform a start in the morning.
- A short to voltage in the crankshaft position sensor signal circuit may set a DTC.
- As little as 2 Ω on either circuit of the high pressure fuel pump actuator will cause these DTCs to set. Test the circuits of the high pressure fuel pump actuator for a high resistance if you suspect a condition.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON
2. Verify DTC P0016, P0017, P0018, P0019, P0090, P0091, P0092, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0178, P0179, P0191, P0192, P0193, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0627, P0628, P1682, or P2269 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 idling.
4. Verify the 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 Circuit/System Testing.

⇓ **If between 1.9–5.0 MPa (276–725 psi)**

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5. Verify the Fuel Rail Pressure Sensor increases and decreases when commanding the Fuel Rail Pressure Control with a scan tool.

⇒ **If the Fuel Rail Pressure Sensor does not increase and decrease with each command**

Refer to Circuit/System Testing.

⇓ **If the Fuel Rail Pressure Sensor increases and decreases with each command**

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.

6. Road test the vehicle and perform a wide open acceleration from a stop until the transmission shifts into second gear. On manual transmission applications, shift to second gear or stop the test near 7,000 RPM. Repeat the test at least three times.
7. Verify DTCs P0089, P00C6, P228C, and P228D do not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

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 DTCs P0089, P00C6, P228C, and P228D do not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

10. All OK.

Circuit/System Testing

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

1. Clear all DTCs.

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. Road test the vehicle and perform a wide open acceleration from a stop until the transmission shifts into second gear. On manual transmission applications, shift to second gear or stop the test near 7,000 RPM. Repeat the test at least three times.
3. Verify the Fuel Rail Pressure Sensor parameter is between 14–17 MPa (2,031–2,466 psi) while under load near 7,000 RPM.

⇒ **If not between 14–17 MPa (2,031–2,466 psi)**

3.1. Remove the G18 High Pressure Fuel Pump.

3.2. Inspect the lobes on the camshaft for unusual wear.

⇒ If the camshaft lobes are worn, replace the camshaft.

⇒ If the camshaft lobes appear normal, test or replace the G18 High Pressure Fuel Pump.

⇓ **If between 14–17 MPa (2,031–2,466 psi)**

4. Verify none of the conditions listed below exist:

4.1. Contaminates in the fuel system, Refer to Alcohol/Contaminants-in-Fuel Diagnosis

4.2. A Leak in the high pressure fuel system.

4.3. A restricted fuel feed pipe between the G18 High Pressure Fuel Pump and the B47B Fuel Rail Fuel Pressure Sensor.

4.4. A leaking or restricted Q17 Fuel Injector, Refer to Fuel Injector Solenoid Coil Test and Fuel Injector Balance Test.

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4.5. High resistance in the G18 High Pressure Fuel Pump actuator circuits.

⇒ **If a condition exist**

Repair as necessary.

⇓ **If none of the conditions exist**

5. All OK.

Component Testing

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

   Note: The DMM and test leads must be calibrated to 0 Ω in order to prevent misdiagnosis.
2. Test for 9–11 Ω at 25°C (77°F) of resistance between G18 High Pressure Fuel Pump actuator low control circuit terminal 1 and high control circuit terminal 2.

⇒ **If not within the specified range**

Replace the G18 High Pressure Fuel Pump.

⇓ **If within the specified range**

3. Test for infinite resistance between each G18 High Pressure Fuel Pump actuator terminal and the G18 High Pressure Fuel Pump housing/case.

⇒ **If less than infinite resistance**

Replace the G18 High Pressure Fuel Pump.

⇓ **If infinite resistance**

4. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair

- Camshaft Replacement - Left Side
- Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail
- Fuel Pump Replacement

  Note: Some vehicles do not support the Fuel Rail Pressure Relief Valve Reset procedure. Applications not supporting this procedure will return an error message stating "Parameter ID not supported. Check for proper vehicle selection."
- Perform the Fuel Rail Pressure Relief Valve Reset procedure.

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DTC P0090-P0092, P00C8, P00C9, or P00CA

Diagnostic Instructions

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

DTC Descriptors

DTC P0090

Fuel Pressure Regulator Control Circuit

DTC P0091

Fuel Pressure Regulator Control Circuit Low Voltage

DTC P0092

Fuel Pressure Regulator Control Circuit High Voltage

DTC P00C8

Fuel Pressure Regulator High Control Circuit

DTC P00C9

Fuel Pressure Regulator High Control Circuit Low Voltage

DTC P00CA

Fuel Pressure Regulator High Control Circuit High Voltage

Diagnostic Fault Information

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

Circuit/System Description

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

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The high fuel pressure necessary for direct injection is supplied by the high pressure fuel pump. The high pressure fuel pump is mounted on the rear of the engine and is driven by a three-lobe cam on the Bank 2 exhaust camshaft. This high pressure fuel 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 ECM requests pressure ranging from 2–15 MPa (290–2,176 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.

It is important to note that the high pressure fuel pump is a trailing-edge control system, meaning that if 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 (2,538 psi).

Note: The fuel rail pressure sensor is diagnosed separately from the fuel pressure control system and should not be replaced for any codes referenced in this document.

The fuel rail pressure sensor operates on a 5 V reference circuit and it provides the feedback necessary to the ECM to control the high pressure fuel pump and the fuel injectors.

Conditions for Running the DTC

- The ignition voltage is between 11–18 V.
- The DTCs run continuously within the enabling conditions.

Conditions for Setting the DTC

P0090

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

P0091

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

P0092

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

P00C8

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

P00C9

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

P00CA

- The engine control module detects a short to voltage in the high pressure fuel pump actuator high control circuit.

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- The DTC sets when the above condition is present for 4 s.

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0685, or P1682 are 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 parameters listed below do not display Malfunction when commanding the Fuel Pressure Regulator ON and OFF with a scan tool.
    - Fuel Pressure Regulator Control Circuit High Voltage Test Status
    - Fuel Pressure Regulator Control Circuit Open Test Status
    - Fuel Pressure Regulator Control Circuit Low Voltage Test Status
    - Fuel Pressure Regulator High Control Circuit High Voltage Test Status
    - Fuel Pressure Regulator High Control Circuit Open Test Status
    - Fuel Pressure Regulator High Control Circuit Low Voltage Test Status

⇒ **If Malfunction is displayed**
Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

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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 from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the 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 1 and ground.

⇒ **If the test lamp illuminates**

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

2.2. 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 2 and ground.

⇒ **If the test lamp illuminates**

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

3.2. Test for less than 1 V between the 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 1 and B+.

⇒ **If the test lamp illuminates**

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

4.2. 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 2 and B+.

⇒ **If the test lamp illuminates**

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

5.2. 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**

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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.

⇒ **If Malfunction is not displayed**

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

7.2. 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**

9.1. Ignition OFF, remove the fused jumper, disconnect the harness connector at the K20 Engine Control Module.

9.2. 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

Static Test

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

   Note: The DMM and test leads must be calibrated to 0 Ω in order to prevent misdiagnosis.
2. Test for 9–11 Ω at 25°C (77°F) of resistance between low control circuit terminal 1 and high control circuit terminal 2.

⇒ **If not within the specified range**

Replace the G18 High Pressure Fuel Pump.

⇓ **If within the specified range**

3. Test for infinite resistance between each terminal and the High Pressure Fuel Pump housing/case.

⇒ **If less than infinite resistance**

Replace the G18 High Pressure Fuel Pump.

⇓ **If infinite resistance**

4. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Pump Replacement for G18 High Pressure Fuel Pump replacement.
- Control Module References for K20 Engine Control Module replacement, programming, and setup.

  Note: Some vehicles do not support the Fuel Rail Pressure Relief Valve Reset procedure. Applications not supporting this procedure will return an error message stating "Parameter ID not supported. Check for proper vehicle selection."
- Perform the Fuel Rail Pressure Relief Valve Reset procedure.

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DTC P0096 or P0111

Diagnostic Instructions

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

DTC 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, P0114**, P2199**	P0111, P0113, P0114**, P2199**	P0113*, P0114**, P2199**	P0111, P2199**
Low Reference	—	P0111, P0113, P0114**, P2199**, P2229, P2230	P0113*, P0114**, P2199**, P2227, P2229	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199**	P0096, P0097, P00F4, P0101, P0102, P2199**	P0690	P0096, P0101, P0103
Signal	P0096, P0097,	P0096, P0097,	P0096*, P0097,	P0096

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
	P00F5, P2199**	P00F3, P2199**	P00F3, P2199**	
Ground	—	P0096, P0097, P00F3, P0102, P0178, P2199**, P2230	—	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

[Typical Scan Tool Data]

IAT Sensor 1

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

IAT Sensor 2

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

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Circuit	Short to Ground	Open or High Resistance	Short to Voltage
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

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

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

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

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

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

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

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

IAT Sensor 1 — Temperature, Resistance, Voltage Table

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

IAT Sensor 2 — Temperature, Frequency Table

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

Conditions for Running the DTCs

P0096 and P0111

- DTCs P0097, P0098, P0112, P0113, P0116, P0117, P0118, P0119, or P1682 are not set.

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- 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

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

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

P0111

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

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

Action Taken When the DTCs Set

DTCs P0096 and P0111 are Type B DTCs.

Conditions for Clearing the DTCs

DTCs P0096 and P0111 are Type B DTCs.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

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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.

Circuit/System Verification

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

⇒ **If any of the DTCs are set**

Refer to DTC P0641, P0651, P0697, or P06A3 for further diagnosis.

⇓ **If none of the DTCs are set**

Note: To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 3 and 4of this verification procedure only if the ignition has been OFF for 8 hours or more.

3. Ignition ON.
4. Verify the following scan tool parameters are within 10°C (18°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - Start-Up ECT

⇒ **If not within 10°C (18°F)**

Refer to Circuit/System Testing.

⇓ **If within 10°C (18°F)**

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

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

Refer to Circuit/System Testing.

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

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. Verify none of the following conditions exist:
   - A restricted or collapsed air intake duct
   - An intake manifold leak

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- A MAP sensor seal that is leaking, missing, or damaged
- A restricted or collapsed air intake duct
- A misaligned or damaged air intake duct
- Any water intrusion in the induction system
- An Intake Manifold Resonator with a leaking seal, or a cracked or broken housing

⇒ **If a condition exists**

Repair or replace component as appropriate.

⇓ **If no condition exists**

2. Ignition OFF, and all vehicle systems OFF, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air sensor.
3. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.

⇒ **If 2 Ω or greater**

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

3.2. Test for less than 2 Ω in the low reference circuit end to end.

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

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

⇓ **If less than 2 Ω**

4. Ignition OFF, test for less than 2 Ω between the ground circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

4.1. Ignition OFF. Disconnect the sensor chassis ground.

4.2. 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**

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

5.2. 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**

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

5.2. 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

5.3. 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**

6. Ignition ON, test for 4.8–5.2 V between the intake air temperature signal 1 circuit terminal 1 and ground.

⇒ **If less than 4.8 V**

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

6.2. Test for infinite resistance between the signal circuit and ground.

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

⇓ If infinite resistance

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

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

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

⇒ **If greater than 5.2 V**

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

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

6.2. Ignition ON, test for less than 1 V between the signal circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

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

⇒ **If not colder than −39°C (−38°F).**

Replace the engine control module.

⇓ **If colder than −39°C (−38°F).**

8. Ignition OFF. Install a 3 A fused jumper wire between the signal circuit terminal 1 and low reference circuit terminal 3.

9. Ignition ON. Verify the scan tool IAT Sensor 1 parameter is warmer than 149°C (300°F).

⇒ **If not warmer than 149°C (300°F).**

Replace the K20 Engine Control Module.

⇓ **If warmer than 149°C (300°F).**

10. Ignition ON, 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**

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

10.2. 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

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

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

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

⇒ **If greater than 5.2 V**

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

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

10.2. Ignition ON, test for less than 1 V between the signal circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

11. Determine if *EL-38522-A* Variable Signal Generator or equivalent is available.

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

11.1. Replace the K20 Engine Control Module.

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11.2. 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.

11.3. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to step 15.

⇓ **If the DTC does not set**

11.4. All OK.

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

12. Ignition OFF, connect the leads of the *EL-38522-A* Variable Signal Generator as follows:
    - Red lead to the signal circuit terminal 8 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
13. Set the *EL-38522-A* Variable Signal Generator to the following specifications.
    - Signal switch to 5 V
    - Duty Cycle switch to 50 % (Normal)
    - Frequency switch to 30 Hz
14. Ignition ON, verify the scan tool IAT Sensor 2 parameter is between 28–32 Hz.

⇒ **If not between 28–32 Hz**

Replace the K20 Engine Control Module.

⇓ **If between 28–32 Hz**

15. Test or replace the appropriate temperature sensor.

Component Testing

Multifunction Intake Air Sensor

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

   Note: A thermometer can be used to test the sensor off the vehicle.
2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the Temperature Versus Resistance - Intake Air Temperature Sensor table for Hitachi Sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range**

3. All OK

Multifunction Intake Air Sensor

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

⇒ **If not within the specified range**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range**

2. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Mass Airflow Sensor with Intake Air Temperature Sensor Replacement for multifunction intake air sensor replacement

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

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DTC P0097, P0098, or P0099

Diagnostic Instructions

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

DTC Descriptors

DTC P0097

Intake Air Temperature (IAT) Sensor 2 Circuit Low Voltage

DTC P0098

Intake Air Temperature (IAT) Sensor 2 Circuit High Voltage

DTC P0099

Intake Air Temperature (IAT) Sensor 2 Circuit Intermittent

Diagnostic Fault Information

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199**	P0096, P0097, P00F4, P0101, P0102, P2199**	P0690	P0096, P0101, P0103
Signal	P0096, P0097, P00F5, P2199**	P0096, P0097, P00F3, P2199**	P0096*, P0097, P00F3, P2199**	P0096
Ground	—	P0096, P0097, P00F3, P0102, P0178, P2199**, P2230	—	P0096, P0102

*Internal ECM or sensor damage may occur if the circuit is shorted to B+.
**Where used.

Typical Scan Tool Data

IAT Sensor 2

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

Circuit/System Description

The 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 IAT sensor 2 and the humidity sensor share the same circuit. The IAT sensor 2 signal is displayed by the scan tool as Hertz (Hz) and °C (°F).

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

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

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

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

IAT Sensor 1 — Temperature, Resistance, Voltage Table

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

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IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage

IAT Sensor 2 — Temperature, Frequency Table

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

Conditions for Running the DTCs

P0097, P0098, and P0099

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

Conditions for Setting the DTCs

P0097

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

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

P0098

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

P0099

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

Reference Information

Schematic Reference

Engine Controls Schematics

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Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to Special 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 for further diagnosis.

⇓ **If none of the DTCs are set**

Note: To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 3 and 4of this verification procedure only if the ignition has been OFF for 8 hours or more.

3. Ignition ON.
4. Verify the following scan tool parameters are within 10°C (18°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - Start-Up ECT

⇒ **If not within 10°C (18°F)**

Refer to Circuit/System Testing.

⇓ **If within 10°C (18°F)**

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

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

Refer to Circuit System Testing.

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

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. Ignition OFF. Disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Test for less than 2 Ω between the ground circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

2.1. Ignition OFF. Disconnect the sensor chassis ground.

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

⇒ If 2 Ω or greater, repair the open 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**

3. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.

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

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

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

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

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

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

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

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

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

⇓ If infinite resistance

3.3. 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**

4. Ignition ON, test for 4.8–5.2 V between the intake air temperature sensor 2 signal circuit terminal 8 and ground.

⇒ **If less than 4.8 V**

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

4.2. Test for infinite resistance between the signal circuit and ground.

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

⇓ If infinite resistance

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

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

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

⇒ **If greater than 5.2 V**

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

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

4.2. Ignition ON, test for less than 1 V between the signal circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

5. Determine if *EL-38522-A* Variable Signal Generator or equivalent is available.

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

5.1. Replace the K20 Engine Control Module.

5.2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.

5.3. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to step 9.

⇓ **If the DTC does not set**

5.4. All OK.

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

6. Ignition OFF, connect the leads of the *EL-38522-A* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 8 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
7. Set the *EL-38522-A* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Duty Cycle switch to 50 % (Normal)
   - Frequency switch to 30 Hz
8. Ignition ON, verify the scan tool IAT Sensor 2 parameter is between 28–32 Hz.

⇒ **If not between 28–32 Hz**

Replace the K20 Engine Control Module.

⇓ **If between 28–32 Hz**

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

Component Testing

Multifunction Intake Air Sensor

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

⇒ **If not within the specified range**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range**

2. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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

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DTC P00F4-P00F6

Diagnostic Instructions

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

DTC Descriptors

DTC P00F4

Intake Air Humidity Sensor Circuit Low Voltage

DTC P00F5

Intake Air Humidity Sensor Circuit High Voltage

DTC P00F6

Intake Air Humidity Sensor Circuit Erratic

Diagnostic Fault Information

Intake Air Humidity

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199**	P0096, P0097, P00F4, P0101, P0102, P2199**	P0690	P0096, P0101, P0103
Signal	P0096, P0097, P00F5, P2199**	P0096, P0097, P00F4, P2199**	P0096*, P0097, P00F4, P2199**	P0096
Ground	—	P0096, P0097, P00F4, P0102, P2199**, P2230	—	P0096, P0102

*Internal ECM or sensor damage may occur if the circuit is shorted to B+.
**Where used.

Typical Scan Tool Data

Intake Air Humidity

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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 humidity sensor measures the ambient humidity of the air in the sensor bore. The signal varies with intake air humidity and is displayed by the scan tool as duty cycle %. The ECM applies 5 V to the circuit. The signal circuit is shared by the humidity sensor and the intake air temperature (IAT) sensor 2. 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

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

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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

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to Special 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 10°C (18°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - Start-Up ECT

⇒ **If not within 10°C (18°F)**

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Refer to Circuit/System Testing.

⇓ **If within 10°C (18°F)**

3. Engine idling, verify the scan tool Intake Air Humidity parameter is between 5 and 90 %.

⇒ **If not between 5 and 90 %**

Refer to Circuit/System Testing.

⇓ **If between 5 and 90 %**

4. Operate the vehicle within the conditions for running the DTC to verify that the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
5. Verify the DTCs do not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

6. All OK

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Ignition OFF, all vehicle systems OFF, test for less than 2 Ω between the ground circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

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

2.2. Test for less than 2 Ω in the 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**

3. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.

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

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

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

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

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

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

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

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

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

⇓ If infinite resistance

3.3. 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**

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

⇒ **If less than 4.8 V**

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

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4.2. Test for infinite resistance between the signal circuit and ground.

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

⇓ If infinite resistance

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

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

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

⇒ **If greater than 5.2 V**

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

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

4.2. Ignition ON, test for less than 1 V between the signal circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

5. Determine if *EL-38522-A* Variable Signal Generator or equivalent is available.

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

5.1. Replace the K20 Engine Control Module.

5.2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.

5.3. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to step 9.

⇓ **If the DTC does not set**

5.4. All OK.

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

6. Ignition OFF, connect the leads of the *EL-38522-A* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 8 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
7. Set the *EL-38522-A* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Frequency switch to 250 Hz
   - Duty Cycle switch to 50 % (Normal)
8. Ignition ON, observe the scan tool Intake Air Humidity parameter. The scan tool parameter should be between 45–55 %.

⇒ **If not between 45–55 %.**

Replace the K20 Engine Control Module.

⇓ **If between 45–55 %.**

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

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, or the parameter does not change, replace the B75C Multifunction Intake Air sensor.

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⇒ **If not within the specified range, or the parameter does not change**
Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range and the parameter does change**

2. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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

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DTC P0101

Diagnostic Instructions

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

DTC Descriptor

DTC P0101

Mass Air Flow (MAF) Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199**	P0096, P0097, P00F4, P0101, P0102, P2199**	P0690	P0096, P0101, P0103
Signal	P0102	P0102	P0102*	P0101, P0103, P1101
Ground	—	P0096, P0097, P00F4, P0102, P2199**	—	P0096, P0102

*Internal ECM or sensor damage may occur if the circuit is shorted to B+.
**Where used.

Typical Scan Tool Data

MAF Sensor

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

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Circuit	Short to Ground	Open	Short to Voltage
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit Description

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

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

Conditions for Running the DTCs

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

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTC P0101 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0101 is a Type B DTC.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

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

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to Special 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 for further diagnosis.

⇓ **If none of the DTCs are set**

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

⇒ **90 % or greater**

Refer to Throttle Body Inspection and Cleaning.

⇓ **If less than 90 %**

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

⇒ **If Disagree**

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

⇓ **If Agree**

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

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

Refer to DTC P0106 for further diagnosis.

⇓ **If the MAP Sensor parameter is 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.
   7.1. Engine idling
   7.2. Perform the scan tool snapshot function.
   7.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
   7.4. Exit from the scan tool snapshot and review the data.
   7.5. Observe the MAF Sensor parameter frame by frame with a scan tool.

⇒ **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**

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.

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9. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing for further diagnosis.

⇓ **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.

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

2. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
3. Test for less than 2 Ω between the ground circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

3.1. Ignition OFF. Disconnect the sensor chassis ground.

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

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

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

⇓ **If less than 2 Ω**

4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.

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

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

4.2. 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**

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

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4.2. 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
4.3. 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**

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

⇒ **If greater than 5.2 V**

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

⇓ **If between 4.8–5.2 V**

6. Determine if *EL-38522-A* Variable Signal Generator or equivalent is available.

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

6.1. Replace the K20 Engine Control Module.
6.2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
6.3. Verify the DTC does not set.
⇒ **If the DTC sets**
Refer to step 10.
⇓ **If the DTC does not set**
6.4. All OK.

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

7. Ignition OFF, connect the leads of the *EL-38522-A* Variable Signal Generator as follows:
- Red lead to the signal circuit terminal 6 at the harness connector
- Black leads to ground
- Battery voltage supply lead to B+

8. Set the *EL-38522-A* Variable Signal Generator to the following specifications.
- Signal switch to 5 V
- Frequency switch to 5 kHz
- Duty Cycle switch to 50 % (Normal)

9. Engine idling, observe the scan tool MAF Sensor parameter. The scan tool MAF Sensor parameter should be between 4,950–5,050 Hz.

⇒ **If not between 4,950–5,050 Hz.**

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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.

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

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DTC P0102 or P0103

Diagnostic Instructions

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

DTC Descriptors

DTC P0102

Mass Air Flow (MAF) Sensor Circuit Low Frequency

DTC P0103

Mass Air Flow (MAF) Sensor Circuit High Frequency

Diagnostic Fault Information

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

Typical Scan Tool Data

MAF Sensor

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

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Circuit	Short to Ground	Open	Short to Voltage
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

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Conditions for Running the DTC

- The engine is running for greater than 1 s.
- 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 800 Hz (about 0.90 g/s) for greater than 10 s.

P0103

The ECM detects that the MAF Sensor Signal parameter is greater than 14,500 Hz (about 630 g/s) 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

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to Special 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 for further diagnosis.

⇓ **If none of the DTCs are set**

3. Engine idling, observe the scan tool MAF Sensor parameter. The reading should be between 2.5–8.8 g/s.

⇒ **If not between 2.5–8.8 g/s**

Refer to Circuit/System Testing.

⇓ **If between 2.5–8.8 g/s**

4. 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.
   - 4.1. Engine idling
   - 4.2. Perform the scan tool snapshot function.
   - 4.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
   - 4.4. Exit from the scan tool snapshot and review the data.
   - 4.5. Observe the MAF Sensor parameter frame by frame with a scan tool.

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

Refer to Circuit/System Testing.

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

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 for further diagnosis.

⇓ **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, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Test for less than 2 Ω between the ground circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

2.1. Ignition OFF. Disconnect the sensor chassis ground.

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

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

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

⇓ **If less than 2 Ω**

3. Ignition ON, 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**

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

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

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

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

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

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

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

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

⇓ If infinite resistance

3.3. 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 2 Ω or greater, repair the open or high resistance in the circuit.

⇒ If the circuit tests normal and the fuse is open, test all the components connected to the circuit and repair or replace as necessary.

⇓ **If a test lamp illuminates**

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

⇒ **If less than 4.8 V**

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

4.2. Test for infinite resistance between the signal circuit and ground.

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

⇓ If infinite resistance

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

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

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

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⇒ **If greater than 5.2 V**

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

4.2. Ignition ON, test for less than 1 V between the signal circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

5. Determine if *EL-38522-A* Variable Signal Generator or equivalent is available.

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

5.1. Replace the K20 Engine Control Module.

5.2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.

5.3. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to step 9.

⇓ **If the DTC does not set**

5.4. All OK.

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

6. Ignition OFF, connect the leads of the *EL-38522-A* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 6 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
7. Set the *EL-38522-A* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Frequency switch to 5 kHz
   - Duty Cycle switch to 50 % (Normal)
8. Engine idling, verify the scan tool MAF Sensor parameter is between 4,950–5,050 Hz.

⇒ **If not between 4,950–5,050 Hz.**

If not between 4,950–5,050 Hz, replace the K20 Engine Control Module.

⇓ **If between 4,950–5,050 Hz.**

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

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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

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DTC P0106

Diagnostic Instructions

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

DTC Descriptor

DTC P0106

Manifold Absolute Pressure (MAP) Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P0107, P0641	P0106, P0697	P0107	P0106, P0697	P0106, P0107
Signal	P0107	P0106, P0107	P0107	P0108*	P0106, P0107, P1101
Low Reference	—	P0106, P0108	P0106, P0108	—	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)	0 kPa (0 PSI)	127 kPa (18.4 PSI)
Signal	0 kPa (0 PSI)	0 kPa (0 PSI)	127 kPa (18.4 PSI)*
Low Reference	—	127 kPa (18.4 PSI)	—
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

MAP Sensor, if equipped with Turbocharger

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

Circuit Description

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

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

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

Conditions for Running the DTC

- DTC P0102, P0103, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0128, P0335 or P0336 is not set.
- The engine speed is between 400–7,000 RPM.
- The intake air temperature (IAT) Sensor parameter is between −20° to +125°C (−4° to +257°F).
- The engine coolant temperature (ECT) Sensor parameter is between 69–127°C (156–260°F).
- This DTC runs continuously when the above conditions are met.

Conditions for Setting the DTCs

The ECM determines if the MAP Sensor is not within the normal operating range. It accomplishes this by running 3 different models within the software to determine the values, for greater than 0.5 S.

Action Taken When the DTC Sets

DTC P0106 is a Type B DTC.

Conditions for Clearing the MIL/DTC

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DTC P0106 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

GE-23738-A Vacuum Pump

For equivalent regional tools, refer to Special 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 for further diagnosis.

⇓ **If none of the DTCs are set**

2. If you were sent here from DTC P0068, P0101, P0121, 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 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**

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

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

Refer to Circuit/System Testing.

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

8. 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.
   8.1. Engine idling
   8.2. Perform the scan tool snapshot function.
   8.3. Increase the engine speed slowly to 3000 RPM and then back to idle.
   8.4. Exit from the scan tool snapshot and review the data.
   8.5. Observe the MAF Sensor parameter frame by frame with a scan tool.

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

Refer to DTC P0101 for further diagnosis.

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

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 the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

11. All OK.

Circuit/System Testing

1. Verify the integrity of the entire air induction system and verify that none of the following conditions exist:
   - Any damaged components
   - Improper operation of turbocharger wastegate actuator or bypass valve, if equipped
   - Loose or improper installation of the turbocharger and the charge air cooler, including the flexible ductwork, if equipped
   - An air flow restriction
   - Any vacuum leak
   - Improperly routed vacuum hoses
   - In cold climates, inspect for any snow or ice buildup at the BARO port on the ECM, if equipped
   - A restriction in the MAP Sensor port or the BARO port
   - Proper operation of the Positive Crankcase Ventilation (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 2 Ω between the low reference circuit terminal 2 and ground.

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⇒ **If 2 Ω or greater**

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

3.2. Test for less than 2 Ω in the low reference circuit end to end.

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

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

⇓ **If less than 2 Ω**

4. Ignition ON, test for 4.8–5.2 V between the 5 V reference circuit terminal 1 and ground.

⇒ **If less than 4.8 V**

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

4.2. Test for infinite resistance between the 5 V reference circuit and ground.

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

⇓ If infinite resistance

4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

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

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

Note: If the signal circuit is shorted to a voltage the ECM or the MAP Sensor may be damaged.

⇒ **If greater than 5.2 V**

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

4.2. Ignition ON, test for less than 1 V between the 5 V reference circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

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

⇒ **If 0.5 V or greater**

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

5.2. Ignition ON, test for less than 1 V between the signal circuit terminal 3 and ground.

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

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

⇓ **If less than 0.5 V**

6. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 3 and the 5 V reference circuit terminal 1.

7. Ignition ON, verify the scan tool MAP Sensor voltage parameter is greater than 4.5 V.

⇒ **If 4.5 V or less**

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

7.2. Remove the jumper wire, test for infinite resistance between the signal circuit terminal 3 and ground.

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

⇓ If infinite resistance

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

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

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

⇓ **If greater than 4.5 V**

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

Component Testing

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

Skewed Sensor Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor from the engine. Connect the harness to the sensor, if disconnected.
2. Ignition ON, apply 17 kPa (5.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the *GE-23738-A*. Verify the scan tool MAP pressure parameter decreases between 13–21 kPa (1.8–3.0 PSI).

⇒ **If the parameter does not decrease between 13–21 kPa (1.8–3.0 PSI).**

Replace the B74 Manifold Absolute Pressure Sensor.

⇓ **If the parameter does decrease between 13–21 kPa (1.8–3.0 PSI).**

3. Apply 34 kPa (10.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the *GE-23738-A*. Verify the scan tool MAP pressure parameter decreases between 30–38 kPa (4.4–5.5 PSI).

⇒ **If the parameter does not decrease between 30–38 kPa (4.4–5.5 PSI).**

Replace the B74 Manifold Absolute Pressure Sensor.

⇓ **If the parameter does decrease between 30–38 kPa (4.4–5.5 PSI).**

4. All OK.

Erratic Signal Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor and disconnect the harness.
2. Install a 3 A fused jumper wire between the 5 V reference circuit terminal 1 of the sensor and the sensor harness.
3. Install a jumper wire between the low reference circuit terminal 2 of the sensor and ground.
4. Install a jumper wire to the signal circuit terminal 3 of the sensor.
5. Connect a DMM between the jumper wire and ground.
6. Ignition ON, observe the DC voltage on the DMM. Slowly apply between 0-15 kPa (0–4.4 in Hg) of vacuum to the sensor with the *GE-23738-A*.
7. Verify the voltage changes, without any spikes or dropouts, between 0.2–4.9 V.

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

Replace the B74 Manifold Absolute Pressure Sensor.

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

8. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair

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

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DTC P0107 or P0108

Diagnostic Instructions

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

DTC Descriptors

DTC P0107

Manifold Absolute Pressure (MAP) Sensor Circuit Low Voltage

DTC P0108

Manifold Absolute Pressure (MAP) Sensor Circuit High Voltage

Diagnostic Fault Information

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

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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)	0 kPa (0 PSI)	127 kPa (18.4 PSI)
Signal	0 kPa (0 PSI)	0 kPa (0 PSI)	127 kPa (18.4 PSI)*
Low Reference	—	127 kPa (18.4 PSI)	—

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Circuit	Short to Ground	Open	Short to Voltage
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

MAP Sensor, if equipped with Turbocharger

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

Circuit Description

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

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

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

Conditions for Running the DTC

P0107

This DTC runs continuously.

P0108

This DTC runs continuously.

Conditions for Setting the DTC

P0107

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

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P0108

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

Action Taken When the DTC Sets

DTCs P0107 and P0108 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0107 and P0108 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

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.

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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 for further diagnosis.

⇓ **If none of the DTCs are set**

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

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

Refer to Circuit/System Testing for further diagnosis.

4. Verify the engine is equipped with a turbocharger.

⇒ **If not equipped with a turbocharger**

Refer to Step 6.

⇓ **If equipped with a turbocharger**

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

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

Refer to Circuit/System Testing.

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

Refer to Step 7.

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

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

Refer to Circuit/System Testing.

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

7. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
8. Verify the DTC does not set.

⇒ **If 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 B74 Manifold Absolute Pressure Sensor.
2. Ignition OFF and all vehicle systems OFF. It may take up to 2 min for all vehicle systems to power down. Test for less than 2 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 2 Ω or greater**

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

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

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

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

⇓ **If less than 2 Ω**

3. Ignition ON, test for 4.8–5.2 V between the 5 V reference circuit terminal 1 and ground.

⇒ **If less than 4.8 V**

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

3.2. Test for infinite resistance between the 5 V reference circuit and ground.

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

⇓ If infinite resistance

3.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

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

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

Note: If the signal circuit is shorted to a voltage the ECM or the MAP Sensor may be damaged.

⇒ **If greater than 5.2 V**

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

3.2. Ignition ON, test for less than 1 V between the 5 V reference circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

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

⇒ **If 0.5 V or greater**

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

4.2. Ignition ON, test for less than 1 V between the signal circuit terminal 3 and ground.

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

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

⇓ **If less than 0.5 V**

5. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 3 and the 5 V reference circuit terminal 1.

6. Ignition ON, verify the scan tool MAP Sensor voltage parameter is greater than 4.5 V.

⇒ **If 4.5 V or less**

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

6.2. Remove the jumper wire, test for infinite resistance between the signal circuit terminal 3 and ground.

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

⇓ If infinite resistance

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

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

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

⇓ **If greater than 4.5 V**

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 pressure parameter decreases between 13–21 kPa (1.8–3.0 PSI).

⇒ **If the parameter does not decrease between 13–21 kPa (1.8–3.0 PSI).**

Replace the B74 Manifold Absolute Pressure Sensor.

⇓ **If the parameter does decrease between 13–21 kPa (1.8–3.0 PSI).**

3. Apply 34 kPa (10.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the *GE-23738-A*. Verify the scan tool MAP pressure parameter decreases between 30–38 kPa (4.4–5.5 PSI).

⇒ **If the parameter does not decrease between 30–38 kPa (4.4–5.5 PSI).**

Replace the B74 Manifold Absolute Pressure Sensor.

⇓ **If the parameter does decrease between 30–38 kPa (4.4–5.5 PSI).**

4. All OK.

Erratic Signal Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor and disconnect the harness.
2. Install a 3 A fused jumper wire between the 5 V reference circuit terminal 1 of the sensor and the sensor harness.
3. Install a jumper wire between the low reference circuit terminal 2 of the sensor and ground.
4. Install a jumper wire to the signal circuit terminal 3 of the sensor.

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5. Connect a DMM between the jumper wire and ground.
6. Ignition ON, observe the DC voltage on the DMM. Slowly apply between 0-15 kPa (0–4.4 in Hg) of vacuum to the sensor with the *GE-23738-A*.
7. Verify the voltage changes, without any spikes or dropouts, between 0.2–4.9 V.

⇒ **If not between 0.2–4.9 V or has spikes or dropouts**
Replace the B74 Manifold Absolute Pressure Sensor.

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

8. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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

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DTC P0112, P0113, or P0114

Diagnostic Instructions

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

DTC Descriptors

DTC P0112

Intake Air Temperature (IAT) Sensor 1 Circuit Low Voltage

DTC P0113

Intake Air Temperature (IAT) Sensor 1 Circuit High Voltage

DTC P0114

Intake Air Temperature (IAT) Sensor 1 Circuit Intermittent

Diagnostic Fault Information

IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0112, P0114**, P2199**	P0111, P0113, P0114**, P2199**	P0113*, P0114**, P2199**	P0111, P2199**
Low Reference	—	P0111, P0113, P0114**, P2199**, P2227, P2228, P2229,	P0113*, P0114**, P2199**, P2227, P2229	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running **Parameter Normal Range:** Varies with ambient temperature			
Signal	150°C (302°F)	−40°C (−40°F)	

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Circuit	Short to Ground	Open	Short to Voltage
			−40°C (−40°F) *
Low Reference	—	−40°C (−40°F)	−40°C (−40°F) *
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

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

The multifunction intake air sensor houses the following:

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

IAT Sensor 1 — Temperature, Resistance, Voltage Table

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

Conditions for Running the DTCs

P0112 and P0113

- The engine run time is greater than 1 s.
- The DTCs run continuously when the above conditions are met.

P0114

- The ignition is ON or the engine is running.
- Where used, this DTC runs continuously within the enabling conditions.

Conditions for Setting the DTCs

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

P0112

The ECM detects that the IAT sensor 1 signal is warmer than 149°C (300°F) for greater than 5 s.

P0113

The ECM detects that the IAT sensor 1 signal is colder than −60°C (−76°F) for greater than 5 s.

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P0114

Where used, 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.
- **Where used.
- The ECM commands the cooling fans ON.

Conditions for Clearing the DTCs

- DTCs P0112, P0113, and P0114** are Type B DTCs.
- **Where used.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

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 10°C (18°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - Start-Up ECT

⇒ **If not within 10°C (18°F)**
Refer to Circuit/System Testing.

⇓ **If within 10°C (18°F)**

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

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

Refer to Circuit/System Testing.

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

4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
5. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

6. All OK

Circuit/System Testing

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

1. Ignition OFF, and all vehicle systems OFF, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.

⇒ **If 2 Ω or greater**

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

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

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

⇒ If less than 2 Ω replace the K20 engine control module.

⇓ **If less than 2 Ω**

3. Ignition ON, test for 4.8–5.2 V between the intake air temperature sensor 1 signal circuit terminal 1 and ground.

⇒ **If less than 4.8 V**

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

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

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

⇓ If infinite resistance

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

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

⇒ If less than 2 Ω, replace the K20 engine control module.

⇒ **If greater than 5.2 V**

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

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

3.2. Ignition ON, test for less than 1 V between the signal circuit and ground.

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

⇒ If less than 1 V, replace the K20 engine control module.

⇓ **If between 4.8–5.2 V**

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4. Ignition ON, verify the scan tool IAT Sensor 1 parameter is colder than −39°C (−38°F).

⇒ **If warmer than −39°C (−38°F).**

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

4.2. Test for infinite resistance between the signal circuit terminal 1 and ground.

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

⇓ If infinite resistance

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

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

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

⇓ **If colder than −39°C (−38°F).**

5. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3.

6. Verify the scan tool IAT Sensor 1 parameter is warmer than 148°C (298°F).

⇒ **If colder than 148°C (298°F).**

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

6.2. Test for less than 1 V between the signal circuit and ground.

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

⇓ If less than 1 V

6.3. Ignition OFF.

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

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

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

⇓ **If warmer than 148°C (298°F).**

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

Component Testing

Multifunction Intake Air Sensor

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

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

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the Temperature Versus Resistance - Intake Air Temperature Sensor table for Hitachi Sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range**

3. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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

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DTC P0116

Diagnostic Instructions

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

DTC Descriptor

DTC P0116

Engine Coolant Temperature (ECT) Sensor Performance

Diagnostic Fault Information

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

Typical Scan Tool Data

ECT Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** −39 to 149°C (−38 to 300°F)			
ECT Sensor	150°C (302°F)	−40°C (−40°F)	−40°C (−40°F)
Low Reference	—	−40°C (−40°F)	—

Circuit/System Description

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

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

Conditions for Running the DTC

- DTC P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0502, P0503, P0601, or P2610 is not set.
- The vehicle has had a minimum ignition OFF time of 8 h.

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- The ignition is ON.
- The start-up IAT is warmer than −7° C (+19° F).
- The Fuel Level Sensor is greater than 2.5 %.
- This DTC runs once per ignition cycle when the above conditions are met..

Conditions for Setting the DTC

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

  OR
- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 15° C (59° F) warmer than the IAT sensor, and NO engine block heater was not detected.

  OR
- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 15° C (59° F) warmer than the IAT sensor, the engine cranked for greater than 10 s without starting and NO engine block heater was not detected.

Action Taken When the DTC Sets

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

Conditions for Clearing the MIL/DTC

DTC P0116 is a Type B DTC.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

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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.
2. Verify the scan tool ECT Sensor parameter is warmer than −40° C (−40° F) and colder than 150° C (302° F) and changes with engine run time.

⇒ **If colder than −39° C (−38° F) or warmer than 149° C (300° F) or does not change**

Refer to Circuit/System Testing.

⇓ **If warmer than −40° C (−40°F) and colder than 150° C (302° F) and changes**

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

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

5. All OK.

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 terminal A or 2 and ground.

⇒ **If 5 Ω or greater**

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

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

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

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

⇓ **If less than 5 Ω**

3. Ignition ON.
4. Verify the scan tool ECT Sensor parameter is colder than −39°C (−38°F).

⇒ **If warmer than −39° C (−38° F)**

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

4.2. Test for infinite resistance between the signal circuit terminal B or 1 and ground.

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

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

⇓ **If colder than -39° C (-38° F)**

5. Install a 3 A fused jumper wire between the signal circuit terminal B or 1 and the low reference circuit terminal A or 2.
6. Verify the scan tool ECT sensor parameter is warmer than 149°C (300°F).

⇒ **If 149° C (300° F) or colder**

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

6.2. Test for less than 1 V between the signal circuit and ground.

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

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⇓ If less than 1 V

6.3. Ignition OFF

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

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

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

⇓ **If warmer than 149° C (300° F)**

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

Component Testing

1. Ignition OFF, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor.
2. Test the ECT sensor by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the Temperature Versus Resistance - Engine Coolant Temperature Sensor table. The resistance values should be in range of the table values.

⇒ **If not within the specified range**

Replace the B34 Engine Coolant Temperature Sensor.

⇓ **If within the specified range**

3. Test for infinite resistance between each terminal and the sensor housing.

⇒ **If less than infinite resistance**

Replace the B34 Engine Coolant Temperature Sensor.

⇓ **If infinite resistance**

4. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

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

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DTC P0117, P0118, or P0119

Diagnostic Instructions

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

DTC 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:** Varies with coolant temperature			
Signal	150°C (302°F)	−40°C (−40°F)	−40°C (−40°F)
Low Reference	—	−40°C (−40°F)	—

Circuit/System Description

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

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Conditions for Running the DTC

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 −7°C (19°F).
- This DTC runs continuously within the enabling conditions.

P0119

- No active DTCs set.
- The ignition is ON.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

P0117

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

P0118

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

P0119

The ECM detects that the ECT is intermittent or has abruptly changed for greater than 3 seconds.

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Cooling System 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 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool ECT Sensor parameter is warmer than −40° C (−40° F) and colder than 150° C (302° F) and changes with engine run time.

⇒ **If colder than −39° C (−38° F) or warmer than 149° C (300° F) or does not change**

Refer to Circuit/System Testing.

⇓ **If warmer than −40° C (−40°F) and colder than 150° C (302° F) and changes**

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

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the B34 Engine Coolant Temperature sensor harness connector at the sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal A or 2 and ground.

⇒ **If 5 Ω or greater**

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

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

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

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

⇓ **If less than 5 Ω**

3. Ignition ON.
4. Verify the scan tool ECT Sensor parameter is colder than −39° C (−38° F).

⇒ **If warmer than −39° C (−38° F)**

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

4.2. Test for infinite resistance between the signal circuit terminal B or 1 and ground.

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

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

⇓ **If colder than -39° C (-38° F)**

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5. Install a 3 A fused jumper wire between the signal circuit terminal B or 1 and the low reference circuit terminal A or 2.
6. Verify the scan tool ECT sensor parameter is warmer than 149° C (300° F).

⇒ **If 149° C (300° F) or colder**

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

6.2. Test for less than 1 V between the signal circuit and ground.

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

⇓ If less than 1 V

6.3. Ignition OFF.

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

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

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

⇓ **If warmer than 149° C (300° F)**

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

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 ECM replacement, programming, and setup.

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

Diagnostic Instructions

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

DTC Descriptors

DTC P0121

Throttle Position Sensor 1 Performance

DTC P0122

Throttle Position Sensor 1 Circuit Low Voltage

DTC P0123

Throttle Position Sensor 1 Circuit High Voltage

DTC P0222

Throttle Position Sensor 2 Circuit Low Voltage

DTC P0223

Throttle Position Sensor 2 Circuit High Voltage

DTC P16A0

Sensor Communication Circuit Low Voltage

DTC P16A1

Sensor Communication Circuit High Voltage

DTC P16A2

Sensor Communication Circuit Performance

DTC P2135

Throttle Position Sensors 1-2 Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P06A3	P0122*, P0222*, P16A0	P06A3	P0121, P16A2, P2135*
Signal	P0122*, P0222*, P16A0	P0122*, P0222*, P16A1	P0123*, P0223*, P16A1**	P0121, P16A2, P2135*

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

Typical Scan Tool Data

Throttle Position Sensor 1

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

Throttle Position Sensor 2

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

Circuit/System Description

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

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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 +126°C (19–259°F).
- The intake air temperature (IAT) is −20 to +125°C (−4 to +257°F).
- The DTC runs continuously when the above conditions are met.

P0122, P0123, P0222, P0223

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

P16A0, P16A1, or P16A2

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

P2135

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

Conditions for Setting the DTC

P0121

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

P0122

The ECM detects the throttle position sensor 1 signal voltage is less than 0.32 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

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

P16A0

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

P16A1

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

P16A2

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

P2135

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

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

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

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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

Note: If you were sent here from DTC P0068, P0101, P0106, or P1101 refer to Circuit/System Testing.

1. Ignition ON.
2. Verify that DTC P0601–P0606, P06A3, and P16F3 is not set.

⇒ **If a DTC is set**

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

⇓ **If a DTC is not set**

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

⇒ **If 90 % or greater**

Refer to Throttle Body Inspection and Cleaning.

⇓ **If less than 90 %**

4. Verify that DTC P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, or P2135 are not set.

⇒ **If DTC P0122, P0123, P0222, P0223, or P2135 are the only DTCs set**

Replace the Q38 Throttle Body.

⇒ **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**

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

⇒ **If Agree is not displayed**

Replace the Q38 Throttle Body.

⇓ **If Agree is displayed**

6. 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**

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

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

Refer to DTC P0106.

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

9. Engine idling.
10. Verify the scan tool MAP Sensor pressure parameter is between 26–52 kPa (3.8–7.5 psi) and changes with accelerator pedal input.

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

Refer to DTC P0106.

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

11. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.

    11.1. Engine idling

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11.2. Perform the scan tool snapshot function.

11.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.

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

11.5. Observe the MAF Sensor parameter frame by frame with a scan tool.

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

Refer to DTC P0101.

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

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

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

14. All OK.

Circuit/System Testing

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

1. Ignition OFF, and all vehicle systems OFF, disconnect the harness connector at Q38 Throttle Body. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 4 and ground.

⇒ **If 5 Ω or greater**

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

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

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

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

⇓ **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 5 and ground.

⇒ **If less than 4.8 V**

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

4.2. Test for infinite resistance between the 5 V reference circuit and ground.

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

⇓ If infinite resistance

4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

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

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

⇒ **If greater than 5.2 V**

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

4.2. Test for less than 1 V between the 5 V reference circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

5. Ignition ON.
6. Test for 4.8–5.2 V between the signal circuit terminal 3 and ground.

⇒ **If less than 4.8 V**

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

6.2. Test for infinite resistance between the signal circuit and ground.

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

⇓ If infinite resistance

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

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

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

⇒ **If greater than 5.2 V**

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

6.2. Test for less than 1 V between the signal circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

7. Replace the Q38 Throttle Body.

Repair Instructions

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

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
5. Ignition ON.
6. Verify the TP Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.

⇒ **If Agree is not displayed**

Replace the Q38 Throttle Body.

⇓ **If Agree is displayed**

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

⇒ **If DTC sets**

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

⇓ **If DTC does not set**

8. All OK.

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DTC P0128

Diagnostic Instructions

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

DTC Descriptor

DTC P0128

Engine Coolant Temperature (ECT) Below Thermostat Regulating Temperature

Diagnostic Fault Information

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

Typical Scan Tool Data

ECT Sensor

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

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- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0502, P0503, P1104, P16F3, P2101, or P2135 is not set.
- The start-up ECT is colder than 66°C (151°F).
- The start-up IAT is between −7 to +55°C (+19 to +131°F).
- The engine Not ran for greater than 30 minutes.
- The engine run time is greater than 30 seconds.
- The vehicle has traveled greater than 2.4 kilometers (1.5 miles) at greater than 8 km/h (5 mph).
- The Ethanol in the fuel is less than 87 %.
- The mass air flow (MAF) average is greater than 1 g/s.
- This DTC runs once per ignition cycle within the enabling conditions.

Conditions for Setting the DTC

The ECM detects that the maximum amount of cumulative airflow has been attained, and the minimum ECT of 70°C (158°F) has not been met with a start-up IAT colder than 10°C (50°F).

OR

The ECM detects that the maximum amount of cumulative airflow has been attained, and the minimum ECT of 80°C (176°F) has not been met with a start-up IAT warmer than 10°C (50° F).

Action Taken When the DTC Sets

- DTC P0128 is a Type B DTC.
- The Engine Coolant Temperature Gauge is inoperative.
- 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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify the cooling system is filled to the correct coolant level. Refer to Cooling System Leak Testing and Cooling System Draining and Filling.

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

Repair as necessary

⇓ **If the coolant level is correct**

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

2. Verify the proper heat range and the operation of the thermostat. Refer to Thermostat Diagnosis.

⇒ **If a condition is found**

Replace the Thermostat.

⇓ **If a condition is not found**

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

⇒ **If the DTC sets**

Refer to Step 1.

⇓ **If the DTC does not set**

5. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Engine Coolant Thermostat Replacement

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DTC P0131, P0132, P0134, P0137, P0138, P0140, P0151, P0152, P0154, P0157, P0158, or P0160

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0134

HO2S Circuit Insufficient Activity 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 P0140

HO2S Circuit Insufficient Activity 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 P0154

HO2S Circuit Insufficient Activity Bank 2 Sensor 1

DTC P0157

HO2S Circuit Low Voltage Bank 2 Sensor 2

DTC P0158

HO2S Circuit High Voltage Bank 2 Sensor 2

DTC P0160

HO2S Circuit Insufficient Activity 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, P0134, P0138, P0140, P0152, P0154, P0158, P0160	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	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D

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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.

P0134, P0140, P0154, or P0160

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455, P0496, P1516, P2101, P2119, P2135, P2176 are not set.
- The ignition voltage is between 10–32 V.
- The engine run time is greater than 150 s.
- The fuel system is in Closed Loop.
- The DTCs run continuously when the above conditions are met.

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.

P0134 or P0154

- The ECM detects that the HO2S 1 voltage is between 350–550 mV.
- The HO2S heater warm-up cycle is complete.
- The DTCs set within 15 s when the above conditions are met.

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P0140 or P0160

- The ECM detects that the HO2S 2 voltage is not varying.
- The HO2S heater warm-up cycle is complete.
- The DTCs set within 15 s when the above conditions are met.

Action Taken When the DTC Sets

DTCs P0131, P0132, P0134, P0137, P0138, P0140, P0151, P0152, P0154, P0157. P0158, and P0160 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0131, P0132, P0134, P0137, P0138, P0140, P0151, P0152, P0154, P0157, P0158, and P0160 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no HO2S heater DTCs are set

⇒ **If a DTC is set**
Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If a DTC is not set**

3. Engine running.
4. Verify the scan tool HO2S 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.

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⇓ **If the DTC does not set**

7. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the appropriate B52 Heated Oxygen Sensor harness connector. It may take up to 2 minutes for all vehicle systems to power down. Ignition ON.
2. Test for 1.7–3.0 V between the high signal circuit terminal B and ground.

⇒ **If less than 1.7 V**

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

2.2. Test for infinite resistance between the high signal circuit and ground.

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

⇓ If infinite resistance

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

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

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

⇒ **If greater than 3.0 V**

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

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

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

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

⇓ **If between 1.7–3.0 V**

3. Verify the scan tool 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**

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

3.2. Test for infinite resistance between the low signal circuit terminal A and ground.

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

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

⇓ **If between 1.7–2.1 V**

4. Connect a 3 A fused jumper wire between the high signal circuit terminal B and the low signal circuit terminal A.

Note: The low signal circuit is tied to a pull-up circuit within the engine control module. A voltage of 0.0–1.10 V on the low signal circuit is normal.

5. Verify the scan tool HO2S Bank 1 or 2 Sensor 1 or 2 parameter displays 0.0 V.

⇒ **If greater than 0.0 V**

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

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

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

⇓ If less than 2 Ω

5.3. Test for less than 1 V between the low signal circuit terminal A 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 following conditions exist:

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- Water intrusion in the B52 HO2S harness connector
- Low or high fuel system pressure—Refer to Fuel System Diagnosis.
- Fuel that is contaminated—Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
- Fuel saturation of the evaporative emission (EVAP) canister
- Exhaust leaks
- Engine vacuum leaks

⇒ **If any of the conditions exist**

Repair as necessary.

⇓ **If none of the conditions exist.**

7. Test or replace the B52 Heated Oxygen Sensor

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Heated Oxygen Sensor Replacement - Bank 1 Sensor 1
- Heated Oxygen Sensor Replacement - Bank 1 Sensor 2
- Heated Oxygen Sensor Replacement - Bank 2 Sensor 1
- 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

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DTC P0133, P013A-P013F, P014A, P014B, P0153, P1133, P1153, or P2270-P2273

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P1133

HO2S Insufficient Switching Bank 1 Sensor 1

DTC P1153

HO2S Insufficient Switching Bank 2 Sensor 1

DTC P2270

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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	High Resistance	Open	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	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P1133, P1153
HO2S Low Signal	P0131, P0137, P0151, P0157	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	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, P1133, P1153

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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

P0133, P0153, P1133, or P1153

- 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 54°C (129°F).
- The intake air temperature (IAT) is warmer than −40°C (−40°F)
- The ignition voltage is between 10–32 V.
- The fuel level is greater than 10 percent.
- 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 percent.
- 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 percent.
- 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

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- 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 percent.
- 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.

P013B P013D, P013F, or P014B

- Before the ECM can report DTC P2270, P2271, P2272, or P2273 failed, DTCs P013A, P013B, P013C, P013D, P013E, P013F, P014A, and P014B must run and pass.
- DTCs P0036, P0037, P0038, P0137, P0138, P0140, P0141, P0443, P0458, P0459, P2232 are not set.
- The ignition voltage is between 10–32 V.
- The engine speed is between 1,025–2,325 RPM.
- The mass air flow (MAF) is between 3–12 g/s.
- The vehicle speed is between 64–128 km/h (40–80 mph).
- The fuel level is greater than 10 percent.
- The fuel system is in Closed Loop.
- The predicted catalytic converter temperature is between 500–980°C (932–1,796°F).
- The HO2S heater is ON for more than 180 s.
- The DTCs run once per ignition cycle, during decel fuel cut-off, when the above conditions are met.

P2270 or P2272

- 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 percent.
- 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 600–900°C (1,112–1,652°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,

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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 percent.
- 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 500–980°C (1,112–1,652°F).
- DTCs P013A, P013E, and P2270 have run and passed.
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- 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 or P0153

- 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.

P013E or P014A

The ECM detects that the O2 sensor voltage has not decreased below 450 mV within a calibrated value of accumulated air flow.

P013F or P014B

The ECM detects that the O2 sensor voltage has not increased above 350 mV within a calibrated value of accumulated air flow.

P1133 or P1153

- The ECM detects that the HO2S 1 rich-to-lean counts, or the lean-to-rich counts are less than a calibrated value.
- The DTCs set within 60 s when the above condition is met.

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

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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, P1133, and P1153 are Type B DTCs.
- DTCs P013A, P013B, P013C, and P013D are Type A DTCs.

Conditions for Clearing the DTC

- DTCs P0133, P013E, P013F, P014A, P014B, P0153, P1133, and P1153 are Type B DTCs.
- DTCs P013A, P013B, P013C, and P013D are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no HO2S heater DTCs are set

⇒ **If a DTC is set**
Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If a DTC is not set**

3. Verify none of the conditions listed below exist:
   - Lean or rich fuel injectors—Refer to Fuel Injector Solenoid Coil Test.
   - Water intrusion in the HO2S harness connector
   - Low or high fuel system pressure—Refer to Fuel System Diagnosis.
   - Fuel that is contaminated—Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
   - Fuel saturation of the evaporative emission (EVAP) canister
   - Exhaust leaks—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 above conditions exist**
   Repair as necessary.

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⇓ **If any 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 diagnostic procedure.

- Heated Oxygen Sensor Replacement - Bank 1 Sensor 1
- Heated Oxygen Sensor Replacement - Bank 1 Sensor 2
- Heated Oxygen Sensor Replacement - Bank 2 Sensor 1
- 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

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DTC P0171, P0172, P0174, or P0175

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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

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, P0050, P0053, P0059, P0101, P0102, P0103, P0106, P0107, P0108, P0131–P0135, P0151–P0155, P015A, P015B, P015C, P015D, P0178, P0179, P0201–P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0275, P0277, P0300–P0306, P0442, P0455, P0458, P0496, P0506, P0507, P1133, P1153, P1248, P1249, P124A, P124B, P124C, P124D, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P2227–P2230, or P2269 are not set.
- The engine is in Closed Loop status.
- The catalyst monitor diagnostic intrusive test, post 02 diagnostic intrusive test, device control, and EVAP leak test are not active.
- The engine coolant temperature (ECT) is between −20 and +150°C (−4 and +302°F).
- The intake air temperature (IAT) is between −20 and +150°C (−4 and +302°F).
- The manifold absolute pressure (MAP) is between 5–255 kPa (1.45–37 psi).
- The engine speed is between 400–6,600 RPM.

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- The mass air flow (MAF) is between 0.5–510 g/s.
- The barometric pressure (BARO) is greater than 70 kPa (10.2 psi).
- The fuel level is greater than 10 %.
- This diagnostic runs continuously when the above conditions have been met.

Conditions for Setting the DTC

- The average long term fuel trim weighted average value is greater or less than a calibrated value.
- The above condition is present for approximately 3 min after the Conditions for Running the DTC have been met.

Action Taken When the DTC Sets

DTCs P0171, 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 value should vary from approximately 40 mV to approximately 900 mV, and respond to fueling changes.
- The normal Short Term Fuel Trim and Long Term Fuel Trim parameters should be between +10 and −10 % with 0 % the optimum, with the engine running at operating temperature.
- Any un-metered air into the engine causes this DTC to set. Thoroughly inspect all areas of the engine for vacuum leaks.
- A MAF sensor condition can cause this DTC without setting a MAF DTC. If there is a MAF sensor condition, the MAF sensor parameters will appear to be within range.
- Inspect the air filter for being the correct one for this application. Make sure that the engine oil fill cap is in place and that it is tight. Verify that the engine oil dip stick is fully seated.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

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Reference Information

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Observe the DTC information with a scan tool. DTC P0171, P0172, P0174, or P0175 should not be set.
2. Engine running, observe the DTC information with a scan tool. Verify there are no HO2S DTCs set.
   ⇒ If any HO2S DTCs are set, refer to Diagnostic Trouble Code (DTC) List - Vehicle.
3. Ignition ON, observe the manifold absolute pressure (MAP) sensor parameter. The MAP sensor pressure should be within the range specified for your altitude. Refer to Altitude Versus Barometric Pressure.
   ⇒ If not the specified range, refer to DTC P0106.

   Note: EVAP purge enablement may cause the Fuel Trim to be momentarily outside the normal range.
4. Allow the engine to reach operating temperature. With the engine running, observe the affected Long Term Fuel Trim parameter with a scan tool. The value should be between −25.5 % and +34.5 %.
   ⇒ If not the specified range, inspect for the following:
   - Mass air flow (MAF) sensor signal skewed—If the Short Term Fuel Trim parameters for both banks changes greater than 20 % when the MAF sensor is disconnected, refer to DTC P0101.
   - Fuel contamination—Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
   - Missing, restricted, or leaking exhaust components—Refer to Symptoms - Engine Exhaust.
   - Malfunctioning fuel injectors—Refer to Fuel Injector Solenoid Coil Test.
   - Vacuum hoses for splits, kinks, and improper connections
   - Insufficient fuel in the tank
   - Low fuel pressure—Refer to Fuel System Diagnosis.
   - Vacuum leaks at the intake manifold, the throttle body, and the injector O-rings.
   - Leaks in the air induction system and the air intake ducts
   - Missing air filter element
   - Cracked EVAP canister
   - Evaporative pipes obstructed or leaking
   - Leaks in the crankcase ventilation system—Refer to Crankcase Ventilation System Inspection/Diagnosis.
   - Mass air flow (MAF) sensor signal skewed—If the Short Term Fuel Trim parameters for both banks changes greater than 20 % when the MAF sensor is disconnected, refer to DTC P0101.
   - Fuel contamination—Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
   - Missing, restricted, or leaking exhaust components—Refer to Symptoms - Engine Exhaust.
   - Malfunctioning fuel injectors—Refer to Fuel Injector Solenoid Coil Test,
   - Air intake duct collapsed or restricted
   - Excessive fuel pressure — Refer to Fuel System Diagnosis
   - Air filter dirty or restricted
   - Objects blocking the throttle body
   - Improper operation of the evaporative emissions control system
   - Excessive fuel in the crankcase—Change the engine oil as necessary.
5. If all conditions test normal, test the engine for a mechanical condition. Refer to Symptoms - Engine Mechanical.

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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.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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DTC P0178 (LFW, LFX)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0178

Fuel Composition Sensor Circuit Low Frequency

Circuit/System Description

Alcohol content information is supplied to the Engine Control Module from the Fuel Composition Sensor. The Fuel Composition Sensor has a battery positive circuit, a signal circuit, and a ground circuit. The Fuel Composition Sensor uses a microprocessor inside the sensor to measure the ethanol percentage and changes the output signal accordingly. The signal circuit carries the ethanol percentage via the frequency signal. The Engine Control Module provides an internal pull up to 5 V on the signal circuit, and the Fuel Composition Sensor pulls the 5 V to ground in pulses. The normal range of operating frequency is between 50–150 Hz. The microprocessor inside the sensor is capable of a certain amount of self-diagnosis. An output frequency between 180 Hz and 190 Hz indicates that the fuel is contaminated.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The Engine Control Module detects that the Fuel Composition Sensor output frequency is less than 45 Hz for greater than 6 s.

Action Taken When the DTC Sets

DTC P0178 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0178 is a Type B DTC.

Diagnostic Aids

- The Fuel Composition Sensor scan tool parameter reacts immediately to any change in the fuel composition sensor circuits, but may not react long enough to set a DTC.
- An intermittent condition may not be detected because the sensor does not immediately power down and the connection may be restored before voltage drops below the operating threshold.
- If this DTC will not reset and the parameters are steady, thoroughly inspect all fuel composition sensor circuits for an intermittent open.

Reference Information

Schematic Reference

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Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- *J 38522* Variable Signal Generator
- *J 44175–A* Fuel Composition Tester

For equivalent regional tools, refer to Special Tools.

Circuit/System Verification

1. Engine running,
2. Verify the scan tool Fuel Composition Sensor parameter is between 50–150 Hz.

⇒ **If not between 50–150 Hz**

Refer to Circuit/System Testing.

⇓ **If between 50–150 Hz**

3. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

⇒ **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 B198 Fuel Composition Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the ground circuit terminal 2 and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF.

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

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

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

⇓ **If less than 5 Ω**

3. Ignition ON.
4. Verify that a test lamp illuminates between the B+ circuit terminal 1 and ground.

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

4.1. Ignition OFF, remove the test lamp.

4.2. Test for less than 2 Ω in the B+ circuit end to end.

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

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

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

4.1. Ignition OFF, remove the test lamp.

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

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

⇒ If infinite resistance, replace the B198 Fuel Composition Sensor.

⇓ **If the test lamp illuminates**

5. Ignition ON.
6. Test for 4.8–5.2 V between the signal circuit terminal 3 and ground.

⇒ **If less than 4.8 V**

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

6.2. Test for infinite resistance between the signal circuit and ground.

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

⇓ If infinite resistance

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

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

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

⇒ **If greater than 5.2 V**

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

6.2. Ignition ON.

6.3. 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, replace the K20 Engine Control Module.

⇓ **If between 4.8–5.2 V**

7. Ignition OFF, connect the red lead of the *EL 38522–A* Variable Signal Generator to the signal circuit terminal 3 at the B198 Fuel Composition Sensor harness connector.
8. Connect the battery voltage supply to B+, and the black lead to ground.
9. Set the *EL 38522–A* Variable Signal Generator Signal to 5 V, the Frequency to 60 Hz, and the Duty Cycle to Normal.
10. Ignition ON.
11. Verify the scan tool Fuel Composition Sensor parameter is at 60 Hz.

⇒ **If not the specified value**

Replace the K20 Engine Control Module.

⇓ **If the specified value**

12. Test or replace the B198 Fuel Composition Sensor.

Component Testing

1. Test the fuel composition using the *CH 44175–A* Alcohol Tester Kit and the CH 44175–A Instruction Manual. Record the frequency.
2. Compare the special tool test frequency and the scan tool Fuel Composition Sensor frequency parameter.
3. Verify the difference between the tool and the sensor is 12 Hz or less.

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⇒ **If greater than the specified value**
Replace the B198 Fuel Composition Sensor.

⇓ **If less than the specified value**

4. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Flexible Fuel Sensor Replacement
- Control Module References for K20 Engine Control Module programming, replacement, and setup.

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DTC P0178 (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0178

Fuel Injector Control Module Requested Torque Circuit Low Frequency

Circuit/System Description

When Warm Up Mode is activated, the fuel injector control module will vary the requested torque signal sent to the engine control module (ECM) requesting a reduction in engine torque. The requested torque signal has a square wave 50% duty cycle. The frequency of the signal will vary from 50 Hz to 150 Hz. The ECM provides an internal pull up to 5 V on the signal circuit, and the fuel injector control module pulls the 5 V to ground in pulses.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects that the requested torque signal output frequency is less than 45 Hz for greater than 5 s.

Action Taken When the DTC Sets

DTC P0178 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P0178 is a Type A DTC.

Diagnostic Aids

- The Fuel Injector Control Module Requested Torque scan tool parameter reacts immediately to any change in the requested torque signal, but may not react long enough to set a DTC.
- An intermittent condition may not be detected because the connection may be restored before voltage drops below the operating threshold.
- If this DTC will not reset and the parameters are steady, thoroughly inspect all fuel injector control module circuits for an intermittent open.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

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Description and Operation

LPG 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

Special Tools

J 38522 Variable Signal Generator

For equivalent regional tools, refer to Special Tools.

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Circuit/System Verification

1. Engine running.
2. Verify the scan tool Fuel Injector Control Module Requested Torque parameter is between 50–150 Hz.

⇒ **If not between 50–150 Hz**

Refer to Circuit/System Testing

⇓ **If between 50–150 Hz**

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. It may take up to 2 minutes for all vehicle systems to power down. Disconnect the harness connector at the A714 fuel injector control module.
2. Test for less than 5 Ω between the ground circuit terminal X1–21 and ground.

⇓ **If 5 Ω or greater**

2.1. Ignition OFF.

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

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

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

3. Ignition ON.
4. Verify that a test lamp illuminates between the B+ circuit terminal X1–22 and ground.

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

4.1. Ignition OFF.
4.2. Test for less than 2 Ω in the B+ circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit
⇒ If less than 2 Ω, verify the fuse is OK and there is voltage at the fuse.

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

4.1. Ignition OFF.
4.2. Test for infinite resistance between the B+ circuit and ground.
⇒ If less than infinite resistance, repair the short to ground in the circuit.
⇒ If infinite resistance, replace the A714 fuel injector control module.

⇓ **If the test lamp illuminates**

5. Ignition ON.
6. Test for 4.8–5.2 V between the signal circuit terminal X2–1 and ground.

⇒ **If less than 4.8 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.
6.2. Test for infinite resistance between the signal circuit and ground.
⇒ If less than infinite resistance, repair the short to ground in the circuit.
⇓ If infinite resistance
6.3. Test for less than 2 Ω in the signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 engine control module.

⇒ **If greater than 5.2 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.
6.2. Ignition ON.
6.3. 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, replace the K20 engine control module.

⇓ **If between 4.8–5.2 V**

7. Ignition OFF, connect the red lead of the *J 38522* Variable Signal Generator to the signal circuit terminal X2–1 at the A714 fuel injector control module harness connector.
8. Connect the battery voltage supply to B+, and the black lead to ground.
9. Set the *J 38522* Variable Signal Generator Signal to 5 V, the Frequency to 60 Hz, and the Duty Cycle to Normal.
10. Ignition ON.
11. Verify the scan tool Fuel Injector Control Module Requested Torque parameter is at 60 Hz.

⇒ **If not at the specified value**

Replace the K20 engine control module.

⇓ **If the specified value**

12. Test or replace the A714 fuel injector control module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Control Module References for engine control module or fuel injector control module replacement, programming, and setup.

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DTC P0179 (LFW, LFX)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0179

Fuel Composition Sensor Circuit High Frequency

Circuit/System Description

Alcohol content information is supplied to the Engine Control Module from the Fuel Composition Sensor. The Fuel Composition Sensor has a battery positive circuit, a signal circuit, and a ground circuit. The Fuel Composition Sensor uses a microprocessor inside the sensor to measure the ethanol percentage and changes the output signal accordingly. The signal circuit carries the ethanol percentage via the frequency signal. The Engine Control Module provides an internal pull up to 5 V on the signal circuit, and the Fuel Composition Sensor pulls the 5 V to ground in pulses. The normal range of operating frequency is between 50–150 Hz. The microprocessor inside the sensor is capable of a certain amount of self-diagnosis. An output frequency between 180 Hz and 190 Hz indicates that the fuel is contaminated.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The Engine Control Module detects that the Fuel Composition Sensor output frequency is between 155–185 Hz for greater than 6 s.

Action Taken When the DTC Sets

DTC P0179 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0179 is a Type B DTC.

Diagnostic Aids

A momentary slug of water in the fuel system may set this DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End 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

- *J 38522* Variable Signal Generator
- *J 44175–A* Fuel Composition Tester

For equivalent regional tools, refer to Special Tools.

Circuit/System Verification

1. Engine running,
2. Verify the scan tool Fuel Composition Sensor parameter is between 50–150 Hz.

⇒ **If not between 50–150 Hz**

Refer to Circuit/System Testing.

⇓ **If between 50–150 Hz**

3. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

4. All OK.

Circuit/System Testing

1. Verify that there are no contaminants, water, or too high of a concentration of ethanol in the fuel. Refer to Alcohol/Contaminants-in-Fuel Diagnosis and the *CH 44175–A* Instruction Manual.
2. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B198 Fuel Composition Sensor. It may take up to 2 minutes for all vehicle systems to power down.
3. Test for less than 5 Ω between the ground circuit terminal 2 and ground.

⇒ **If 5 Ω or greater**

3.1. Ignition OFF.

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

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

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

⇓ **If less than 5 Ω**

4. Ignition ON.
5. Verify that a test lamp illuminates between the B+ circuit terminal 1 and ground.

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

5.1. Ignition OFF, remove the test lamp.

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5.2. 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 OK and there is voltage at the fuse.

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

5.1. Ignition OFF, remove the test lamp.
5.2. Test for infinite resistance between the B+ circuit and ground.
⇒ If less than infinite resistance, repair the short to ground in the circuit.
⇒ If infinite resistance, replace the B198 Fuel Composition Sensor.

⇓ **If the test lamp illuminates**

6. Ignition ON.
7. Test for 4.8–5.2 V between the signal circuit terminal 3 and ground.

⇒ **If less than 4.8 V**

7.1. Ignition OFF, disconnect the harness connector X1 at the K20 Engine Control Module.
7.2. Test for infinite resistance between the signal circuit and ground.
⇒ If less than infinite resistance, repair the short to ground in the circuit.
⇓ If infinite resistance
7.3. Test for less than 2 Ω in the signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 5.2 V**

7.1. Ignition OFF, disconnect the harness connector X1 at the K20 Engine Control Module.
7.2. Ignition ON.
7.3. 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, replace the K20 Engine Control Module.

⇓ **If between 4.8–5.2 V**

8. Ignition OFF, connect the red lead of the *EL 38522–A* Variable Signal Generator to the signal circuit terminal 3 at the B198 Fuel Composition Sensor harness connector.
9. Connect the battery voltage supply to B+, and the black lead to ground.
10. Set the *EL 38522–A* Variable Signal Generator Signal to 5 V, the Frequency to 60 Hz, and the Duty Cycle to Normal.
11. Ignition ON.
12. Verify the scan tool Fuel Composition Sensor parameter is at 60 Hz.

⇒ **If not the specified value**

Replace the K20 Engine Control Module.

⇓ **If the specified value**

13. Test or replace the B198 Fuel Composition Sensor.

Component Testing

1. Test the fuel composition using the *CH 44175–A* Alcohol Tester Kit and the CH 44175–A Instruction Manual. Record the frequency.
2. Compare the special tool test frequency and the scan tool Fuel Composition Sensor frequency parameter.
3. Verify the difference between the tool and the sensor is 12 Hz or less.

⇒ **If greater than the specified value**

Replace the B198 Fuel Composition Sensor.

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⇓ **If less than the specified value**

4. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Flexible Fuel Sensor Replacement
- Fuel System Cleaning
- Control Module References for K20 Engine Control Module programming, replacement, and setup.

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DTC P0179 (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0179

Fuel Injector Control Module Requested Torque Circuit High Frequency

Circuit/System Description

When Warm Up Mode is activated, the fuel injector control module will vary the requested torque signal sent to the engine control module (ECM) requesting a reduction in engine torque. The requested torque signal has a square wave 50% duty cycle. The frequency of the signal will vary from 50 Hz to 150 Hz. The ECM provides an internal pull up to 5 V on the signal circuit, and the fuel injector control module pulls the 5 V to ground in pulses.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects that the requested torque signal output frequency is between 155–185 Hz for greater than 5 s.

Action Taken When the DTC Sets

DTC P0179 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P0179 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG System Description and Operation

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- 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

Special Tools

J 38522 Variable Signal Generator

For equivalent regional tools, refer to Special Tools.

Circuit/System Verification

1. Engine running.
2. Verify the scan tool Fuel Injector Control Module Requested Torque parameter is between 50–150 Hz.

⇒ **If not between 50–150 Hz**

Refer to Circuit/System Testing

⇓ **If between 50–150 Hz**

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. It may take up to 2 minutes for all vehicle systems to power down. Disconnect the harness connector at the A714 fuel injector control module.
2. Test for less than 5 Ω between the ground circuit terminal X1–21 and ground.

⇓ **If 5 Ω or greater**

2.1. Ignition OFF.

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

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

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

3. Ignition ON.
4. Verify that a test lamp illuminates between the B+ circuit terminal X1–22 and ground.

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

4.1. Ignition OFF.

4.2. Test for less than 2 Ω in the B+ circuit end to end.

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

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

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

4.1. Ignition OFF.

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

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

⇒ If infinite resistance, replace the A714 fuel injector control module.

⇓ **If the test lamp illuminates**

5. Ignition ON.
6. Test for 4.8–5.2 V between the signal circuit terminal X2–1 and ground.

⇒ **If less than 4.8 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.

6.2. Test for infinite resistance between the signal circuit and ground.

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

⇓ If infinite resistance

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

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

⇒ If less than 2 Ω, replace the K20 engine control module.

⇒ **If greater than 5.2 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.

6.2. Ignition ON.

6.3. 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, replace the K20 engine control module.

⇓ **If between 4.8–5.2 V**

7. Ignition OFF, connect the red lead of the *J 38522* Variable Signal Generator to the signal circuit terminal X2–1 at the A714 fuel injector control module harness connector.
8. Connect the battery voltage supply to B+, and the black lead to ground.
9. Set the *J 38522* Variable Signal Generator Signal to 5 V, the Frequency to 60 Hz, and the Duty Cycle to Normal.
10. Ignition ON.
11. Verify the scan tool Fuel Injector Control Module Requested Torque parameter is at 60 Hz.

⇒ **If not at the specified value**

Replace the K20 engine control module.

⇓ **If the specified value**

12. Test or replace the A714 fuel injector control module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Control Module References for engine control module or fuel injector control module replacement, programming, and setup.

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DTC P018B-P018D (LFW, LFX)

Diagnostic Instructions

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

DTC Descriptors

DTC P018B

Fuel Pressure Sensor Performance

DTC P018C

Fuel Pressure Sensor Circuit Low Voltage

DTC P018D

Fuel Pressure Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C, P0641, P06A6	P018C	P018D	P06A6
Signal	P018C	P018C	P018D	P018B
Low Reference	—	P018D	—	P06A6

Circuit/System Description

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

Conditions for Running the DTC

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

Conditions for Setting the DTC

The fuel pump driver control module does not detect a change in the fuel pressure of at least 30 kPa (4.4 psi) when the fuel pump is operating. The fuel pressure sensor performance diagnostic provides a means to detect fuel pressure sensor output that is stuck within the normal operating range of the sensor.

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Action Taken When the DTC Sets

DTC P018B, P018C and P018D are Type B DTCs.

Conditions for Clearing the DTC

DTC P018B, P018C and P018D are Type B DTCs.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC U18A2 is not set or stored in history.

⇒ **If DTC U18A2 is set or stored in history**
Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If DTC U18A2 is not set or stored in history**

3. Engine running.
4. Verify the scan tool Fuel Pressure Sensor Voltage parameter is between 0.2–4.8 V.

⇒ **If not between 0.2–4.8 V**
Refer to Circuit/System Testing.

⇓ **If between 0.2–4.8 V**

5. All OK.

Circuit/System Testing

Note: Verify that the fuel tank is not empty. Only perform this diagnostic if there is at least 2 gallons of fuel in the fuel tank. Clear the DTC, and start and run the engine. Verify that

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the DTC resets before proceeding with the circuit system testing. If the DTC does not reset, refer to diagnostic aids.

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

⇒ **If 10 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module.

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

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

⇒ If less than 2 Ω, replace the K111 Fuel Pump Driver Control Module.

⇓ **If less than 10 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 3 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module.

4.2. Test for infinite resistance between the 5 V reference circuit and ground.

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

⇓ If infinite resistance

4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

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

⇒ If less than 2 Ω, replace the K111 Fuel Pump Driver Control Module.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module, ignition ON.

4.2. Test for less than 1 V between the 5 V reference circuit and ground.

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

⇒ If less than 1 V, replace the K111 Fuel Pump Driver Control Module.

⇓ **If between 4.8–5.2 V**

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

⇒ **If 1 V or greater**

5.1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module, ignition ON.

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

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

⇒ If less than 1 V, replace the K111 Fuel Pump Driver Control Module.

⇓ **If less than 1 V**

6. Install a 3 A fused jumper wire between the signal circuit terminal 1 and the 5 V reference circuit terminal 3, wait 15 seconds.
7. Verify the scan tool Fuel Pressure Sensor Voltage parameter is greater than 4.8 V.

⇒ **If 4.8 V or less**

7.1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module.

7.2. Test for infinite resistance between the signal circuit terminal 1 and ground.

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

⇓ If infinite resistance

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

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

⇒ If less than 2 Ω, replace the K111 Fuel Pump Driver Control Module.

⇓ **If greater than 4.8 V**

8. Test or replace the B47 Fuel Pressure Sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Pressure Sensor Replacement - Fuel Feed Pipe
- Control Module References for K111 Fuel Pump Driver Control Module replacement, programming, and setup.

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DTC P018C or P018D (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P018C

Alternative Fuel Tank Pressure Sensor Circuit Low Voltage

DTC P018D

Alternative Fuel Tank Pressure Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C, P0641, P069E	P018C, P069E	P018D, P0641, P069E	—
Signal	P018C, P069E	P018C, P069E	P018D, P069E	—
Low Reference	—	—	—	—

Circuit/System Description

The Chassis Control Module receives fuel pressure information from the Fuel Tank Pressure Sensor and controls the operation of the Fuel Pump located within the fuel tank. The Chassis Control Module sends a 25 kHz PWM signal to the Fuel Pump. The pump speed is changed by varying the duty cycle of this signal. The Fuel Pump will be on if the fuel tank pressure is less than 490 kPa (71 psi) and off if the fuel tank pressure is greater than 510 kPa (74 psi). When the Fuel Pump is on the duty cycle will vary from 50% to 100% based on the fuel flow requirements.

Conditions for Running the DTC

- DTC P0641 is not set.
- The ignition is in Run or Crank.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P018C

The Fuel Tank Pressure Sensor voltage is less than 0.1 V for 1 s.

P018D

The Fuel Tank Pressure Sensor voltage is greater than 4.9 V for 1 s.

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Action Taken When the DTC Sets

- DTCs P018C and P018D are Type A DTCs.
- The Fuel Pump runs continuously.

Conditions for Clearing the DTC

DTCs P018C and P018D are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG 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. Verify no other DTCs are set.

⇒ **If any DTCs are set**
Refer to Diagnostic Trouble Code (DTC) List - Vehicle for further diagnosis.

⇓ **If no other DTCs set**

2. Verify DTC P018C or P018D is not set.

⇒ **If DTC P018C or P018D is set**
Refer to Circuit/System Testing.

⇓ **If DTC P018C or P018D does not set**

3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
4. Verify DTC P018C or P018D is not set.

⇒ **If DTC P018C or P018D is set**
Refer to Circuit/System Testing.

⇓ **If DTC P018C or P018D is not set**

5. All OK.

Circuit/System Testing

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

⇒ **If 1 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module.
2.2. Test for less than 1 Ω in the low reference circuit end to end.
⇒ If 1 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 1 Ω, replace the K38 Chassis Control Module.

⇓ **If less than 1 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 3 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module.
4.2. Test for infinite resistance between the 5 V reference circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K38 Chassis Control Module.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module, ignition ON.
4.2. Test for less than 1 V between the 5 V reference circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K38 Chassis Control Module.

⇓ **If between 4.8–5.2 V**

5. Verify the scan tool Alternative Fuel Tank Pressure parameter is less than 0.1 V.

⇒ **If 0.1 V or greater**

5.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module, ignition ON.
5.2. Test for less than 1 V between the signal circuit terminal 1 and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K38 Chassis Control Module.

⇓ **If less than 0.1 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 Alternative Fuel Tank Pressure parameter is greater than 3.2 V.

⇒ **If 3.2 V or less**

7.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module.
7.2. Test for infinite resistance between the signal circuit terminal 1 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
7.3. Test for less than 2 Ω in the signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K38 Chassis Control Module.

⇓ **If greater than 3.2 V**

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8. Replace the Fuel Tank Pressure Sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Pump Replacement
- Control Module References for K38 Chassis Control Module programming, replacement, and setup.

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DTC P0192 or P0193 (LFW, LFX)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0192

Fuel Rail Pressure Sensor Circuit Low Voltage

DTC P0193

Fuel Rail Pressure Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference Voltage	P0192, P0193, P0340, P0345, P0365, P0390, P0506, P0641, P2227	P0192	P0193, P0641, P2227, P2229	P0191
Fuel Rail Pressure Sensor Signal	P0192	P0192, P0193	P0193	P0191
Low Reference	—	P0193	P0193	P0191

Circuit/System Description

The Fuel Rail Fuel Pressure Sensor detects fuel pressure within the fuel rail. The Engine Control Module (ECM) provides a 5 V reference voltage on the 5 V reference circuit and ground on the reference ground circuit. The ECM receives a varying signal voltage on the signal circuit. The ECM monitors the voltage on the Fuel Rail Fuel Pressure Sensor circuits. When the fuel pressure is high, the signal voltage is high. When the fuel pressure is low, the signal voltage is low.

Conditions for Running the DTC

- The engine is running.
- The ignition voltage is between 11–18 V.
- The DTCs run continuously within the enabling conditions.

Conditions for Setting the DTC

P0192

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The Engine Control Module detects that the Fuel Rail Fuel Pressure Sensor signal voltage is low.

P0193

The Engine Control Module detects that the Fuel Rail Fuel Pressure Sensor signal voltage is high.

Action Taken When the DTC Sets

- DTCs P0192 and P0193 are Type A DTCs.
- A message center or an indicator may display Reduced Engine Power.

Conditions for Clearing the DTC

DTCs P0192 and P0193 are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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

⇒ **If any of the DTCs are set**
Refer to DTC P0641, P0651, P0697, or P06A3.

⇓ **If none of the DTCs are set**

3. Engine running.
4. Verify the scan tool Fuel Rail Pressure Sensor parameter is between 0.25–4.75 V.

⇒ **If not between 0.25–4.75 V**
Refer to Circuit/System Testing.

⇓ **If between 0.25–4.75 V**

5. Verify the scan tool Fuel Rail Pressure Sensor increases or decreases when commanding an increase and decrease in Fuel Rail Pressure with a scan tool.

⇒ **If the parameter does not change**

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Refer to Circuit/System Testing.

⇓ **If the parameter 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 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, all vehicle systems OFF, disconnect the B47B Fuel Rail Fuel Pressure Sensor connector. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal C and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector X2 at the K20 Engine Control Module.
2.2. Test for less than 2 Ω in the low reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal A and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the harness connector X2 at the K20 Engine Control Module.
4.2. Test for infinite resistance between the 5 V reference circuit and ground.
⇒ If less than infinite resistance, repair the short to ground in the circuit.
⇓ If infinite resistance
4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the harness connector X2 at the K20 Engine Control Module, ignition ON.
4.2. Test for less than 1 V between the 5 V reference circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If within the specified range**

5. Verify the scan tool Fuel Rail Pressure Sensor voltage parameter is less than 0.02 V.

⇒ **If 0.02 V or greater**

5.1. Ignition OFF, disconnect the harness connector X2 at the K20 Engine Control Module, ignition ON.
5.2. Test for less than 1 V between the signal circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If less than 0.02 V**

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6. Connect a 3 A fused jumper wire between the signal circuit terminal B and the 5 V reference circuit terminal A.
7. Verify the scan tool Fuel Rail Pressure Sensor Voltage parameter is greater than 4.96 V.

⇒ **If 4.96 V or less**

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

7.2. Test for infinite resistance between the signal circuit terminal 12 and ground.

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

⇓ If infinite resistance

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

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

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

⇓ **If greater than 4.96 V**

8. Test or replace the B47B Fuel Rail Fuel Pressure Sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail
- Control Module References for K20 Engine Control Module programming, replacement, and setup.

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DTC P0192 or P0193 (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0192

Fuel Rail Pressure Sensor Circuit Low Voltage

DTC P0193

Fuel Rail Pressure Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference Voltage	P0641, P2227, P2228	P0131, P0151, P0192	P0641, P2227, P2228	—
Fuel Rail Pressure Sensor Signal	P0131, P0151, P0192	P0131, P0151, P0192	P0131, P0151, P0193	—
Low Reference	—	P0131, P0151, P0193	P0036, P0056, P062F	—

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Circuit/System Description

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

Conditions for Running the DTC

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

Conditions for Setting the DTC

P0192

The ECM detects that the fuel rail pressure sensor signal voltage is less than 0.26 V for 5 s.

P0193

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The ECM detects that the fuel rail pressure sensor signal voltage is greater than 4.75 V for 5 s.

Action Taken When the DTC Sets

- DTCs P0192 and P0193 are Type A DTCs.
- A message center or an indicator may display Power Reduced.

Conditions for Clearing the DTC

DTCs P0192 and P0193 are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG 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 DTC P0641 is not set.

⇒ **If DTC P0641 is set**
Refer to DTC P0641, P0651, P0697, or P06A3

⇓ **If DTC P0641 is not set**

3. Engine idling.
4. Verify DTC P0192 or P0193 are not set

⇒ **If DTC P0192 or P0193 is set**
Refer to Circuit/System Testing

⇓ **If DTC P0192 or P0193 are not set**

5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify DTC P0192 or P0193 is not set.

⇒ **If DTC P0192 or P0193 is set**
Refer to Circuit/System Testing

⇓ **If DTC P0192 or P0193 do not set**

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7. All OK

Circuit/System Testing

1. Ignition OFF, and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down. Disconnect the B47B fuel rail pressure sensor connector.
2. Test for less than 5 Ω between the low reference circuit terminal A and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the X2 harness connector at the K20 engine control module.
2.2. Test for less than 2 Ω in the low reference circuit end to end.
⇒ If greater than 2 Ω, repair the open or high resistance in the circuit.
⇒ If 2 Ω or less, replace the K20 engine control module.

⇓ **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal B and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 engine control module.
4.2. Test for infinite resistance between the 5 V reference circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 engine control module.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 engine control module.
4.2. Ignition ON.
4.3. 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. Ignition ON.
6. Verify the scan tool Fuel Rail Pressure Sensor voltage parameter is less than 0.02 V.

⇒ **If 0.02 V or greater**

6.1. Ignition OFF, disconnect the X2 harness connector at the K20 engine control module.
6.2. Ignition ON.
6.3. Test for less than 1 V between the signal 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 less than 0.02 V**

7. Ignition OFF, connect a 3 A fused jumper wire between the signal circuit terminal C and the 5 V reference circuit terminal B. Ignition ON.
8. Verify the scan tool Fuel Rail Pressure Sensor Voltage parameter is greater than 4.96 V.

⇒ **If 4.96 V or less**

8.1. Ignition OFF, disconnect the X2 harness connector at the K20 engine control module.
8.2. Test for less than 2 Ω in the signal circuit end to end.
⇒ If greater than 2 Ω, repair the open or high resistance in the circuit.
⇒ If 2 Ω or less, replace the K20 engine control module.

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⇓ **If greater than 4.96 V**

9. Test or replace the B47B fuel rail pressure sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail
- Control Module References for engine control module replacement, programming, and setup

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DTC P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, or P0277 (LWR)

Diagnostic Instructions

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

DTC Descriptors

DTC P0201

Injector 1 Control Circuit

DTC P0202

Injector 2 Injector Control Circuit

DTC P0203

Injector 3 Injector Control Circuit

DTC P0204

Injector 4 Injector Control Circuit

DTC P0205

Injector 5 Injector Control Circuit

DTC P0206

Injector 6 Injector Control Circuit

DTC P0261

Injector 1 Injector Control Circuit Low Voltage

DTC P0262

Injector 1 Injector Control Circuit High Voltage

DTC P0264

Injector 2 Injector Control Circuit Low Voltage

DTC P0265

Injector 2 Injector Control Circuit High Voltage

DTC P0267

Injector 3 Injector Control Circuit Low Voltage

DTC P0268

Injector 3 Injector Control Circuit High Voltage

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DTC P0270

Injector 4 Injector Control Circuit Low Voltage

DTC P0271

Injector 4 Injector Control Circuit High Voltage

DTC P0273

Injector 5 Injector Control Circuit Low Voltage

DTC P0274

Injector 5 Injector Control Circuit High Voltage

DTC P0276

Injector 6 Injector Control Circuit Low Voltage

DTC P0277

Injector 6 Injector Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Supply Cylinder 1	P2147	P0201	P2148	P1248
Direct Fuel Injector High Voltage Control Cylinder 1	P0261	P0201	P0262	P1248
Direct Fuel Injector High Voltage Supply Cylinder 2	P2150	P0202	P2151	P1249
Direct Fuel Injector High Voltage Control Cylinder 2	P0264	P0202	P0265	P1249
Direct Fuel Injector High Voltage Supply Cylinder 3	P2153	P0203	P2154	P124A
Direct Fuel Injector High Voltage Control Cylinder 3	P0267	P0203	P0268	P124A
Direct Fuel Injector High Voltage Supply Cylinder 4	P2156	P0204	P2157	P124B
Direct Fuel Injector High Voltage Control Cylinder 4	P0270	P0204	P0271	P124B
Direct Fuel Injector High Voltage Supply Cylinder 5	P216B	P0205	P216C	P124C
	P0273	P0205	P0274	P124C

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Control Cylinder 5				
Direct Fuel Injector High Voltage Supply Cylinder 6	P216E	P0206	P216F	P124D
Direct Fuel Injector High Voltage Control Cylinder 6	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 fuel injector high voltage control circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- DTC P062B is not set.
- The engine is running.
- The ignition voltage is greater than 11 V.
- The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0201, P0202, P0203, P0204, P0205, or P0206

The ECM detects the injector high voltage supply circuit or the injector high voltage control circuit is open for greater than 1 s.

P0261, P0264, P0267, P0270, P0273, or P0276

The ECM detects the injector high voltage control circuit is shorted to ground for greater than 1 s.

P0262, P0265, P0268, P0271, P0274, or P0277

The ECM detects the injector high voltage control circuit is shorted to voltage for greater than 1 s.

Action Taken When the DTC Sets

DTCs P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, and P0277 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, and P0277 are Type A DTCs.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to Fuel Injector Solenoid Coil Test.

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- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Injector Circuit Status parameters. An Injector Circuit Status parameter will change from OK or Not Running to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG 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 DTC P0685 or P1682 are not set.

⇒ **If DTC P0685 or P1682 are set**
Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If DTC P0685 or P1682 are not set**

3. Engine operating.
4. Verify DTC P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, or P0277 are not set.

⇒ **If any of the specified DTCs are set**
Refer to Circuit/System Testing

⇓ **If none of the specified DTCs are set**

5. Ignition ON.
6. Verify the scan tool Cylinder 1–6 Injector Circuit Status parameters display OK.

⇒ **If the Cylinder 1–6 Injector Circuit Status parameters do not display OK**
Refer to Circuit/System Testing

⇓ **If the Cylinder 1–6 Injector Circuit Status parameters display OK**

7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
8. Verify DTC P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, or P0277 are not set.

⇒ **If any of the specified DTCs are set**
Refer to Circuit/System Testing

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⇓ **If none of the specified DTCs are set**

9. All OK

Circuit/System Testing

1. Ignition OFF, disconnect the X160 engine harness to fuel injector harness connector. Ignition ON.
2. Verify the appropriate scan tool Cylinder 1–6 Injector Circuit Status parameter displays Open.

⇒ **If the appropriate scan tool Cylinder 1–6 Injector Circuit Status parameter does not display Open.**

2.1. Ignition OFF, disconnect the X3 harness connector at the K20 engine control module.

2.2. Test for infinite resistance between the appropriate high voltage supply circuit, ECM side and ground.

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

⇓ If infinite resistance

2.3. Ignition ON.

2.4. Test for less than 1 V between the appropriate high voltage control circuit, ECM side 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 appropriate scan tool Cylinder 1–6 Injector Circuit Status parameter displays Open.**

3. Ignition ON, connect a test lamp between the appropriate high voltage supply circuit and the high voltage control circuit.
4. Verify the Injector Circuit Status parameter transitions from Open to OK.

⇓ **If the Injector Circuit Status parameter does not transition from Open to OK.**

4.1. Ignition OFF, disconnect the X3 harness connector at the K20 engine control module.

4.2. Test for infinite resistance between the appropriate high voltage supply circuit, ECM side and ground.

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

⇓ If infinite resistance

4.3. Test for less than 2 Ω on the appropriate high voltage supply circuit, ECM side end to end.

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

⇓ If less than 2 Ω

4.4. Test for infinite resistance between the appropriate high voltage control circuit, ECM side and ground.

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

⇓ If infinite resistance

4.5. Test for less than 2 Ω on the appropriate high voltage control circuit, ECM side end to end.

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

⇒ If less than 2 Ω, replace the K20 engine control module.

⇓ **If the Injector Circuit Status parameter transitions from Open to OK.**

Note: Testing for the following steps is performed on the fuel injector side of the multi-way harness connector. It may be necessary to remove the intake manifold to isolate the condition.

5. Ignition OFF.
6. Test for infinite resistance between the appropriate high voltage supply circuit and ground.

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⇒ **If less than infinite resistance**

6.1. Disconnect the harness connector at the appropriate Q17 fuel injector.

6.2. Test for infinite resistance between the appropriate high voltage supply circuit and ground.

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

⇓ If infinite resistance

6.3. Test for infinite resistance between the appropriate high voltage control circuit and ground.

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

⇒ If infinite resistance, test or replace the appropriate Q17 fuel injector.

⇓ **If infinite resistance**

7. Test for 1.5-2.5 Ω between the appropriate high voltage supply circuit and high voltage control circuit.

⇒ **If less than the specified range**

7.1. Disconnect the harness connector at the appropriate Q17 fuel injector.

7.2. Test for infinite resistance between the appropriate high voltage supply circuit and high voltage control circuit.

⇒ If less than infinite resistance, repair the short on the circuits.

⇒ If infinite resistance, replace the appropriate Q17 fuel injector.

⇒ **If greater than the specified range**

7.1. Disconnect the harness connector at the appropriate Q17 fuel injector.

7.2. Test for less than 2 Ω on appropriate high voltage supply circuit end to end

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

⇓ If less than 2 Ω

7.3. Test for less than 2 Ω on appropriate high voltage 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 appropriate Q17 fuel injector.

⇓ **If within the specified range**

8. Preform the Fuel Injector Solenoid Coil Test.

Component Testing

Fuel Injector Solenoid Coil Test

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel Injector and Fuel Rail Replacement
- Control Module References for ECM replacement, programming, and setup.

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DTC P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, or P0277 (LFW, LFX)

Diagnostic Instructions

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

DTC Descriptors

DTC P0201

Injector 1 Control Circuit

DTC P0202

Injector 2 Control Circuit

DTC P0203

Injector 3 Control Circuit

DTC P0204

Injector 4 Control Circuit

DTC P0205

Injector 5 Control Circuit

DTC P0206

Injector 6 Control Circuit

DTC P0261

Injector 1 Control Circuit Low Voltage

DTC P0262

Injector 1 Control Circuit High Voltage

DTC P0264

Injector 2 Control Circuit Low Voltage

DTC P0265

Injector 2 Control Circuit High Voltage

DTC P0267

Injector 3 Control Circuit Low Voltage

DTC P0268

Injector 3 Control Circuit High Voltage

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DTC P0270

Injector 4 Control Circuit Low Voltage

DTC P0271

Injector 4 Control Circuit High Voltage

DTC P0273

Injector 5 Control Circuit Low Voltage

DTC P0274

Injector 5 Control Circuit High Voltage

DTC P0276

Injector 6 Control Circuit Low Voltage

DTC P0277

Injector 6 Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Supply Cylinder 1	P2147	P0201	P2148	P1248
Direct Fuel Injector High Voltage Control Cylinder 1	P0261	P0201	P0262	P1248
Direct Fuel Injector High Voltage Supply Cylinder 2	P2150	P0202	P2151	P1249
Direct Fuel Injector High Voltage Control Cylinder 2	P0264	P0202	P0265	P1249
Direct Fuel Injector High Voltage Supply Cylinder 3	P2153	P0203	P2154	P124A
Direct Fuel Injector High Voltage Control Cylinder 3	P0267	P0203	P0268	P124A
Direct Fuel Injector High Voltage Supply Cylinder 4	P2156	P0204	P0270, P2157	P124B
Direct Fuel Injector High Voltage Control Cylinder 4	P0270, P2156	P0204	P0271, P2157	P124B
Direct Fuel Injector High Voltage Supply Cylinder 5	P216B	P0205	P216C	P124C
	P0273	P0205	P0274	P124C

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Control Cylinder 5				
Direct Fuel Injector High Voltage Supply Cylinder 6	P216E	P0206	P216F	P124D
Direct Fuel Injector High Voltage Control Cylinder 6	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 fuel injector high voltage control circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- The engine is running.
- The ignition voltage is between 11–18 V.
- The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0201, P0202, P0203, P0204, P0205, or P0206

The engine control module detects the fuel injector high voltage supply circuit or the fuel injector high voltage control circuit is open for greater than 2 s.

P0261, P0264, P0267, P0270, P0273, or P0276

The engine control module detects the fuel injector high voltage control circuit is shorted to ground for greater than 2 s.

P0262, P0265, P0268, P0271, P0274, or P0277

The engine control module detects the fuel injector high voltage control circuit is shorted to voltage for greater than 2 s.

Action Taken When the DTC Sets

DTCs P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, and P0277 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, and P0277 are Type A DTCs.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to Fuel Injector Solenoid Coil Test.
- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Cylinder 1–6 Injector Circuit Status

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parameters. An Injector Circuit Status parameter will change from OK or Not Run to Fault if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0685 or P1682 is not set.

⇒ **If DTC P0685 or P1682 is set**

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

⇓ **If DTC P0685 or P1682 is not set**

3. Engine idling.
4. Verify the scan tool Cylinder 1–6 Injector Control Circuit Status parameters display OK.

⇒ **If any parameters do not display OK**

Refer to Circuit/System Testing.

⇓ **If all parameters display OK**

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 P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, or P0277 does not set.

⇒ **If any DTC sets**

Refer to Circuit/System Testing.

⇓ **If no DTC sets**

7. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the appropriate multi-way harness connector X160 or X161, at the rear of the intake manifold, ignition ON. It may take up to 2 min for all vehicle systems to power down.

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2. Verify the scan tool Cylinder 1–6 Injector Control Circuit Status parameters display Open.

⇒ **If Open is not displayed**

2.1. Ignition OFF, disconnect the harness connector X3 at the K20 Engine Control Module.

Note: Test on the engine control module side of the multi-way harness connector.

2.2. Test for infinite resistance between the appropriate Q17 Fuel Injector control circuit and ground.

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

⇓ If infinite resistance

2.3. Ignition ON.

2.4. Test for less than 1 V between the appropriate 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, test or replace the K20 Engine Control Module.

⇓ **If Open is displayed**

3. Ignition ON, connect a test lamp between the appropriate Q17 Fuel Injector high voltage supply circuit and control circuits.

4. Verify the appropriate Cylinder 1–6 Injector Control Circuit Status transitions from Open to OK.

⇒ **If the parameter does not transition**

4.1. Ignition OFF, remove the test lamp, disconnect the harness connector X3 at the K20 Engine Control Module.

4.2. Test for less than 2 Ω on the appropriate Q17 Fuel Injector high voltage supply circuit end to end.

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

⇓ If less than 2 Ω

4.3. Test for less than 2 Ω on the appropriate Q17 Fuel Injector low control circuit end to end.

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

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

⇓ **If the parameter transitions**

Note: Testing for the following steps is performed on the fuel injector side of the multi-way harness connector. It may be necessary to remove the intake manifold to isolate the condition.

5. Test for 2-3 Ω between the appropriate Q17 Fuel Injector high voltage supply circuit and control circuit.

⇒ **If less than 2 Ω**

5.1. Disconnect the harness connector at the appropriate Q17 Fuel Injector.

5.2. Test for infinite resistance between the appropriate Q17 Fuel Injector high voltage supply circuit and control circuit.

⇒ If less than infinite, repair the short between the circuits.

⇒ If infinite resistance, test or replace the Q17 Fuel Injector.

⇒ **If greater than 3 Ω**

5.1. Disconnect the harness connector at the appropriate Q17 Fuel Injector.

5.2. Test for less the 2 Ω in the appropriate Q17 Fuel Injector high voltage supply circuit end to end.

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

⇓ If less than 2 Ω

5.3. Test for less the 2 Ω in the appropriate Q17 Fuel Injector control 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, test or replace the Q17 Fuel Injector.

⇓ **If between 2-3 Ω**

6. Test for infinite resistance between the appropriate Q17 Fuel Injector control circuit and ground.

⇒ **If less than infinite resistance**

6.1. Disconnect the harness connector at the appropriate Q17 Fuel Injector.

6.2. Test for infinite resistance between the appropriate Q17 Fuel Injector high voltage supply circuit and ground.

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

⇓ If infinite resistance

6.3. Test for infinite resistance between the appropriate Q17 Fuel Injector control circuit and ground.

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

⇒ If infinite resistance, test or replace the Q17 Fuel Injector.

⇓ **If infinite resistance**

7. Ignition ON.
8. Test for less than 1 V between the appropriate 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**

9. All OK.

Component Testing

- Fuel Injector Solenoid Coil Test
- Fuel Injector Balance Test

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Injection Fuel Rail Assembly Replacement - Bank 1
- Fuel Injection Fuel Rail Assembly Replacement - Bank 2
- Control Module References for K20 Engine Control Module replacement, programming, and setup.

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DTC P0231 or P0232 (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0231

Fuel Pump Control Circuit Low Voltage

DTC P0232

Fuel Pump Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Fuel Pump Supply Voltage	P0231	P0231	P0232	—
Low Reference	—	—	—	—

Circuit/System Description

The Chassis Control Module receives fuel pressure information from the Fuel Tank Pressure Sensor and controls the operation of the Fuel Pump located within the fuel tank. The Chassis Control Module sends a 25 kHz PWM signal to the Fuel Pump. The pump speed is changed by varying the duty cycle of this signal. The Fuel Pump will be on if the fuel tank pressure is less than 490 kPa (71 psi) and off if the fuel tank pressure is greater than 510 kPa (74 psi). When the Fuel Pump is on the duty cycle will vary from 50% to 100% based on the fuel flow requirements.

Conditions for Running the DTC

P0231

- The ignition voltage is greater than 9 V.
- The ignition is in Run or Crank.
  OR
- The high speed communication is enabled.
  OR
- The fuel pump control is enabled.

P0232

- The fuel pump is commanded OFF.
- The fuel pump control is not enabled.
- The above conditions are met for greater than 4 s.
- This DTC runs once per trip.

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Conditions for Setting the DTC

P0231

The Fuel Pump current is greater than 14.48 A for 1 s.

P0232

The Fuel Pump voltage is greater than 3.86 V for 0.5 s.

Action Taken When the DTC Sets

DTCs P0231 and P0232 are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0231 and P0232 are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG 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

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Circuit/System Verification

1. Ignition ON.
2. Verify the Fuel Pump Enable Command parameter turns on & off when commanding the Fuel Pump Enable ON and OFF with a scan tool.

⇒ **If the Fuel Pump Enable Command does not change**

Refer to Circuit/System Testing.

⇓ **If the Fuel Pump Enable Command changes**

3. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the Fuel Pump. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 3 Ω between the ground circuit terminal G and ground.

⇒ **If 3 Ω or greater**

2.1. Ignition OFF.

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

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

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

⇒ **If less than 3 Ω**

3. Ignition ON, connect a test lamp between the control circuit terminal A and the ground circuit terminal G.

4. Verify the test lamp turns ON and OFF when commanding the Fuel Pump Enable ON and OFF with a scan tool.

⇒ **If the test lamp is always OFF**

4.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K38 Chassis Control Module.

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

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

⇓ If infinite resistance

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

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

⇒ If less than 2 Ω, replace the fuel pump control module.

⇒ **If the test lamp is always ON**

4.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K38 Chassis Control Module, ignition ON.

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

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

⇒ If less than 1 V, replace the K38 Chassis Control Module.

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

5. Replace the Fuel Pump.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Pump Replacement
- Control Module References for K38 Chassis Control Module programming, replacement, and setup.

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DTC P0231, P0232, or P023F

Diagnostic Instructions

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

DTC Descriptors

DTC P0231

Fuel Pump Control Circuit Low Voltage

DTC P0232

Fuel Pump Control Circuit High Voltage

DTC P023F

Fuel Pump Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0231	P023F	P0232	P023F, P2635
Low Reference	—	P023F	—	P023F, P2635

Circuit/System Description

The Engine Control Module (ECM) supplies voltage to the chassis control module when the ECM detects that the ignition is on. The voltage from the ECM to the chassis control module remains active for 2 seconds, unless the engine is in crank or run. While this voltage is being received, the chassis control module supplies a varying voltage to the fuel tank pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

P0231, P023F

The ignition voltage is between 9–18 V.

P0232

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

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTCs P0231 and P023F are Type A DTCs.

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DTCs P0232 is a Type B DTC.

Conditions for Clearing the DTC

DTCs P0231 and P023F are Type A DTCs.

DTCs P0232 is a Type B DTC.

Diagnostic Aids

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

On vehicles equipped with a high pressure mechanical pump on direct fuel injection engines, the vehicle may continue to run even though the pump in the fuel tank is not operating.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

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

⇒ **If 10 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module.

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

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

⇒ If less than 2 Ω, replace the K38 Chassis Control Module.

⇓ **If less than 10 Ω**

3. Connect a test lamp between the control circuit terminal 1 and the low reference circuit terminal 2.
4. Ignition ON.

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5. Verify the test lamp turns ON and OFF when commanding the fuel pump ON and OFF using the scan tool ECM fuel pump enable control function.

⇒ **If the test lamp is always OFF**

5.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module.

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

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

⇓ If infinite resistance

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

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

⇒ If less than 2 Ω, replace the K38 Chassis Control Module.

⇒ **If the test lamp is always ON**

5.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module, ignition ON.

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

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

⇒ If less than 1 V, replace the K38 Chassis Control Module.

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

6. Test or replace the A7 Fuel Pump and Level Sensor Assembly.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Control Module References for K38 Chassis Control Module replacement, programming, and setup.

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DTC P0300-P0306

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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

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 sensors in order to determine when an engine misfire is occurring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM detects individual misfire events. A misfire rate that is high enough can cause 3-way catalytic converter damage. The malfunction indicator lamp (MIL) flashes ON and OFF when the conditions for catalytic converter damage are present.

DTCs P0301 through P0306 correspond to cylinders 1 through 6. If the ECM is able to determine that a specific cylinder is misfiring, the DTC for that cylinder is set, and the corresponding fuel injector is disabled. To retest for a misfire, the ECM re-enables the fuel injector(s) after 4 crankshaft revolutions or after 8 crankshaft revolutions for manual transmission equipped vehicles. For catalyst damaging misfires the ECM re-enables the fuel injector(s) after a 30 second delay to retest for a misfire. This 30 second periodic re-enabling occurs until the end of the drive cycle or until no further catalyst damaging misfire events are present.

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,

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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, P1104, P1682, P160D, P160E, P16A0, P16A1, P16A2, P16F3, P2100, P2101, P2102, P2103, P2135, P2227, P2228, P2229, or P2230 is not set.

- The engine speed is between 350 and 7,000 RPM.

  OR

- The engine speed is greater than 1,000 RPM and DTC P0315 is set.
- The engine coolant temperature (ECT) is between −7 and +127°C.
- If the ECT is colder than −7°C (+19°F) at start-up, this diagnostic will not run until the ECT is more than +21°C (+69°F).
- The ignition voltage is between 9 and 32 V.
- The evaporative emissions (EVAP) leak detection is not active.
- The ECM is not in fuel cut-off or decel fuel cut-off mode.
- The fuel level is greater than 10 %.
- Torque Converter Clutch (TCC) is not applied/active.
- DTCs P0300 through P0306 run continuously when the above conditions exist for at least 1,000 engine revolutions.
- DTCs P0300 through P0306 run continuously when the above conditions exist and the ECT is warmer than 47°C (117°F) for at least 1,000 engine revolutions for the first failure occurrence, 200 engine revolutions after the fist failure occurrence for catalyst damaging misfire(s).

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.

P0301, P0302, P0303, P0304, P0305, 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 B DTCs.
- The ECM disables the fuel injector of the misfiring cylinder when a misfire is present.

Conditions for Clearing the DTC

DTCs P0300–P0306 are Type B DTCs.

Diagnostic Aids

- A misfire DTC could be caused by an excessive vibration from sources other than the engine. Inspect for the following possible sources:
  - A tire or wheel that is out of round or out of balance
  - Variable thickness brake rotors
  - An unbalanced drive shaft
  - Certain rough road conditions
  - Transmission operation
  - A damaged accessory drive component or belt; remove the belt and safely operate the engine to evaluate

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- 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 Malfunction if a condition exists.
- A condition in the heated O2 sensor (HO2S) heater control circuits may set a DTC P0300.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

J 26792 HEI Spark Tester

For equivalent regional tools, refer to Special Tools.

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Circuit/System Verification

Note: Before starting vehicle, review freeze frame data to determine if misfire sets during cold start or warmed up operation. If the vehicle has a cold start problem and the vehicle is started, the vehicle will require a soak of many hours before next attempt to operate the vehicle within the fail conditions.

1. Engine idling at the normal operating temperature.
2. Verify there is no abnormal engine noise.

⇒ **If there is an abnormal engine noise**
Refer to Symptoms - Engine Mechanical.

3. Verify no DTCs other than P0300–P0306 are set.

⇒ **If any DTCs other than P0300–P0306 are set**
Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇒ **If only DTCs P0300–P0306 are set**
Refer to Circuit/System Testing.

⇓ **If no DTCs are set**

4. Verify the scan tool Cylinder 1–6 Current Misfire Counter parameters are not incrementing.

⇒ **If Misfire Current Counters are incrementing**
Refer to Circuit/System Testing.

⇓ **If Misfire Current Counters are not incrementing**

5. Engine idling.
6. Verify the engine speed changes when performing the Cylinder Power Balance Test with a scan tool.

⇒ **If engine speed does not change**

Refer to Circuit/System Testing.

⇓ **If engine speed changes**

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

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

9. All OK.

Circuit/System Testing

1. Verify that the following conditions do not exist:
   - Vacuum hose splits, kinks, and incorrect connections
   - Engine vacuum leaks
   - Crankcase ventilation system for vacuum leaks
   - Fuel pressure that is too low or too high—Refer to Fuel System Diagnosis.
   - Contaminated Fuel—Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
   - Exhaust system restrictions

   ⇒ **If a condition exists**

   Repair or replace as necessary.

⇓ **If no conditions exists**

2. Ignition OFF, remove the T8 Ignition Coil of the misfiring cylinder, but leave the electrical connector connected.
3. Verify none of the conditions listed below exist with the boot of the T8 Ignition Coil:
   - Holes
   - Tears
   - Carbon tracking
   - Oil contamination
   - Water intrusion

   ⇒ If you find any of the above conditions, repair as necessary.

   ⇒ **If a condition exists**

   Repair or replace component as appropriate.

⇓ **If no conditions exist**

4. Install the *J 26792* HEI Spark Tester to the boot of the appropriate T8 Ignition Coil and ground.

   Note: An erratic or weak spark is considered a no spark condition.
5. Verify the *J 26792 (EL 26792)* HEI Spark Tester sparks while cranking or starting the engine.

⇒ **If there is no spark**

Refer to Electronic Ignition System Diagnosis for diagnosis of the ignition coil.

⇓ **If there is spark**

6. Ignition OFF, remove the spark plug from the misfiring cylinder.

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7. Verify none of the conditions listed below exist with the spark plug:
    - Gas, coolant, or oil fouled—Refer to Spark Plug Inspection.
    - Cracked, worn, incorrectly gapped—Refer to Ignition System Specifications.

⇒ **If a condition exists**

Replace the spark plug.

⇓ **If no conditions exist**

8. Exchange the suspected spark plug with another cylinder that is operating correctly.
9. Engine idling.
10. Verify the scan tool Cylinder 1–6 Current Misfire Counter parameter does not increment on the spark plug coil it was removed from.

⇒ **If the misfire does follow the spark plug exchange**

Replace the spark plug.

⇓ **If the misfire does not follow the spark plug exchange**

11. If all conditions test normal, test or inspect for the following:
    - A lean or rich Q17 Fuel Injector—Refer to Fuel Injector Solenoid Coil Test.
    - An engine mechanical condition—Refer to Symptoms - Engine Mechanical.

Repair Instructions

- Spark Plug Replacement
- Ignition Coil Replacement - Bank 1
- Ignition Coil Replacement - Bank 2

Repair Verification

1. Perform the Diagnostic Repair Verification after completing the diagnostic procedure.
2. 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.
3. Clear the DTCs.
4. Turn OFF the ignition for 2 min.
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 Diagnostic Trouble Code (DTC) List - Vehicle the Diagnostic Trouble Code (DTC) List - Vehicle and perform the appropriate diagnostic procedure.
6. Engine idling, observe the Misfire Current Cyl. 1–6 parameters with a scan tool. The misfire counter parameters should not be incrementing.

    ⇒ If the misfire counter parameters are incrementing, a misfire still exists.
7. To verify that the performance of the catalytic converter has not been affected by the condition that set this DTC, perform the Repair Verification for DTC P0420. Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

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DTC P0315

Diagnostic Instructions

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

DTC Descriptor

DTC P0315

Crankshaft Position System Variation Not Learned

Circuit/System Description

The crankshaft position variation learn feature is used to calculate reference period errors caused by slight tolerance variations in the crankshaft, and the crankshaft position sensor. The calculated error allows the engine control module (ECM) to accurately compensate for reference period variations. This enhances the ability of the ECM to detect misfire events over a wider range of engine speed and load conditions.

The crankshaft position system variation compensating values are stored in ECM memory after a learn procedure has been performed and the ignition switch is turned to the OFF position for at least 30 s. If the actual variation is not within the crankshaft position system variation compensating values stored in the ECM, DTC P0300 may set.

If the crankshaft position system variation values are not stored in the ECM memory or a proper ECM power down does not occur after completing the Crankshaft Position Learn Procedure, DTC P0315 sets.

Conditions for Running the DTC

Engine is Running.

The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects that the crankshaft position system variation values are not stored in memory.

Action Taken When the DTC Sets

DTC P0315 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P0315 is a Type A DTC.

Diagnostic Aids

This test procedure requires that the vehicle battery has passed a load test and is completely charged. Refer to Battery Inspection/Test.

Reference Information

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. Perform the scan tool Crankshaft Position System Variation Learn procedure.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
3. Verify the DTC is not set.

⇒ **If the DTC sets**

Replace the K20 Engine Control Module.

⇓ **If the DTC does not set**

4. All OK

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 P0324, P0326, P0331, P06B6, or P06B7

Diagnostic Instructions

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

DTC Descriptors

DTC P0324

Knock Sensor System Performance

DTC P0326

Knock Sensor 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 Signal	P0327	P0325	P0328	P0326
Knock Sensor 2 Signal	P0332	P0330	P0333	P0331
Knock Sensor 1 Low Reference	P0327	P0325, P06B6	P0328	P0326
Knock Sensor 2 Low Reference	P0332	P0330, P06B7	P0333	P0331

Circuit/System Description

The knock sensors enable the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensors produce an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the two knock sensor signals. The ECM receives the two knock sensor signals through 2 isolated circuits. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges. The ECM monitors for a normal knock sensor signal. The ECM monitors the two internal knock sensor processors by verifying a 20 KHz signal generated on the signal circuits is detected on the sensors' low reference circuits.

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Conditions for Running the DTCs

P0324, P0326, and P0331–Condition 1

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

P0326 and P0331–Condition 2

- Engine speed is greater than 2,200 RPM.
- Engine is running for greater than 1 s.
- The ECT is warmer than −40°C (−40°F).
- The IAT sensor 1 is warmer than −40°C (−40°F).
- The DTCs run continuously when the above conditions are met.

P06B6 and P06B7

- Engine speed is between 400 and 4,000 RPM.
- Engine is running greater than 2 s.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0324

The ECM detects that the knock sensor signal's performance is out of the normal expected range due to an excessive engine knock, or abnormal noise, or a flat signal; for greater than 10 s for at least 1 single cylinder.

P0326

- The ECM detects that the knock sensor signal indicates the harness is connected, but the sensor is not properly bolted to the engine.
- The above condition exist for greater than 10 s.

  OR
- The ECM detects that the knock sensor signal indicates an excessive engine knock is present.
- The above condition exist for greater than 10 s.

P06B6 and P06B7

The ECM has detected an internal knock sensor processor fault.

Action Taken When the DTCs Set

- DTCs P0324, P0326, and P0331 are Type C DTCs.
- DTCs P06B6 and P06B7 are Type B DTCs.
- The ignition timing maybe retarded to reduce the potential of engine damaging spark knock.

Conditions for Clearing the DTCs

- DTCs P0324, P0326, and P0331 are Type C DTCs.
- DTCs P06B6 and P06B7 are Type B DTCs.

Reference Information

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Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine running, observe the DTC information with a scan tool. Verify DTC P0325, P0327, P0328, P0330, P0332, P0333, P06B6, and P06B7 is not set.
   ⇒ If DTC P0325, P0327, P0328, P0330, P0332, or P0333 is set with P06B6 or P06B7 refer to DTC P0325, P0327, P0328, P0330, P0332, or P0333 for further diagnosis.
   ⇒ If only DTC P06B6 or P06B7 is set, and no external knock sensor circuit issues exist, replace the K20 electronic control module.
2. Ignition OFF, inspect for the following:
   - The affected B68 knock sensor for physical damage. A sensor that is dropped or damaged may cause a DTC to set
   - The sensor for proper installation. A sensor that is loose or not at the correct torque may cause a DTC to set. Refer to Fastener Tightening Specifications.
   - The sensor mounting surface for burrs, casting flash, and foreign material
   - The sensor must be clear of hoses, brackets, and engine electrical wiring
   - Loose brackets
   - Loose or broken accessory drive belts, brakcets, components
   - An engine mechanical condition—Refer to Symptoms - Engine Mechanical

   ⇒ If a condition is found, repair as necessary.
3. If there is no mechanical condition, test or replace the B68 knock sensor.
4. Operate the vehicle within the conditions for running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure Records data.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Knock Sensor Replacement - Bank 1
- Knock Sensor Replacement - Bank 2
- Control Module References for engine control module replacement, programming, and setup.

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DTC P0325, P0327, P0328, P0330, P0332, or P0333

Diagnostic Instructions

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

DTC Descriptors

DTC P0325

Knock Sensor 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 Signal	P0327	P0325	P0328	P0326
Knock Sensor 2 Signal	P0332	P0330	P0333	P0331
Knock Sensor 1 Low Reference	P0327	P0325, P06B6	P0328	P0326
Knock Sensor 2 Low Reference	P0332	P0330, P06B7	P0333	P0331

Circuit/System Description

The knock sensors enable the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensors produce an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the two knock sensor signals. The ECM receives the two knock sensor signals through 2 isolated circuits. The ECM learns a minimum knock

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sensor noise level for all of the engine speed ranges. The ECM monitors for a normal knock sensor signal. The ECM monitors the two internal knock sensor processors by verifying a 20 KHz signal generated on the signal circuits is detected on the sensors' low reference circuits.

Conditions for Running the DTCs

P0325 and P0330

- Engine speed is between 400 and 8,500 RPM.
- Engine is running at least 2 s.
- The ECT is warmer than −40°C (−40°F).
- The IAT sensor 1 is warmer than −40°C (−40°F).
- The DTCs run continuously when the above conditions are met.

P0327, P0328, P0332, and P0333

- Engine speed is less than 8,500 RPM.
- The DTCs run continuously when the above condition is met.

Conditions for Setting the DTCs

P0325 and P0330

The ECM detects that a knock sensor signal circuit is open for longer than 6 s.

P0327 and P0332

The ECM detects that a knock sensor signal circuit is shorted to ground for longer than 6 s.

P0328 and P0333

The ECM detects that a knock sensor signal circuit is shorted to voltage for longer than 6 s.

Action Taken When the DTCs Set

- DTCs P0325, P0327, P0328, P0330, P0332, and P0333 are Type B DTCs.
- The ignition timing is retarded to reduce the potential of engine damaging spark knock.

Conditions for Clearing the DTCs

DTCs P0325, P0327, P0328, P0330, P0332, and P0333 are Type B DTCs.

Diagnostic Aids

- Inspect the affected knock sensor for physical damage. A sensor that is dropped or damaged may cause a DTC to set.
- The sensor mounting surface must be free of burrs, casting flash, and foreign material.
- The sensor must be clear of hoses, brackets, and engine electrical wiring.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

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- Connector Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine running, observe the DTC information with a scan tool. Verify DTC P0325, P0327, P0328, P0330, P0332, P0333, P06B6, and P06B7 are not set.
   ⇒ If DTC P0325, P0327, P0328, P0330, P0332, or P0333 is set with P06B6 or P06B7 continue with Circuit/System Testing.
   ⇒ If only DTC P06B6 or P06B7 is set, and no external knock sensor circuit issues exist, replace the K20 electronic control module.
2. Move the related harnesses and connectors for the affected knock sensor circuits while observing the scan tool parameters listed below. The parameters should display NO.
   - Knock Detected Cyl. 1
   - Knock Detected Cyl. 2
   - Knock Detected Cyl. 3
   - Knock Detected Cyl. 4
   - Knock Detected Cyl. 5
   - Knock Detected Cyl. 6

   ⇒ If the parameters change, repair the wiring or the harness connectors.
3. Observe the DTC information with a scan tool. DTC P0325, P0327, P0328, P0330, P0332, or P0333 should not set.
4. Operate the vehicle within the conditions for running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.

Circuit/System Testing

1. Verify the affected B68 knock sensor is properly tightened, refer to Fastener Tightening Specifications.
   ⇒ If not the specified value, correct the condition as appropriate.
2. Ignition OFF, disconnect the harness connector at the B68 knock sensor.
3. Ignition ON, measure for 1–4 V between each of the following circuits and ground on the K20 ECM side of the harness connector:
   - The signal circuit, terminal 1
   - The low reference circuit, terminal 2

   ⇒ If less than the specified range, test the circuits for a short to ground or an open/high resistance. If the circuits test normal, replace the K20 electronic control module.
   ⇒ If greater than the specified range, test the circuits for a short to voltage. If the circuits test normal, replace the K20 electronic control module.
4. If all circuits test normal, replace the B68 knock sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Knock Sensor Replacement - Bank 1
- Knock Sensor Replacement - Bank 2
- Control Module References for ECM replacement, programming, and setup.

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DTC P0335 or P0336

Diagnostic Instructions

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

DTC Descriptors

DTC P0335

Crankshaft Position Sensor Circuit

DTC P0336

Crankshaft Position Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P057C, P0335, P0651	P0335	P0651	P0336
Signal	P0335, P0506	P0335	P0335	P0336
Low Reference	—	P0335	—	P0336

Circuit/System Description

The crankshaft position sensor circuits consist of an engine control module (ECM) supplied 5 V reference circuit, low reference circuit, and an output signal circuit. The crankshaft position sensor is an internally magnetic biased digital output integrated circuit sensing device. The sensor detects magnetic flux changes of the teeth and slots of a 58-tooth reluctor wheel on the crankshaft. Each tooth on the reluctor wheel is spaced at 60-tooth spacing, with 2 missing teeth for the reference gap. The crankshaft position sensor produces an ON/OFF DC voltage of varying frequency, with 58 output pulses per crankshaft revolution. The frequency of the crankshaft position sensor output depends on the velocity of the crankshaft. The crankshaft position sensor sends a digital signal, which represents an image of the crankshaft reluctor wheel, to the ECM as each tooth on the wheel rotates past the crankshaft position sensor. The ECM uses each crankshaft position signal pulse to determine crankshaft speed and decodes the crankshaft reluctor wheel reference gap to identify crankshaft position. This information is then used to determine the optimum ignition and injection points of the engine. The ECM also uses crankshaft position sensor output information to determine the camshaft relative position to the crankshaft, to control camshaft phasing, and to detect cylinder misfire.

Conditions for Running the DTC

P0335 Condition 1

- The starter is engaged and the engine control module detects camshaft position sensor pulses.

Or

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- 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

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The ECM does not detect the synchronization gap on the reluctor wheel for 1.5 s after the starter was engaged.

Condition 4

The ECM detects less than 51 or greater than 65 crankshaft position sensor pulses during 1 engine revolution for 8 out of 10 engine revolutions.

Action Taken When the DTC Sets

- DTCs P0335 and P0336 are Type B DTCs.
- 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 B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0651 is not set.

⇒ **If the DTC is set**
Refer to DTC P0641, P0651, P0697, or P06A3.

⇓ **If the DTC is not set**

3. Engine running.
4. Verify the scan tool Crankshaft Position Active Counter parameter increments.

⇒ **If the counter does not increment**
Refer to Circuit/System Testing.

⇓ **If the counter increments**

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5. Verify the scan tool Crankshaft Position Resync Counter parameter displays 0 counts and the engine does not stumble or stall while moving the related harness/connectors of the B26 Crankshaft Position Sensor.

⇒ **If greater than 0 counts and the engine stumbles or stalls**

Refer to Circuit/System Testing.

⇓ **If 0 counts and the engine does not stumble or stall**

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

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

8. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B26 Crankshaft Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 1 and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

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

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

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

⇓ **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 3 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

4.2. Test for infinite resistance between the 5 V reference circuit and ground.

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

⇓ If infinite resistance

4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

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

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

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.

4.2. Test for less than 1 V between the 5 V reference and ground.

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

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

⇓ **If between 4.8–5.2 V**

5. Test for 4.8–5.2 V between the signal circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

5.2. 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.

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

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

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

⇒ **If greater than 5.2 V**

5.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.

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

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

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

⇓ **If between 4.8–5.2 V**

6. Ignition OFF, connect a 3 A fused jumper wire to the signal circuit terminal 2, ignition ON.

Note: Additional DTCs may set when performing this test.

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

⇒ **If the counter does not increment**

Replace the K20 Engine Control Module.

⇓ **If the counter increments**

8. Verify DTC P0336 is not set.

⇒ **If the DTC is set**

Inspect for the conditions listed below:

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

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

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

⇓ **If the DTC is not set**

9. Test or replace the B26 Crankshaft Position Sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Crankshaft Position Sensor Replacement
- Control Module References for engine control module replacement, programming, and setup

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DTC P0340, P0341, P0345, P0346, P0365, P0366, P0390, or P0391

Diagnostic Instructions

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

DTC Descriptors

DTC P0340

Intake Camshaft Position Sensor Circuit 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	P0340, P0345, P0365, P0390	P0193, P0236, P0345, P0453, P0506, P0533, P0641, P1101, P2227, P222B	—

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
	P0641, P2228			
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.

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.

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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.

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 MIL/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

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intermittent and a DTC will not set. Inspect all camshaft position sensor circuits for poor connections.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0641 or P0651 is not set.

⇒ **If any of the DTCs are set**

Refer to DTC P0641, P0651, P0697, or P06A3.

⇓ **If none of the DTCs are set**

3. Engine running.
4. Verify the scan tool parameters listed below increment:
   - Exhaust Camshaft Position Active Counter 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.

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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 and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
2.2. Test for less than 2 Ω in the low reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If 2 Ω or less, replace the K20 Engine Control Module.

⇓ **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 3 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
4.2. Test for infinite resistance between the 5 V reference circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance.
4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω , replace the K20 Engine Control Module.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
4.2. Test for less than 1 V between the 5 V reference circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If between 4.8–5.2 V**

5. Test for 4.8–5.2 V between the signal circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
5.2. Test for infinite resistance between the signal circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance.
5.3. Test for less than 2 Ω in the signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 5.2 V**

5.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
5.2. Test for less than 1 V between the signal circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If between 4.8–5.2 V**

6. Verify DTC P0341, P0346, P0366, or P0391 is not set.

⇒ **If any of the DTCs are set**

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Inspect for the conditions listed below:

- Excessive play or looseness of the B23 Camshaft Position Sensor or the reluctor wheel
- Improper installation of the B23 Camshaft Position Sensor
- Foreign material passing between the B23 Camshaft Position Sensor and the reluctor wheel
- Damaged reluctor wheel
- Excessive air gap between the B23 Camshaft Position Sensor and the reluctor wheel
- Engine oil for debris
- Timing chain, tensioner, and sprockets for wear or damage

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

⇒ If all components test normal, test or replace the B23 Camshaft Position Sensor.

⇓ **If none of the DTCs are set**

7. Test or replace the B23 Camshaft Position Sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust
- Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust
- Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake
- Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake
- Control Module References for engine control module replacement, programming, and setup

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DTC P0351-P0356, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, or P2316

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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

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

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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
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

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

Connector End View Reference

Component Connector End Views

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

DTC Type Reference

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Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL 26792 HEI Spark Tester

For equivalent regional tools, refer to Special Tools.

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 A and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF.

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

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

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

⇓ **If less than 5 Ω**

3. Verify the scan tool Ignition Coil Control Circuit Low Voltage Test Status does not display Malfunction.

⇒ **If Malfunction is displayed**

3.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

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

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

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⇒ **If Malfunction is displayed**

4.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

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

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

6.1. Ignition OFF, remove the fused jumper, and disconnect the X3 harness connector at the K20 Engine Control Module.

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

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

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DTC P0420 or P0430 (LFW, LFX)

Diagnostic Instructions

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

DTC Descriptor

DTC P0420

Catalyst System Low Efficiency Bank 1

DTC P0430

Catalyst System Low Efficiency Bank 2

Circuit/System Description

A 3-way catalytic converter controls emissions of hydrocarbons, carbon monoxide (CO) and nitrogen oxide (NOx). The catalyst within the converter promotes a chemical reaction, which oxidizes the hydrocarbons and the CO that are present in the exhaust gas. This process converts the hydrocarbons and the CO into water vapor and carbon dioxide (CO2), and reduces the NOx, converting the NOx into nitrogen. The catalytic converter also stores oxygen. The ECM monitors this process by using a heated oxygen sensor (HO2S) that is in the exhaust stream after the 3-way catalytic converter. The HO2S 2 produces an output signal that the ECM uses to calculate the oxygen storage capacity of the catalyst. This indicates the ability of the catalyst to convert the exhaust emissions efficiently. The ECM monitors the efficiency of the catalyst by allowing the catalyst to heat, then wait for a stabilization period while the engine is idling. The ECM then adds and removes fuel while monitoring the HO2S 2. When the catalyst is functioning properly, the HO2S 2 response to the extra fuel is slow compared to the response of the HO2S 1, which is located before the 3-way catalytic converter. When the HO2S 2 response is near that of the HO2S 1, the oxygen storage capability and efficiency of the catalyst may be degraded below an acceptable threshold.

Conditions for Running the DTC

- DTC P0030, P0036, P0050, P0053, P0054, P0056, P0059, P0060, P0068, P0101, P0102, P0103, P0112, P0113, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013C, P013D, P013E, P013F, P0140, P0141, P014A, P014B, P0151, P0152, P0153, P0155, P0157, P0158, P015A, P015B, P015C, P015D, P0160, P0161, P0171, P0172, P0174, P0175, P0222, P0223, P0300, P0301, P0302, P0303, P0304, P0305, P0306, P0335, P0336, P0443, P0506, P0507, P0606, P16A0, P16A1, P16A2, P16F3, P2101, P2227, P2228, P2229, P2230, P2270, P2271, P2272, or P2273 is not set.
- Before the ECM performs the idle test, the vehicle must be driven under the conditions listed below:
  - The engine speed is greater than 915 RPM
  - The engine run time is greater than a calibrated value
  - Both conditions exist for at least 25 s
- Divers foot is off accelerator pedal
- The throttle is in the rest position.
- The intake air temperature (IAT) is between −20 to +250°C (−4 to +482°F).
- The ignition voltage is greater than 11 V.

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- The engine coolant temperature (ECT) is between 40–127°C (104–261°F).
- The barometric pressure (BARO) is greater than 70 kPa.
- The engine has been idling less than 50 s.
- The vehicle speed is less than 2 km/h (1 mph).
- The short term fuel trim is between 0.6–1.4 %.
- The mass air flow (MAF) is between 3–13 g/s.
- The evaporative emission (EVAP), Fueltrim, Post O2, or other intrusive tests are not active
- The catalytic converter calculated temperature is between 300–900°C (572–1,652°F).
- Closed loop fueling is active.
- The transmission is not in P/N (automatic transmission only).

This diagnostic attempts one test during each valid idle period once the above conditions have been met. This diagnostic attempts up to 8 tests during each drive cycle.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTC P0420 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:

- An engine misfire
- High engine oil or high coolant consumption
- Retarded spark timing
- A weak or poor spark
- A lean fuel mixture
- A rich fuel mixture
- A damaged oxygen sensor or wiring harness

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify there are no other DTCs set.

⇒ **If a DTC is set**

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

⇓ **If a DTC is not set**

3. Operate the vehicle within the Conditions for Running the DTC.

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4. Verify the scan tool Catalyst Monitor Not At Idle Test Conditions Met parameter changes to Yes.

⇒ **If Yes is not displayed**

Refer to step 3.

⇓ **If Yes is displayed**

5. When the conditions are safe, stop and idle the vehicle in gear (If equipped with automatic transmission) or neutral (If equipped with manual transmission).
6. Verify the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters display Pass when performing the steps listed below:
   6.1. Apply the service brake.
   6.2. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.

   Note: When the test has completed, the Catalyst Monitor Test Counter 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.

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

⇒ **If the Catalyst Monitor Test Result Bank 1 or Bank 2 parameter indicates No Result**

Repeat steps 3–6 until the Test Result parameters indicate Passed or Failed

⇒ **If the Catalyst Monitor Test Result Bank 1 or Bank 2 parameter indicates Failed**

Refer to Circuit /System Testing

⇓ **If the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters indicate Pass**

7. 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
   - 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:
   - The HO2S is not at the correct 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**

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4. Test or replace the catalytic converters.

Repair Instructions

Note: A new converter with less than 100 miles on it may set DTC P0420 or P0430 due to out-gassing of the internal matting. Operating the vehicle at highway speeds for approximately 1 hour may correct the condition.

- Exhaust Leakage
- Restricted Exhaust
- Catalytic Converter Replacement - Left Side for catalytic converter replacement.
- Catalytic Converter Replacement - Right Side
- 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.

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Turn OFF the ignition for 60 s
5. Operate the vehicle within the Conditions for Running the DTC.
6. Verify the scan tool Catalyst Monitor Not At Idle Test Conditions Met parameter changes to Yes.

⇒ **If Yes is not displayed**

Refer to step 5.

⇓ **If Yes is displayed**

7. When the conditions are safe, stop and idle the vehicle in gear (If equipped with automatic transmission) or neutral (If equipped with manual transmission).
8. Verify the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters display Pass when performing the steps listed below:
   8.1. Apply the service brake.
   8.2. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.
   Note: When the test has completed, the Catalyst Monitor Test Counter 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.
   8.3. Continue to monitor the parameter. When the parameter indicates Inactive, the Catalyst Monitor Test has completed.

⇒ **If the Catalyst Monitor Test Result Bank 1 or Bank 2 parameter indicates No Result**

Repeat steps 5–8 until the Test Result parameters indicate Passed or Failed

⇒ **If the Catalyst Monitor Test Result Bank 1 or Bank 2 parameter indicates Failed**

Refer to Circuit /System Testing

⇓ **If the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters indicate Pass**

9. All OK.

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DTC P0443, P0458, or P0459 (LFX, LFW)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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.

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P0459

The ECM detects the EVAP purge solenoid valve control circuit is shorted to voltage within 0.25 s.

Action Taken When the DTC Sets

DTC P0443, P0458 and P0459 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0443, P0458 and P0459 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

Note: The audible clicking intensity will vary depending on mounting locations and interference with the fuel injectors clicking. You may also feel a change in the frequency of clicking.

1. Ignition ON, verify DTC P0690 is not set.

⇒ **If the DTC is set**

Refer to DTC P0685-P0687, P0689, P0690, or P1682 for further diagnosis.

⇓ **If the DTC is not set**

2. Command the EVAP Purge Solenoid Valve from 0 to 50% and back to 0% with a scan tool while observing the following control circuit status parameters:
   - EVAP Purge Solenoid Valve Control Circuit Open Test Status
   - EVAP Purge Solenoid Valve Control Circuit Low Voltage Test Status
   - EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing

⇓ **If Malfunction is not displayed**

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3. Verify the EVAP Purge Solenoid Valve control circuit parameters above do not display Malfunction when moving the related harnesses and connectors of the Q12 Evaporative Emission Purge Solenoid Valve.

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing

⇓ **If Malfunction is not displayed**

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

⇒ **If the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve. Ignition ON,
2. Verify that a test lamp illuminates between the ignition voltage circuit terminal A or 1 and ground.

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

2.1. Ignition OFF, remove the test lamp.

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

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

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

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

2.1. Ignition OFF, remove the test lamp.

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

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

⇒ If infinite resistance, test all components connected to the ignition voltage circuit for a short and replace as necessary.

⇓ **If the test lamp illuminates**

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

⇒ **If the test lamp illuminates**

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

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

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

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

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

4. Remove the test lamp.
5. Verify the scan tool EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the EVAP Purge Solenoid Valve to 50% with a scan tool.

⇒ **If OK is not displayed**

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

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

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⇒ 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**

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

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

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

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

⇓ **If Malfunction is displayed**

8. Test or replace the Q12 Evaporative Emission Purge Solenoid Valve.

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 does turns on & off/clicks and flows vacuum.**

4. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Evaporative Emission Canister Purge Solenoid Valve Replacement
- Control Module References for ECM replacement, programming and setup

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DTC P0506 or P0507

Diagnostic Instructions

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

DTC Descriptors

DTC P0506

Idle Speed Low

DTC P0507

Idle Speed High

Circuit/System Description

The throttle actuator control (TAC) motor is a DC motor that is part of the throttle body assembly. The TAC motor drives the throttle valve. The engine control module (ECM) controls the TAC motor based on throttle position sensor input. The idle speed is controlled by the ECM based on various inputs. The ECM commands the TAC motor to open or close the throttle valve in order to maintain the desired idle speed.

Conditions for Running the DTC

- DTCs P0068, P0101, P0102, P0103, P0112, P0113, P0117, P0118, P0121, P0122, P0123, P0171, P0172, P0174, P0175, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268. P0270, P0271, P0273, P0274, P0276, P0277, P0300–P0306, P0351–P0356, P0461–P0464, P0496, P0627, P0628, P0629, P0722, P1516, P2066–P2068, are not set.
- The barometric pressure (BARO) is greater than 70 kPa.
- The engine coolant temperature (ECT) is greater than 60°C (140°F).
- The engine run time is greater than 60 s.
- The ignition voltage is between 11–32 V.
- The transmission is not changing gears.
- The torque converter clutch (TCC) is not changing states.
- The intake air temperature (IAT) is warmer than −20°C (−4°F).
- The vehicle speed is less than 3 km/h (2 mph).
- The commanded engine speed is steady within 25 RPM.
- The engine is idling for greater than 5 s.
- The DTCs run when the above conditions are met.

Conditions for Setting the DTC

P0506

The actual engine speed is 94 RPM less than the desired idle speed for 10 s.

P0507

The actual engine speed is 188 RPM greater than the desired idle speed for 10 s.

Action Taken When the DTC Sets

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DTCs P0506 and P0507 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0506 and P0507 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

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.

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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

P0506

1. Verify the conditions listed below do not exist.
   - Restricted exhaust
   - Mechanical conditions that limits engine speed
   - Parasitic load on the engine—For example, a transmission condition, a belt driven accessory condition.

⇒ **If a condition is found**

Repair as necessary.

⇓ **If a condition is not found**

2. All OK.

P0507

1. Verify the conditions listed below do not exist.
   - Vacuum leaks
   - A throttle valve that does not close correctly
   - Verify the correct operation of the crankcase ventilation system. Inspect for the conditions listed below:
     - Improper routing of the positive crankcase ventilation (PCV) system
     - Vacuum leaks in the PCV system—Refer to Crankcase Ventilation System Inspection/Diagnosis.

⇒ **If a condition is found**

Repair as necessary.

⇓ **If a condition is not found**

2. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Throttle Body Assembly Replacement

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DTC P057C or P057D (LFW w/LHD)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P057C

Brake Pedal Position Sensor Circuit Low Voltage

DTC P057D

Brake Pedal Position Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P057C	P057C	P057D	—
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. **Brake Pedal Position Sensor Parameter Normal Range:** 0.25–4.75 V			
5 V Reference	0 V	0 V	—
Signal	0 V	0 V	5 V
Low Reference	—	5 V	—

Circuit/System Description

The brake pedal position (BPP) sensor is part of the engine brake pedal override feature. The engine control module (ECM) continuously monitors the vehicle speed and the position of the brake pedal. These two main inputs, along with other ECM inputs are used to determine if the vehicle is decelerating at the proper speed and rate with the brake pedal applied. When the engine brake pedal override system is active, the ECM reduces engine torque to assist in reducing vehicle speed.

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The BPP sensor is a six wire sensor, and is part of a dual brake position sensor. One BPP Sensor is used for the stop lamps and the other BPP Sensor is used for the engine brake pedal override feature. The BPP Sensor for engine brake pedal override communicates with the ECM. The ECM supplies a 5 V reference circuit, low reference circuit, and signal circuit to the BPP sensor. The BPP sensor sends a voltage signal to the ECM on the signal circuit. The voltage on the signal circuit will vary from a voltage greater than 0.25 V when the brake pedal is released to a voltage less than 4.75 V when the brake pedal is fully applied.

For information on the Stop Lamps side of the BPP Sensor, refer to Exterior Lighting Systems Description and Operation.

Conditions for Running the DTC

- Ignition voltage is greater than 10 V.
- DTC runs continuously when above condition is met.

Conditions for Setting the DTC

P057C

ECM detects the BPP sensor voltage is less than 0.25 V for 1 s.

P057D

ECM detects the BPP sensor voltage is greater than 4.75 V for 1 s.

Action Taken When the DTC Sets

- P057C and P057D are Type A DTCs.
- Engine torque is reduced to 50% of available engine torque during brake torque management.
- Brake torque management is active at 25 kPa (3.7 PSI) of brake apply pressure.

Conditions for Clearing the DTC

P057C and P057D are Type A DTCs

Reference Information

Schematic Reference

- Engine Controls Schematics
- Exterior Lights Schematics

Connector End View Reference

- Component Connector End Views
- Inline Harness Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

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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. Verify DTC P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

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

⇓ **If none of the DTCs are set**

2. Ignition ON, transmission in Park, and service brake pedal released.
3. Verify the scan tool Brake Pedal Position Sensor parameter in the ECM displays greater than 0.25 V.

⇒ **If 0.25 V or less**

Refer to Circuit/System Testing.

⇓ **If greater than 0.25 V**

4. Verify the scan tool Brake Pedal Position Sensor parameter voltage changes as the brake pedal is applied and displays less than 4.75 V when the brake pedal is fully applied.

⇒ **If the voltage does not change, or is greater than 4.74 V**

Refer to Circuit/System Testing.

⇓ **If the voltage changes and less than 4.75 V**

5. Verify the scan tool Brake Pedal Position Sensor Learned Release Position parameter is within 0.1 V of the Brake Pedal Position Sensor parameter when the brake pedal is fully released.

⇒ **If difference is greater than 0.1 V**

Perform the Brake Pedal Position Sensor Learn.

⇓ **If difference is 0.1 V or less**

6. Verify the Brake Pedal Position Sensor parameter transitions smoothly without any spikes or dropouts when slowly applying and releasing the brake pedal.

⇒ **If parameter does not transition smoothly or has spikes or dropouts**

Refer to Circuit/System Testing.

⇓ **If parameter transitions smoothly and there are no spikes or dropouts**

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

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

9. All OK.

Circuit/System Testing

Note: You must perform the Circuit/System Verification first.

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B22 Brake Pedal Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.

Note: All terminal references are for the vehicle harness brake pedal position sensor connector.

2. Test for less than 10 Ω between the low reference circuit terminal 5 and ground.

⇒ **If 10 Ω or greater**

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

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

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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 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**

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

4.2. Test for infinite resistance between the 5 V reference circuit and ground.

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

⇓ If infinite resistance.

4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

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

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

⇒ **If greater than 5.2 V**

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

4.2. Test for less than 1 V between the 5 V reference circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

5. Verify the scan tool Brake Pedal Position Sensor parameter is less than 0.25 V.

⇒ **If 0.25 V or greater**

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

5.2. Test for less than 0.25 V between the signal circuit terminal 4 and ground.

⇒ If 0.25 V or greater, repair the short to voltage on the circuit.

⇒ If less than 0.25 V, replace the K20 Engine Control Module.

⇓ **If less than 0.25 V**

6. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 6.
7. Verify the scan tool Brake Pedal Position Sensor parameter is greater than 4.8 V.

⇒ **If 4.8 V or less**

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

7.2. Test for infinite resistance between the signal circuit terminal 4 and ground.

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

⇓ If infinite resistance.

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

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

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

⇓ **If greater than 4.8 V**

8. Replace the B22 Brake Pedal Position Sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Brake Pedal Position Sensor Replacement

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- 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.

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DTC P057C or P057D (LFW w/RHD or LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P057C

Brake Pedal Position Sensor Circuit Low Voltage

DTC P057D

Brake Pedal Position Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Signal	P057C	P057C	P057D
5 V Reference	P057C	P057C	—
Low Reference	—	P057D	P057D

Typical Scan Tool Data

Brake Pedal Position Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON **Brake Pedal Position Sensor Parameter Normal Range:** 0.25–4.75 V			
5 V Reference	0 V	0 V	—
Signal	0 V	0 V	5 V
Low Reference	—	5 V	—

Circuit/System Description

The brake pedal position (BPP) sensor is part of the engine brake pedal override feature. The engine control module (ECM) continuously monitors the vehicle speed and the position of the brake pedal. These two main inputs, along with other ECM inputs are used to determine if the vehicle is decelerating at the proper speed and rate with the brake pedal applied. When the engine brake pedal override system is active, the ECM reduces engine torque to assist in reducing vehicle speed.

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The BPP sensor is a six wire sensor, and is part of a dual brake position sensor. One BPP Sensor is used for the stop lamps and the other BPP Sensor is used for the engine brake pedal override feature. The BPP Sensor for engine brake pedal override communicates with the ECM. The ECM supplies a 5 V reference circuit, low reference circuit, and signal circuit to the BPP sensor. The BPP sensor sends a voltage signal to the ECM on the signal circuit. The voltage on the signal circuit will vary from a voltage greater than 0.25 V when the brake pedal is released to a voltage less than 4.75 V when the brake pedal is fully applied.

For information on the Stop Lamps side of the BPP Sensor, refer to Exterior Lighting Systems Description and Operation.

Conditions for Running the DTC

- Ignition voltage is greater than 10 V.
- DTC runs continuously when above condition is met.

Conditions for Setting the DTC

P057C

BPP sensor voltage is less than 0.25 V for 1 second.

P057D

BPP sensor voltage is greater than 4.75 V for 1 second.

Action Taken When the DTC Sets

- DTCs P057C and P057D are type B DTCs
- Engine torque is reduced to 50 percent of available engine torque.
- Brake torque management is active at 25 kpa (3.7 PSI) of brake apply pressure.

Conditions for Clearing the DTC

P057C and P057D are type B DTCs.

Reference Information

Schematic Reference

- Engine Controls Schematics
- Exterior Lights Schematics

Connector End View Reference

- Component Connector End Views
- Inline Harness Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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Note: The Brake Pedal Position sensor scan tool data is located in the ECM automatic transmission data list.

1. Verify DTC P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

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

⇓ **If none of the DTCs are set**

2. Ignition ON, transmission in Park, and service brake pedal released.
3. Verify the scan tool Brake Pedal Position Sensor parameter in the ECM displays greater than 0.25 V.

⇒ **If 0.25 V or less**

Refer to Circuit/System Testing.

⇓ **If greater than 0.25 V**

4. Verify the scan tool Brake Pedal Position Sensor parameter voltage changes as the brake pedal is applied and displays less than 4.75 V when the brake pedal is fully applied.

⇒ **If the voltage does not change, or is greater than 4.74 V**

Refer to Circuit/System Testing.

⇓ **If the voltage changes and less than 4.75 V**

5. Verify the scan tool Brake Pedal Position Sensor Learned Release Position parameter is within 0.1 V of the Brake Pedal Position Sensor parameter when the brake pedal is fully released.

⇒ **If difference is greater than 0.1 V**

Perform the Brake Pedal Position Sensor Learn.

⇓ **If difference is 0.1 V or less**

6. Verify the Brake Pedal Position Sensor parameter transitions smoothly without any spikes or dropouts when slowly applying and releasing the brake pedal.

⇒ **If parameter does not transition smoothly or has spikes or dropouts**

Refer to Circuit/System Testing.

⇓ **If parameter transitions smoothly and there are no spikes or dropouts**

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

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

9. All OK.

Circuit/System Testing

Note: You must perform the Circuit/System Verification first.

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B22 Brake Pedal Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.

Note: All terminal references are for the vehicle harness brake pedal position sensor connector.

2. Test for less than 10 Ω between the low reference circuit terminal 6 and ground.

⇒ **If 10 Ω or greater**

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

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

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

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

⇓ **If less than 10 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 5 and ground.

⇒ **If less than 4.8 V**

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

4.2. Test for infinite resistance between the 5 V reference circuit and ground.

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

⇓ If infinite resistance.

4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

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

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

⇒ **If greater than 5.2 V**

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

4.2. Test for less than 1 V between the 5 V reference circuit and ground.

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

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

⇓ **If between 4.8–5.2 V**

5. Verify the scan tool BPP Sensor parameter is less than 0.25 V.

⇒ **If 0.25 V or greater**

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

5.2. Test for less than 0.25 V between the signal circuit terminal 4 and ground.

⇒ If 0.25 V or greater, repair the short to voltage on the circuit.

⇒ If less than 0.25 V, replace the K20 Engine Control Module.

⇓ **If less than 0.25 V**

6. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 5.
7. Verify the scan tool Brake Pedal Position Sensor parameter is greater than 4.8 V.

⇒ **If 4.8 V or less**

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

7.2. Test for infinite resistance between the signal circuit terminal 4 and ground.

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

⇓ If infinite resistance.

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

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

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

⇓ **If greater than 4.8 V**

8. Replace the B22 Brake Pedal Position Sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Brake Pedal Position Sensor Replacement

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- 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.

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DTC P0601-P0604, P0606, P062F, or P064A (Fuel Pump Control Module, LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0601

Control Module Read Only Memory (ROM)

DTC P0602

Control Module Not Programmed

DTC P0603

Control Module Long Term Memory Reset

DTC P0604

Control Module Random Access Memory (RAM)

DTC P0606

Control Module Internal Performance

DTC P062F

Control Module Long Term Memory Performance

DTC P064A

Fuel Pump Control Module Performance

Circuit/System Description

This diagnostic applies to internal microprocessor integrity conditions within the fuel pump control module (FPCM). This diagnostic also addresses if the FPCM is not programmed.

Conditions for Running the DTC

These DTCs run when the fuel pump control module is powered up.

Conditions for Setting the DTC

The fuel pump control module has detected an internal malfunction or incomplete programming.

Action Taken When the DTC Sets

- DTC P0601, P0602, P0603, P0604, P0606 and P062F are type A DTCs.
- DTC P064A is a Type B DTC.

Conditions for Clearing the DTC

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- DTC P0601, P0602, P0603, P0604, P0606 and P062F are type A DTCs.
- DTC P064A is a Type B DTC.

Reference Information

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing

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DTC P0601-P0604, P0606, P062B, P062F, P0630, P161C, P16F3, or P262B (ECM)

Diagnostic Instructions

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

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Conditions for Running the DTC

P0601, P0602, P0630, P161C

These DTCs run continuously when the ignition is ON.

P0603, P062F

These DTCs run at power up.

P0604

DTC P0604 runs continuously when the ignition is ON for greater than 30 s.

P0606, P062B

- The ignition is ON.
- System voltage is greater than 11 V.
- These DTCs run continuously when the above conditions are met.

P16F3

- The engine speed is greater than 600 RPM.
- DTCs P0101, P0102, P0103, P0106, P0107, P0108, P2227, P2228, P2229, or P2230 are not set.
- DTC P16F3 runs continuously when the above conditions are met.

P262B

DTC P262B runs on ECM power down.

Conditions for Setting the DTC

The ECM detects an internal failure or incomplete or incorrect programming.

Action Taken When the DTC Sets

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, P161C, and P16F3 are Type A DTCs.
- DTC P062F is a Type B DTC.
- DTC P262B is a Type C DTC.

Conditions for Clearing the DTC

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, P161C, and P16F3 are Type A DTCs.
- DTC P062F is a Type B DTC.
- DTC P262B is a Type C DTC.

Diagnostic Aids

Low voltage or a momentary loss of power or ground to the ECM may cause a DTC to set. Verify for 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

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Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON, observe the DTC information with a scan tool. Verify that DTC P0641, P0651, P0697, or P06A3 does not set.
   ⇒ If a DTC is set, refer to DTC P0641, P0651, P0697, or P06A3 for further diagnosis.
2. Observe the DTC information with a scan tool. DTC P0601, P0602, P0603, P0604, P0606, P062B, P062F, P0630, P161C, P16F3, or P262B should not set.
3. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Circuit/System Testing

1. Ignition ON, clear the DTC information with a scan tool.
2. Observe the scan tool DTC information. Verify that DTC P0602, P0630, or P161C does not set.
   ⇒ If DTC P0602, P0630, or P161C failed this ignition, reprogram the K20 Engine Control Module. Refer to Control Module References. If the DTC resets, replace the K20 Engine Control Module.
3. Observe the DTC information with a scan tool. Verify that DTC P0601, P0603, P0604, P0606, P062B, P062F, P16F3, or P262B does not set.
   ⇒ If a DTC failed this ignition, replace the K20 Engine Control Module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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

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DTC P0628 (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P0628

Fuel Pump Enable Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Fuel Pump Enable	P025A, P0628, P069E	P025A, P069E	P025A, P069E	—

Circuit/System Description

The Chassis Control Module receives fuel pressure information from the Fuel Tank Pressure Sensor and controls the operation of the Fuel Pump located within the fuel tank. The Chassis Control Module sends a 25 kHz PWM signal to the Fuel Pump. The pump speed is changed by varying the duty cycle of this signal. The Fuel Pump will be on if the fuel tank pressure is less than 490 kPa (71 psi) and off if the fuel tank pressure is greater than 510 kPa (74 psi). When the Fuel Pump is on the duty cycle will vary from 50% to 100% based on the fuel flow requirements.

Conditions for Running the DTC

- The engine speed is greater than 0 RPM.
- The ignition voltage is greater than 11 V.
- The DTCs run continuously when the conditions above are met.

Conditions for Setting the DTC

The Engine Control Module detects a short to ground on the Fuel Pump enable circuit for 2 s when the Fuel Pump enable circuit is commanded ON.

Action Taken When the DTC Sets

DTC P0628 is a Type B DTCs.

Conditions for Clearing the DTC

DTC P0628 is a Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

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Connector End View Reference

Component Connector End Views

Description and Operation

LPG 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. Attempt to start the engine.
2. Verify DTC P0628 is not set.

⇒ **If DTC P0628 is set**

Refer to Circuit/System Testing.

⇓ **If DTC P0628 is not set**

3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify DTC P0628 is not set.

⇒ **If DTC P0628 is set**

Refer to Circuit/System Testing.

⇓ **If DTC P0628 is not set**

5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF. Disconnect the K38 Chassis Control Module harness connector. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 1 V on the enable circuit terminal 20 of the K38 Chassis Control Module.

⇒ **If 1 V or greater**

2.1. Disconnect the X2 harness connector at the K20 Engine Control Module.

2.2. Ignition ON.

2.3. Test for less than 1 V on the enable circuit terminal 20 of the K38 Chassis Control Module.

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

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

⇓ **If less than 1 V**

3. Ignition ON, command the Fuel Pump Enable ON with a scan tool.
4. Verify battery voltage on the enable circuit terminal 20 of the K38 Chassis Control Module.

⇒ **If less than the specified range**

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4.1. Disconnect the X2 harness connector at the K20 Engine Control Module.
4.2. Test for infinite resistance between the enable circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
4.3. Test for less than 2 Ω on the enable circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance on the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If within the specified range**

5. Ignition ON.
6. Test for 2–3 V on the enable circuit terminal 20 of the K38 Chassis Control Module.

⇒ **If not within the specified range**
Replace the K20 Engine Control Module.

⇓ **If within the specified range**

7. Test or replace the K38 Chassis Control Module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Control Module References for K20 Engine Control Module or K38 Chassis Control Module programming, replacement, and setup.

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DTC P0628 (LFW, LFX)

Diagnostic Instructions

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

DTC Descriptor

DTC P0628

Fuel Pump Enable Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0171, P0506, P0628, P12A6	P0171, P0506, P12A6	—	P12A6

Circuit/System Description

The Engine Control Module (ECM) provides ignition voltage to the Fuel Pump Driver Control Module whenever the engine is cranking or running. The Engine Control Module enables the Fuel Pump Driver Control Module as long as the engine is cranking or running, and ignition system reference pulses are received. While this enable voltage is being received, the Fuel Pump Driver Control Module supplies a varying voltage to the Fuel Tank Fuel Pump Module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

- The engine speed is greater than 0 RPM.
- The ignition voltage is greater than 11 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

The 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 2 s.

Action Taken When the DTC Sets

DTC P0628 is a Type C DTC.

Conditions for Clearing the DTC

DTC P0628 is a Type C DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

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Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0628 is not set.

⇒ **If the DTC is set**

Refer to Circuit/System Testing.

⇓ **If the DTC is not set**

3. Verify the parameters listed below do not display Malfunction when commanding the Fuel Pump Enable On and Off with a scan tool.
   - Fuel Pump Enable Circuit Low Voltage Test Status
   - Fuel Pump Enable Circuit Open Test Status
   - Fuel Pump Enable Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

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

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle system OFF, disconnect the K111 Fuel Pump Driver Control Module harness connector. It may take up to 2 minutes for all vehicle systems to power down.
2. Ignition ON for 10 s.
3. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.

⇒ **If the test lamp illuminates**

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

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

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

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

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

4. Remove the test lamp.

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

⇒ **If OK is not displayed**

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

5.2. Test for infinite resistance between the control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the K20 Engine Control Module.

⇓ **If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal 2 and ground.

7. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is Malfunction when commanding the Fuel Pump Enable On with a scan tool.

⇒ **If Malfunction is not displayed**

7.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.

7.2. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If Malfunction is displayed**

8. Replace the K111 Fuel Pump Driver Control Module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Control Module References for K20 Engine Control Module or K111 Fuel Pump Driver Control Module programming, replacement, and setup.

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DTC P0641, P0651, P0697, or P06A3 (ECM)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P0641

5V Reference 1 Circuit

DTC P0651

5V Reference 2 Circuit

DTC P0697

5V Reference 3 Circuit

DTC P06A3

5V Reference 4 Circuit

Circuit/System Description

The engine control module (ECM) has 4 internal 5V reference circuits. Each internal reference circuit provides an external 5V reference circuit 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 ignition voltage is greater than 6.4 V.

Conditions for Setting the DTC

The 5V reference circuit voltage is greater or less than a predetermined threshold.

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 following sensors:

- Fuel tank pressure sensor (LFW/LFX)
- Mass air flow/intake air temperature sensor (LFW/LFX)
- Throttle inlet absolute pressure sensor (LWR)
- Fuel rail pressure sensor

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- Air conditioning (A/C) refrigerant pressure sensor
- All four camshaft position sensors

P0651

The 5V reference 2 circuit provides 5 V to the following sensors:

- Crankshaft position sensor
- Brake pedal position sensor
- Clutch pedal position sensor, if equipped (LFW/LFX)

P0697

The 5V reference 3 circuit provides 5 V to the following sensors:

- Manifold absolute pressure sensor
- Accelerator pedal position sensor 2

P06A3

The 5V reference 4 circuit provides 5 V to the following sensors:

- 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

Connector End View Reference

Component Connector End Views

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON, observe the DTC information with a scan tool. DTC P0641, P0651, P0697, or P06A3 should not set.
2. Observe the circuit status parameters listed below:
    - 5V Reference 1 Circuit Status
    - 5V Reference 2 Circuit Status

- 5V Reference 3 Circuit Status
- 5V Reference 4 Circuit Status

Each parameter should display OK.

3. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Circuit/System Testing

Note: Additional DTCs will set when disconnecting the components.

1. Ignition OFF, disconnect the harness connector of all appropriate sensors for the applicable DTC. Refer to Diagnostic Aids.
2. Ignition ON, test for 4.8–5.2 V between one of the affected 5V reference circuits and ground.
   - ⇒ If less than the specified range, test for a short to ground on the 5V reference circuit for each affected component. If all circuits test normal, replace the K20 ECM.
   - ⇒ If greater than the specified range, test for a short to voltage on the 5V reference circuit for each affected component. If all circuits test normal, replace the K20 ECM.

   Note: A short to voltage on the signal circuit of certain components may cause this DTC to set.
3. Connect each component associated with the affected 5 V reference circuit one at a time while monitoring the appropriate scan tool 5V Reference 1, 2, 3, or 4 parameter. The parameter should display 4.8–5.2 V.
   - ⇒ If not within the specified range 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.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Accelerator Pedal Position Sensor Replacement
- Air Conditioning (A/C) Refrigerant Pressure Sensor Replacement
- Brake Pedal Position Sensor Replacement
- Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake
- Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust
- Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake
- Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust
- Clutch Pedal Position Switch Replacement
- Crankshaft Position Sensor Replacement
- Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail
- Manifold Absolute Pressure Sensor Replacement
- Mass Airflow Sensor with Intake Air Temperature Sensor Replacement
- Throttle Body Assembly Replacement
- Throttle Inlet Absolute Pressure Sensor Replacement
- Control Module References for engine control module replacement, setup, and programming

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DTC P0650, P263A, or P263B

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptor

DTC P0650

Malfunction Indicator Lamp (MIL) Control Circuit

DTC P263A

Malfunction Indicator Lamp (MIL) Control Circuit Low

DTC P263B

Malfunction Indicator Lamp (MIL) Control Circuit High

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0650	P0650	—	—
Control	P0650, P263A*	P0650, P263A	P263B	—
* The MIL remains ON				

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 DTC P263A

The ECM detects low voltage during the MIL control circuit driver OFF state. This indicates either a shorted to ground or an open MIL control circuit.

DTC P263B

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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
- Instrument Cluster Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
    - The MIL Control Circuit Low Voltage Test Status
    - The MIL Control Circuit Open Test Status
    - The MIL Control Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

3. Engine running.
4. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.

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- The MIL Control Circuit Low Voltage Test Status
- The MIL Control Circuit Open Test Status
- The MIL Control Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

5. Verify the malfunction indicator lamp turns ON and OFF when commanding the Malfunction Indicator Lamp On and Off with a scan tool.

⇒ **If the malfunction indicator lamp does not turn ON and OFF**

Refer to Circuit/System Testing.

⇓ **If the malfunction indicator lamp turns ON and OFF**

6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

⇒ **If the DTC sets**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle for further diagnosis.

⇓ **If the DTC does not set**

7. All OK.

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON, verify the malfunction indicator lamp does not illuminate.

⇒ **If the malfunction indicator lamp illuminates**

3.1. Test for infinite resistance between the control circuit terminal X1 46 and ground.

⇒ If less than infinite resistance, repair the short to ground in the circuit.

⇒ If infinite resistance, replace the P16 Instrument Cluster.

⇓ **If the malfunction indicator lamp does not illuminate**

4. Connect a 3 A fused jumper wire between the control circuit terminal X1 46 and ground.
5. Verify the malfunction indicator lamp illuminates.

⇒ **If the malfunction indicator lamp illuminates**

Replace the K20 Engine Control Module.

⇒ **If the malfunction indicator lamp does not illuminate**

5.1. Test for less than 1 V between the control circuit terminal X1 46 and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇓ If less than 1 V

5.2. Ignition OFF.

5.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ If less than 2 Ω.

6. Ignition OFF, disconnect the harness connector at the instrument cluster.
7. Ignition ON, verify a test lamp illuminates between the ignition voltage circuit terminal 10 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

7.1. Ignition OFF.

7.2. Test for infinite resistance between the ignition voltage circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

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⇒ **If the test lamp does not illuminate and the circuit fuse is good**

7.1. Ignition OFF.

7.2. Test for less than 2 Ω in the ignition voltage circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ **If the test lamp illuminates**

8. Replace the P16 Instrument Cluster.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Instrument Cluster Replacement
- Control Module References for control module replacement, programming, and setup

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DTC P0685-P0687, P0689, P0690, or P1682

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P0685

Engine Controls Ignition Relay Control Circuit

DTC P0686

Engine Controls Ignition Relay Control Circuit Low Voltage

DTC P0687

Engine Controls Ignition Relay Control Circuit High Voltage

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

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			

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Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: The following illustrates the normal parameter state with no circuit conditions: • Component OFF – OK for Open/Low Voltage test 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.

P1682

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- 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

- DTC P1682 is a Type A DTC.
- DTCs P0685, P0686, P0687, P0689, and P0690 are Type C DTCs.

Conditions for Clearing the DTC

- DTC P1682 is a Type A DTC.
- DTCs P0685, P0686, P0687, P0689, and P0690 are Type C DTCs.

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 1 relay, the ignition run relay, or the ignition relay.

Reference Information

Schematic Reference

- Engine Controls Schematics
- Power Distribution Schematics

Connector End View Reference

Component Connector End Views

Component View Reference

Powertrain Component Views

Electrical Information Reference

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- Circuit Testing
- Connector Repairs
- Electrical Center Identification Views
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

Note:
- A short to voltage on other components may cause DTC P0690 to set. If other DTCs are set, diagnose those DTCs first.
- If you were sent here from Engine Cranks But Does Not Run proceed to Circuit/System Testing.

1. Ignition ON, observe the DTC information with a scan tool. DTC P0685, P0686, P0687, P0689, P0690, or P1682 should not set.
2. Ignition ON, observe the scan tool Ignition 1 Voltage Signal and the Engine Controls Ignition Relay Feedback Signal parameters. There should be less than 3 V difference between the two parameters.
3. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Circuit/System Testing

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 that a test lamp illuminates between ground and the relay circuit terminals listed below:
   - Terminal 85
   - Terminal 30

   ⇒ If the test lamp does not illuminate, test the relay battery voltage circuit for an open/high resistance.

   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.
3. Ignition ON, verify that a test lamp does not illuminate between the ignition voltage circuit terminal 87 and ground.

   ⇒ If the test lamp illuminates, test the ignition voltage circuit for a short to voltage.
4. Connect a 20 A fused jumper wire between the relay switch B+ circuit terminal 30 and the relay switch ignition voltage circuit terminal 87.
5. Ignition ON, observe the scan tool Engine Controls Ignition Relay Feedback Signal parameter. The K20 Engine Control Module should communicate, and the parameter should display B+.

   ⇒ If not the specified value, or the K20 Engine Control Module does not communicate, test the ignition voltage circuit between the engine control module relay and the K20 Engine Control Module for a short to ground or for an open/high resistance. If the circuit/connections test normal, replace the K20 Engine Control Module.

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6. Ignition OFF, connect a DMM set to the diode setting between control circuit terminal 86 and ground. Verify the DMM displays OL.
   ⇒ If not the specified value, test the control circuit for a short to ground. If the circuit tests normal, replace the K20 Engine Control Module.
7. Ignition ON, verify the DMM displays less than 1 V.
   ⇒ If not the specified range, test the control circuit for a short to voltage, or an open/high resistance. If the circuit tests normal, replace the K20 Engine Control Module.
8. If all circuits test normal, replace the KR75 Engine Controls Ignition Relay.

Component Testing

1. Remove the KR75 Engine Controls Ignition Relay.

   Note: Depending on the application, the relay coil resistance will be within one of the following ranges.
2. Test for one of the following resistance specifications between terminals 85 and 86 of the relay:
   - 70–110 Ω
   - 200–250 Ω

   ⇒ If not within the specified range, replace the relay.
3. Test for infinite resistance between the following terminals of the relay:
   - 30 and 86
   - 30 and 87
   - 30 and 85
   - 85 and 87

   ⇒ If not the specified value, replace the relay.
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. Test for less than 2 Ω between terminals 30 and 87.
   ⇒ If greater than the specified range, replace the relay.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Relay Replacement
- Control Module References for Engine Control Module replacement, programming, and setup.

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DTC P069E

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle Prior to using 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 P069E

Fuel Pump Control Module Requested MIL Illumination

Circuit/System Description

The fuel pump control module constantly monitors the fuel pump control system for any condition which may adversely affect vehicle emissions. If a condition is detected, the fuel pump control module sets a DTC and sends a serial data message to the engine control module (ECM). The ECM sets DTC P069E to inform the technician that the fuel pump control module has set the emission related DTC. The serial data message sent by the fuel pump control module also contains a request for the ECM to illuminate the malfunction indicator lamp (MIL).

The technician can observe the DTC that was set by the fuel pump control module by reviewing the ECM Freeze Frame records on the scan tool. The ECM Freeze Frame records also contain the engine operating conditions present when the fuel pump control module DTC set.

Conditions for Running the DTC

The ignition is ON, or the engine is running for greater than 3 s.

Conditions for Setting the DTC

The ECM receives a serial data message from the fuel pump control module indicating that an emission related DTC has set in the fuel pump control module.

Action Taken When the DTC Sets

- DTC P069E is a Type A DTC.
- DTC P069E will continue to be current or active as long as the fuel pump control module is requesting MIL illumination.

Conditions for Clearing the DTC

DTC P069E is a Type A DTC.

Diagnostic Aids

Communication codes, U-codes, as well as powertrain codes, P-codes, set in the fuel pump control module will cause the fuel pump control module to request DTC P069E to be set in the ECM.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

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Control Module References for scan tool information

Circuit/System Verification

Note:

- Do not replace the engine control module for this DTC. DTC P069E is an informational DTC.
- Correct any engine control and communication DTCs before diagnosing fuel pump control module DTCs.

1. Verify there are no engine control or communication DTCs set.

⇒ **If a DTC is set**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If a DTC is not set**

2. Verify there are no fuel pump control module DTCs set.

⇒ **If a DTC is set**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If a DTC is not set**

3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If the DTC does not set**

5. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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DTC P0700

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each of the diagnostic category.

DTC Descriptor

DTC P0700

Transmission Control Module Requested MIL Illumination

Circuit/System Description

The transmission control module (TCM) constantly monitors the transmission system for any condition which may adversely affect vehicle emissions. If a condition is detected, the TCM sets a DTC and sends a serial data message to the engine control module (ECM). The ECM sets DTC P0700 to inform the technician that the TCM has set the emission related DTC. The serial data message sent by the TCM also contains a request for the ECM to illuminate the malfunction indicator lamp (MIL).

The technician can observe the DTC that was set by the TCM by reviewing the ECM Freeze Frame records on the scan tool. The ECM Freeze Frame records also contain the engine operating conditions present when the transmission DTC set.

Conditions for Running the DTC

- The ignition is ON or the engine is operating.
- DTC P0700 runs continuously.

Conditions for Setting the DTC

The ECM receives a serial data message from the TCM indicating that an emission related DTC has set in the TCM.

Action Taken When the DTC Sets

DTC P0700 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P0700 is a Type A DTC.

Diagnostic Aids

Communication codes, U-codes, as well as powertrain codes, P-codes, set in the TCM can cause the TCM to request DTC P0700 to be set in the ECM.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

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Circuit/System Verification

Note:

- Do not replace the engine control module for this DTC. DTC P0700 is an informational DTC.
- Correct any engine controls and communication DTCs before diagnosing transmission control module DTCs.

1. Verify there are no engine control or communication DTCs set.

⇒ **If a DTC is set**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If a DTC is not set**

2. Verify there are no transmission control module DTCs set.

⇒ **If a DTC is set**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If a DTC is not set**

3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If the DTC does not set**

5. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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DTC P121D, P121E, or P2687 (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P2687

Fuel Heater Relay 1 Control Circuit

DTC P121D

Fuel Heater Relay 2 Control Circuit

DTC P121E

Fuel Heater Relay 3 Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
LPG Vaporizer Relay 1 Coil Control	P2687	P2687	—	—
LPG Vaporizer Relay 2 Relay Coil Control	P121D	P121D, P2687	—	—
LPG Vaporizer Relay 3 Relay Coil Control	P121E	P121E	—	—
LPG Vaporizer Relay 1 Ignition Voltage	—	P2687	—	—
LPG Vaporizer Relay 2 Ignition Voltage	—	P121D	—	—
LPG Vaporizer Relay 3 Ignition Voltage	—	P121E	—	—

Circuit/System Description

The fuel injector control module provides a separate ground for each of the 3 LPG vaporizer relays. The fuel injector control module monitors each control circuit for an open, short to ground, short to voltage, or an overloaded condition.

Conditions for Running the DTC

- The ignition is ON.
- DTC P15AE or P15AF is not set.

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- The DTCs run continuously when the above conditions are met for greater than 3 s.

Conditions for Setting the DTC

P2687

- The fuel injector control module detects an open or a short to ground on the LPG vaporizer relay 1 control circuit for 2 s when the LPG vaporizer relay 1 is commanded OFF.
- The fuel injector control module detects a short to voltage on the LPG vaporizer relay 1 control circuit for 2 s when the LPG vaporizer relay 1 is commanded ON.

P121D

- The fuel injector control module detects an open or a short to ground on the LPG vaporizer relay 2 control circuit for 2 s when the LPG vaporizer relay 2 is commanded OFF.
- The fuel injector control module detects a short to voltage on the LPG vaporizer relay 2 control circuit for 2 s when the LPG vaporizer relay 2 is commanded ON.

P121E

- The fuel injector control module detects an open or a short to ground on the LPG vaporizer relay 3 control circuit for 2 s when the LPG vaporizer relay 3 is commanded OFF.
- The fuel injector control module detects a short to voltage on the LPG vaporizer relay 3 control circuit for 2 s when the LPG vaporizer relay 3 is commanded ON.

Action Taken When the DTC Sets

DTC P2687, P121D, and P121E are Type A DTCs

Conditions for Clearing the DTC

DTC P2687, P121D, and P121E are Type A DTCs

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG 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

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1. Ignition ON.
2. Verify that each LPG vaporizer relay turns on & off when commanding each LPG Vaporizer Heater ON and OFF with a scan tool.

⇒ **If the LPG vaporizer relay does not turn on & off**

Refer to Circuit/System Testing

⇓ **If the LPG vaporizer relay turns on & off**

3. Verify DTC P2687, P121D, or P121E is not set

⇒ **If DTC P2687, P121D, or P121E is set**

Refer to Circuit/System Testing

⇓ **If DTC P2687, P121D, or P121E is not set**

4. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify DTC P2687, P121D, or P121E does not set.

⇒ **If DTC P2687, P121D, or P121E is set**

Refer to Circuit/System Testing

⇓ **If DTC P2687, P121D, or P121E is not set**

6. All OK

Circuit/System Testing

1. Ignition OFF, disconnect the appropriate LPG vaporizer relay.
2. Connect a test lamp between the control circuit terminal and ground.
3. With a scan tool command the appropriate LPG Vaporizer Heater ON and OFF. Verify the test lamp turns ON and OFF with each command.

⇒ **If the test lamp is always ON**

3.1. Ignition OFF, disconnect the harness connector at the K103 fuel injector control module. Ignition ON.

3.2. Test for less than 1 V between the appropriate LPG vaporizer relay control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K103 fuel injector control module.

⇒ **If the test lamp is always OFF**

3.1. Ignition OFF.

3.2. Test for less than 2 Ω in the appropriate LPG vaporizer relay control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ If less than 2 Ω.

3.3. Disconnect the harness connector at the K103 fuel injector control module.

3.4. Test for infinite resistance between the appropriate LPG vaporizer relay control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the K103 fuel injector control module.

⇓ **If the test lamp turns ON and OFF**

4. Connect a test lamp between the appropriate control circuit terminal and the relay ground circuit terminal. Ignition ON.
5. With a scan tool command the appropriate LPG Vaporizer Heater ON and OFF. Verify the test lamp turns ON and OFF with each command.

⇒ **If the test lamp does not turn ON and OFF**

5.1. Ignition OFF.

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5.2. Test for less than 2 Ω in the appropriate LPG vaporizer relay ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ **If the test lamp turns ON and OFF**

6. Test or replace the appropriate LPG vaporizer relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the appropriate LPG vaporizer relay.
2. Test for 70–110 Ω between terminals 85 and 86.

⇒ **If less than 70 Ω or greater than 110 Ω**

Replace the relay.

⇓ **If between 70–110 Ω**

3. Test for infinite resistance between the terminals listed below:
   - 30 and 86
   - 30 and 87
   - 30 and 85
   - 85 and 87

⇒ **If less than infinite resistance**

Replace the relay.

⇓ **If infinite resistance**

4. Install a 3 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 5 Ω between terminals 30 and 87.

⇒ **If 10 Ω or greater**

Replace the relay.

⇓ **If less than 5 Ω**

6. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Fuel Injector Control Module Replacement

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DTC P1248-P124D (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P1248

Injector 1 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P1249

Injector 2 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P124A

Injector 3 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P124B

Injector 4 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P124C

Injector 5 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P124D

Injector 6 Positive Voltage Control Circuit Shorted to Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Supply Cylinder 1	P2147	P0201	P2148	P1248
Direct Fuel Injector High Voltage Control Cylinder 1	P0261	P0201	P0262	P1248
Direct Fuel Injector High Voltage Supply Cylinder 2	P2150	P0202	P2151	P1249
Direct Fuel Injector High Voltage Control Cylinder 2	P0264	P0202	P0265	P1249
Direct Fuel Injector High Voltage Supply Cylinder 3	P2153	P0203	P2154	P124A

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Control Cylinder 3	P0267	P0203	P0268	P124A
Direct Fuel Injector High Voltage Supply Cylinder 4	P2156	P0204	P2157	P124B
Direct Fuel Injector High Voltage Control Cylinder 4	P0270	P0204	P0271	P124B
Direct Fuel Injector High Voltage Supply Cylinder 5	P216B	P0205	P216C	P124C
Direct Fuel Injector High Voltage Control Cylinder 5	P0273	P0205	P0274	P124C
Direct Fuel Injector High Voltage Supply Cylinder 6	P216E	P0206	P216F	P124D
Direct Fuel Injector High Voltage Control Cylinder 6	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 fuel injector high voltage control circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- DTC P062B is not set.
- The engine is running.
- The ignition voltage is greater than 11 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects the injector high voltage supply circuit is shorted to the injector high voltage control circuit for greater than 1 s.

Action Taken When the DTC Sets

DTCs P1248, P1249, P124A, P124B, P124C, and P124D are Type A DTCs.

Conditions for Clearing the DTC

DTCs P1248, P1249, P124A, P124B, P124C, and P124D are Type A DTCs.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to Fuel Injector Solenoid Coil Test.

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- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Injector Circuit Status parameters. An Injector Circuit Status parameter will change from OK or Not Running to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG 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 DTC P0685 or P1682 are not set.

⇒ **If DTC P0685 or P1682 are set**
Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If DTC P0685 or P1682 are not set**

3. Engine operating.
4. Verify DTC P1248, P1249, P124A, P124B, P124C, or P124D are not set.

⇒ **If any of the specified DTCs are set**
Refer to Circuit/System Testing

⇓ **If none of the specified DTCs are set**

5. Ignition ON.
6. Verify the scan tool Cylinder 1–6 Injector Circuit Status parameters display OK.

⇒ **If the Cylinder 1–6 Injector Circuit Status parameters do not display OK**
Refer to Circuit/System Testing

⇓ **If the Cylinder 1–6 Injector Circuit Status parameters display OK**

7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
8. Verify DTC P1248, P1249, P124A, P124B, P124C, or P124D are not set.

⇒ **If any of the specified DTCs are set**
Refer to Circuit/System Testing

⇓ **If none of the specified DTCs are set**

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9. All OK

Circuit/System Testing

1. Ignition OFF, disconnect the X160 engine harness to fuel injector harness connector. Ignition ON.
2. Verify the appropriate scan tool Cylinder 1–6 Injector Circuit Status parameter displays Open.

⇒ **If the appropriate scan tool Cylinder 1–6 Injector Circuit Status parameter does not display Open.**

2.1. Ignition OFF, disconnect the X3 harness connector at the K20 engine control module.

2.2. Test for infinite resistance between the appropriate high voltage supply circuit, ECM side and ground.

⇒ If less than infinite, repair the short to ground on the circuit.

⇓ If infinite resistance

2.3. Ignition ON.

2.4. Test for less than 1 V between the appropriate high voltage control circuit, ECM side 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 appropriate scan tool Cylinder 1–6 Injector Circuit Status parameter displays Open.**

3. Ignition ON, connect a test lamp between the appropriate high voltage supply circuit and the high voltage control circuit.
4. Verify the Injector Circuit Status parameter transitions from Open to OK.

⇓ **If the Injector Circuit Status parameter does not transition from Open to OK.**

4.1. Ignition OFF, disconnect the X3 harness connector at the K20 engine control module.

4.2. Test for infinite resistance between the appropriate high voltage supply circuit, ECM side and ground.

⇒ If less than infinite, repair the short to ground on the circuit.

⇓ If infinite resistance

4.3. Test for less than 2 Ω on the appropriate high voltage supply circuit, ECM side end to end.

⇒ If 2 Ω or greater, repair open/high resistance in the circuit.

⇓ If less than 2 Ω

4.4. Test for infinite resistance between the appropriate high voltage control circuit, ECM side and ground.

⇒ If less than infinite, repair the short to ground on the circuit.

⇓ If infinite resistance

4.5. Test for less than 2 Ω on the appropriate high voltage control circuit, ECM side end to end.

⇒ If 2 Ω or greater, repair open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 engine control module.

⇓ **If the Injector Circuit Status parameter transitions from Open to OK.**

Note: Testing for the following steps is performed on the fuel injector side of the multi-way harness connector. It may be necessary to remove the intake manifold to isolate the condition.

5. Ignition OFF.
6. Test for infinite resistance between the appropriate high voltage supply circuit and ground.

⇒ **If less than infinite resistance**

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6.1. Disconnect the harness connector at the appropriate Q17 fuel injector.

6.2. Test for infinite resistance between the appropriate high voltage supply circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

6.3. Test for infinite resistance between the appropriate high voltage control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, test or replace the appropriate Q17 fuel injector.

⇓ **If infinite resistance**

7. Test for 1.5-2.5 Ω between the appropriate high voltage supply circuit and high voltage control circuit.

⇒ **If less than the specified range**

7.1. Disconnect the harness connector at the appropriate Q17 fuel injector.

7.2. Test for infinite resistance between the appropriate high voltage supply circuit and high voltage control circuit.

⇒ If less than infinite resistance, repair the short on the circuits.

⇒ If infinite resistance, replace the appropriate Q17 fuel injector.

⇒ **If greater than the specified range**

7.1. Disconnect the harness connector at the appropriate Q17 fuel injector.

7.2. Test for less than 2 Ω on appropriate high voltage supply circuit end to end

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit

⇓ If less than 2 Ω

7.3. Test for less than 2 Ω on appropriate high voltage 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 appropriate Q17 fuel injector.

⇓ **If within the specified range**

8. Preform the Fuel Injector Solenoid Coil Test.

Component Testing

Fuel Injector Solenoid Coil Test

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel Injector and Fuel Rail Replacement
- Control Module References for engine control module replacement, programming, and setup.

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DTC P1248-P124D (LFW, LFX)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P1248

Injector 1 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P1249

Injector 2 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P124A

Injector 3 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P124B

Injector 4 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P124C

Injector 5 Positive Voltage Control Circuit Shorted to Control Circuit

DTC P124D

Injector 6 Positive Voltage Control Circuit Shorted to Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Supply Cylinder 1	P2147	P0201	P2148	P1248
Direct Fuel Injector High Voltage Control Cylinder 1	P0261	P0201	P0262	P1248
Direct Fuel Injector High Voltage Supply Cylinder 2	P2150	P0202	P2151	P1249
Direct Fuel Injector High Voltage Control Cylinder 2	P0264	P0202	P0265	P1249
Direct Fuel Injector High Voltage Supply Cylinder 3	P2153	P0203	P2154	P124A

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Control Cylinder 3	P0267	P0203	P0268	P124A
Direct Fuel Injector High Voltage Supply Cylinder 4	P2156	P0204	P2157	P124B
Direct Fuel Injector High Voltage Control Cylinder 4	P0270	P0204	P0271	P124B
Direct Fuel Injector High Voltage Supply Cylinder 5	P216B	P0205	P216C	P124C
Direct Fuel Injector High Voltage Control Cylinder 5	P0273	P0205	P0274	P124C
Direct Fuel Injector High Voltage Supply Cylinder 6	P216E	P0206	P216F	P124D
Direct Fuel Injector High Voltage Control Cylinder 6	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 fuel injector high voltage control circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- The engine is running.
- The ignition voltage is between 11–18 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

The engine control module detects the fuel injector high voltage supply circuit is shorted to the fuel injector high voltage control circuit for greater than 2 s.

Action Taken When the DTC Sets

DTCs P1248, P1249, P124A, P124B, P124C, and P124D are Type A DTCs.

Conditions for Clearing the DTC

DTCs P1248, P1249, P124A, P124B, P124C, and P124D are Type A DTCs.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to Fuel Injector Solenoid Coil Test.

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- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Cylinder 1–6 Injector Circuit Status parameters. An Injector Circuit Status parameter will change from OK or Not Run to Fault if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0685 or P1682 is not set.

⇒ **If DTC P0685 or P1682 is set**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If DTC P0685 or P1682 is not set**

3. Engine idling.
4. Verify the scan tool Cylinder 1–6 Injector Control Circuit Status parameters display OK.

⇒ **If any parameters do not display OK**

Refer to Circuit/System Testing.

⇓ **If all parameters display OK**

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 P1248, P1249, P124A, P124B, P124C, or P124D does not set.

⇒ **If any DTC sets**

Refer to Circuit/System Testing.

⇓ **If no DTC sets**

7. All OK.

Circuit/System Testing

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1. Ignition OFF and all vehicle systems OFF, disconnect the appropriate multi-way harness connector X160 or X161, at the rear of the intake manifold, ignition ON. It may take up to 2 min for all vehicle systems to power down.
2. Verify the scan tool Cylinder 1–6 Injector Control Circuit Status parameters display Open.

⇒ **If Open is not displayed**

2.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

Note: Test on the engine control module side of the multi-way harness connector.

2.2. Test for infinite resistance between the appropriate Q17 Fuel Injector high voltage supply circuit and high voltage control circuit.

⇒ If less than infinite, repair the short between the circuits.

⇒ If infinite resistance, replace the K20 Engine Control Module.

⇓ **If Open is displayed**

Note: Testing for the following steps is performed on the fuel injector side of the multi-way harness connector. It may be necessary to remove the intake manifold to isolate the condition.

3. Ignition OFF, disconnect the harness connector at the appropriate Q17 Fuel Injector.
4. Test for infinite resistance between the appropriate Q17 Fuel Injector high voltage supply circuit and high voltage control circuit.

⇒ **If less than infinite resistance**

Repair the short between the circuits.

⇓ **If infinite resistance**

5. Test or replace the appropriate Q17 Fuel Injector.

Component Testing

- Fuel Injector Solenoid Coil Test
- Fuel Injector Balance Test

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Injection Fuel Rail Assembly Replacement - Bank 1
- Fuel Injection Fuel Rail Assembly Replacement - Bank 2
- Control Module References for K20 Engine Control Module replacement, programming, and setup.

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DTC P1255

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P1255

Fuel Pump Control Module Driver Overtemperature

Circuit/System Description

The engine control module (ECM) supplies voltage to the chassis control module when the ECM detects that the ignition is on. The voltage from the ECM to the chassis control module remains active for 2 seconds, unless the engine is in crank or run. While this voltage is being received, the chassis control module supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel pressure.

Conditions for Running the DTC

- The ignition voltage is greater than 9 V.
- The engine is cranking or running.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

The chassis control module detects a driver temperature greater than 302°F (150°C) for less than 0.5 s.

Action Taken When the DTC Sets

DTC P1255 is a Type B DTC.

Conditions for Clearing the DTC

DTC P1255 is a Type B DTC.

Diagnostic Aids

Using the Failure Records data may help locate an intermittent condition. If you cannot duplicate the DTC, the information in the Failure Records can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can help determine how many ignition cycles that the diagnostic test reported a pass and/or a fail.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

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Fuel System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0231, P0232, or P023F is not set.

⇒ **If any of the DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If none of the DTCs are set**

3. Verify that the area where the K38 Chassis Control Module is located is free of debris, clutter, or any insulating material that would cause the K38 Chassis Control Module to overheat.

⇒ **If any debris, clutter, or other material is found**

3.1. Clear the area where the K38 Chassis Control Module is located.

3.2. Clear the DTC and test drive the vehicle.

3.3. Verify DTC P1255 is not set.

⇒ If DTC P1255 is set, replace the K38 Chassis Control Module.

⇓ If DTC P1255 is not set

3.4. All OK.

⇓ **If no debris, clutter, or other material is found**

4. Clear the DTC and test drive the vehicle.
5. Verify DTC P1255 is not set.

⇒ **If DTC P1255 is set**

Replace the K38 Chassis Control Module.

⇓ **If DTC P1255 is not set**

6. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Control Module References for K38 Chassis Control Module programming, replacement, and setup.

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DTC P129B or P129C

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P129B

Fuel Pump Driver Control Module System Voltage Low

DTC P129C

Fuel Pump Driver Control Module System Voltage High

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
B+	P018B, P0506, P129B, P2635, U18A2	P018B, P0506, P129B, P2635, U18A2	P129C

Circuit/System Description

The Fuel Pump Driver Control Module monitors the battery positive voltage circuit to verify the voltage is between the normal operating range. The DTC can set for a circuit or system voltage out of range.

Conditions for Running the DTC

P129B

- The engine is running.
- The ignition voltage is greater than 7 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

P129C

- The engine is not running.
- The ignition voltage is greater than 7 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

P129B

The Fuel Pump Driver Control Module detects the battery positive voltage is less than 7 V for 1 s.

P129C

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The Fuel Pump Driver Control Module detects the battery positive voltage is greater than 18 V for 1 s.

Action Taken When the DTC Sets

DTCs P129B and P129C are Type C DTCs.

Conditions for Clearing the DTC

DTCs P129B and P129C are Type C DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Electrical Center Identification Views
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition OFF.
2. Test for 12.4–12.8 V at the battery terminals and record the reading. The battery voltage should stabilize after a few minutes of turning the ignition OFF.

⇒ **If not between 12.4 V–12.8 V**

Refer to Battery Inspection/Test.

⇓ **If between 12.4 V–12.8 V**

3. Engine running, accessories OFF.
4. Test for 13.4–15 V at the battery terminals and record the reading.

⇒ **If not between 13.4–15 V**

Refer to Charging System Test.

⇓ **If between 13.4–15 V**

5. Verify the Engine Control Module scan tool Ignition 1 Signal voltage parameter is within 1 V of the battery voltage.

⇒ **If not within 1 V of the battery voltage**

Refer to Circuit/System Testing.

⇓ **If within 1 V of the battery voltage**

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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

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module. 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 9 and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF.

2.2. Test for less than 2 Ω in the ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, repair the open/high resistance in the ground connection.

⇓ **If less than 5 Ω**

3. Verify a test lamp illuminates between the B+ circuit terminal 1 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

3.1. Ignition OFF, remove the test lamp.

3.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

3.1. Ignition OFF, remove the test lamp.

3.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the K111 Fuel Pump Driver Control Module.

⇓ **If the test lamp illuminates**

4. Replace the K111 Fuel Pump Driver Control Module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Control Module References for K111 Fuel Pump Driver Control Module programming, replacement, and setup.

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DTC P129D

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptor

DTC P129D

Fuel Pump Driver Control Module Ignition On/Start Switch Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P129D	P129D	—	—

Circuit/System Description

The Fuel Pump Driver Control Module monitors the ignition voltage circuit in order to determine if the voltage is within the normal operating range.

Conditions for Running the DTC

The DTC runs continuously when the modules are awake.

Conditions for Setting the DTC

The Fuel Pump Driver Control Module Power Mode does not agree with the Engine Control Module (ECM) Power Mode for 1 s.

Action Taken When the DTC Sets

DTC P129D is a Type B DTC.

Conditions for Clearing the DTC

DTC P129D is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing

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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 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 DTC P129D is set**

Refer to Circuit/System Testing.

⇓ **If DTC P129D 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 DTC P129D is set**

Refer to Circuit/System Testing.

⇓ **If DTC P129D is not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle system OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module, ignition ON. It may take up to 2 minutes for all vehicle systems to power down.
2. Verify a test lamp illuminates between the ignition circuit terminal 6 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

2.1. Ignition OFF, remove the test lamp.

2.2. Test for less than 2 Ω in the ignition circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

2.1. Ignition OFF, remove the test lamp.

2.2. Test for infinite resistance between the ignition circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the K111 Fuel Pump Driver Control Module.

⇓ **If the test lamp illuminates**

3. Replace the K111 Fuel Pump Driver Control Module.

Repair Instructions

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Perform the Diagnostic Repair Verification after completing the repair .

Control Module References for K111 Fuel Pump Driver Control Module programming, replacement, and setup.

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DTC P12A6

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptor

DTC P12A6

Fuel Pump Driver Control Module Enable Circuit Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0171, P0506, P0628, P12A6	P0171, P0506, P12A6	—	P12A6

Circuit/System Description

The Engine Control Module (ECM) provides ignition voltage to the Fuel Pump Driver Control Module whenever the engine is cranking or running. The Engine Control Module enables the Fuel Pump Driver Control Module as long as the engine is cranking or running, and ignition system reference pulses are received. While this enable voltage is being received, the Fuel Pump Driver Control Module supplies a varying voltage to the Fuel Tank Fuel Pump Module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

- The ignition voltage is greater than 7 V.
- The DTC runs continuously when the condition above is met.

Conditions for Setting the DTC

The Engine Control Module state of the fuel pump enable circuit does not match the state of the fuel pump enable circuit sensed by the Fuel Pump Driver Control Module for 0.5 s.

Action Taken When the DTC Sets

DTC P12A6 is a Type A DTC.

Conditions for Clearing the DTC

DTC P12A6 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P12A6 is not set.

⇒ **If the DTC is set**

Refer to Circuit/System Testing.

⇓ **If the DTC is not set**

3. Verify the parameters listed below do not display Malfunction when commanding the Fuel Pump Enable On and Off with a scan tool.
    - Fuel Pump Enable Circuit Low Voltage Test Status
    - Fuel Pump Enable Circuit Open Test Status
    - Fuel Pump Enable Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module. It may take up to 2 minutes for all vehicle systems to power down.
2. Ignition ON for 10 s.
3. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.

⇒ **If the test lamp illuminates**

3.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

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3.2. Test for less than 1 V between the control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If the test lamp does not illuminate**

4. Remove the test lamp.
5. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is OK when commanding the Fuel Pump Enable On with a scan tool.

⇒ **If OK is not displayed**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

5.2. Test for infinite resistance between the control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the K20 Engine Control Module.

⇓ **If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal 2 and ground.
7. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is Malfunction when commanding the Fuel Pump Enable On with a scan tool.

⇒ **If Malfunction is not displayed**

7.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.

7.2. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If Malfunction is displayed**

8. Replace the K111 Fuel Pump Driver Control Module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Control Module References for K20 Engine Control Module and K111 Fuel Pump Driver Control Module programming, replacement, and setup.

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DTC P129E or P12A8

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for a overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P129E

Fuel Pump Driver Control Module Signal Message Counter Incorrect

DTC P12A8

Fuel Pump Control Signal Message Counter Incorrect

Circuit/System Description

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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- 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**

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 K20 Engine Control Module replacement, programming, and setup

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DTC P135A or P135B

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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

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DTC P135A and P135B are Type B DTCs.

Conditions for Clearing the DTC

DTC P135A and P135B are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References

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 3 A fused jumper wire between the control circuit terminal 72 and ground, ignition ON.
3. Verify a test lamp illuminates between the appropriate ignition circuit terminal listed below and ground.
    - Terminal 62
    - Terminal 67

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

3.1. Ignition OFF, remove the test lamp.

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3.2. Test for less than 2 Ω in the ignition circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

Note: The ignition circuit may supply voltage to other components. Make sure to test all circuits and components for a short to ground that share the ignition circuit.

3.1. Ignition OFF, remove the test lamp, and disconnect all components on the circuit.

3.2. 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

3.3. Replace the fuse, ignition ON.

3.4. 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

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DTC P1380 or P1381

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provide an overview of each diagnostic category.

DTC Descriptors

DTC P1380

Misfire Detected and Rough Road Data Not Available

DTC P1381

Misfire Detected and No Communication with Brake Control Module

System Description

The engine control module (ECM) detects engine misfire by detecting variations in crankshaft deceleration between firing strokes. For accurate detection of engine misfire, the ECM must distinguish between crankshaft deceleration caused by actual misfire and deceleration caused by rough road conditions. The antilock brake system (ABS) can detect if the vehicle is on a rough road based on wheel acceleration/deceleration data supplied by the wheel speed sensors. If the ABS detects rough road above predetermined threshold, this information is sent to the ECM. The ECM uses the rough road information when calculating engine misfire. If the ABS is malfunctioning and cannot detect rough roads, the misfire diagnostic will continue to run; however, if an engine misfire DTC sets, this DTC also sets indicating that rough road data was not available or there was no communication with the brake control module during the misfire calculation due to an ABS malfunction.

Conditions for Running the DTC

- The vehicle speed is greater than 8 km/h (5 mph).
- The engine speed is less than 7,000 RPM.
- The engine load is less than 60 percent.
- Engine misfire is detected and DTC P0300 sets with the MIL illuminated.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P1380

- The ABS controller sends a message to the ECM indicating that a failure has occurred in the ABS module.
- Engine misfire is detected and DTC P0300 set.

P1381

- An ABS malfunction exists for more than 10 s preventing the ECM from receiving rough road detection data.
- Engine misfire is detected and DTC P0300 set.

Action Taken When the DTC Sets

DTCs P1380 and P1381 are Type C DTCs.

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Conditions for Clearing the DTC

DTCs P1380 and P1381 are Type C DTCs.

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

Verify there are no ABS DTCs set.

⇒ **If ABS DTCs are set**
Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If ABS DTCs are not set**
Refer to Symptoms - Antilock Brake System.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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DTC P1400

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provide an overview of each diagnostic category.

DTC Descriptor

DTC P1400

Cold Start Emission Reduction Control System

Circuit/System Description

The 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

- 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 350°C (662°F).
- Engine coolant is greater than −10°C (50°F) and less than 56°C (132°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 900°C (1,652°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

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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. Vehicle OFF, allow the engine to cool to be within the temperatures listed in the Conditions for Running the DTC.
2. Engine running.
3. Operate the vehicle within the Conditions for Running the DTC. 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**

5. Verify that none of the conditions listed below exists with the air intake system:
   - Damage, restriction, or modification
   - Dirty or deteriorating air filter element
   - Crankcase ventilation system for correct operation—Refer to Crankcase Ventilation System Inspection/Diagnosis.
   - Water intrusion
   - Vacuum leak and other unmetered air downstream of the mass air flow (MAF) sensor
   - Intake manifold leak

⇒ **If any of the conditions exist**

Repair as necessary.

⇓ **If none of the conditions exist**

6. Verify that none of the conditions listed below exists with the exhaust system:
   - Exhaust leak
   - Water intrusion
   - Damaged, restricted, modified or enhanced exhaust system—Refer to Symptoms - Engine Exhaust.

⇒ **If any of the above conditions exist**

Repair as necessary.

⇓ **If none of the conditions exist**

7. If all of the above conditions test normal, inspect for an engine mechanical condition that could alter the air flow into the combustion chamber. Refer to Symptoms - Engine Mechanical.

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⇓ **If the DTC does not set**

8. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

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DTC P150C

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptor

DTC P150C

Transmission Control Module Engine Speed Request Signal Message Counter Incorrect

Circuit/System Description

To improve vehicle shift feel, the transmission control module (TCM) is constantly sending the ECM serial data messages with 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.

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:

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- 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

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DTC P1516, P2101, P2119, or P2176

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P1516

Throttle Actuator Control (TAC) Module Throttle Actuator Position Performance

DTC P2101

Throttle Actuator Position Performance

DTC P2119

Throttle Closed Position Performance

DTC P2176

Minimum Throttle Position Not Learned

Diagnostic Fault Information

Circuit	Short to Ground	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.

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Conditions for Running the DTC

P1516

- 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 desired throttle position is steady for greater than 4 S
- 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 that the difference between the actual and desired throttle position is greater than 2 % for greater than 1 S.

P2101

- The ECM detects that the difference between the actual throttle position and the predicted throttle position is greater 7 % for greater than 1 S.

  OR
- The ECM detects the throttle control is driving the throttle in the incorrect direction or has exceed the reduced power limit.

P2119

The ECM determines that the throttle blade did not return to the rest position within 1 s.

P2176

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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 P1516, 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 P1516, 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 when the engine is cranking or running the Desired and Actual Throttle positions should closely match.
- Inspect for a condition in which the throttle valve may have been held open. For example, ice may have formed in the throttle bore causing the throttle valve not to close.
- A high resistance condition on the throttle position and throttle actuator control circuits could cause a DTC to set.
- A low battery condition may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

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

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1. Ignition ON.

   Note: A low battery voltage or charging system condition may cause a DTC to set.
2. Verify DTC P0121, P0122, P0123, P0222, P0223, P0562, P0621, P0622, or P2135 is not set.

⇒ **If any of the DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle for further diagnosis.

⇓ **If none of the DTCs are set**

3. Verify the scan tool Throttle Body Idle Air flow Compensation parameter is less than 90 %.

⇒ **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.
7. Verify the scan tool TAC Motor parameter displays Enabled while slowly depressing the accelerator pedal.

⇒ **If Enabled is Not displayed**

Refer to Circuit/System Testing.

⇓ **If Enabled is displayed**

8. Verify DTC P1516, P2101, P2119, or P2176 is not set.

⇒ **If any of the DTCs are set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs are set**

Note: If there is a condition with the throttle body, the TAC Motor Command parameter will go to 99 % for a predetermined amount of time and then a DTC sets. Once a DTC is set, the TAC Motor Command parameter will go to 0 % and the TAC Motor parameter will display Disabled.

9. Verify the scan tool TAC Motor parameter displays Enabled while performing the Throttle Sweep Test with a scan tool.

⇒ **If Enabled is Not displayed**

Replace the Q38 Throttle Body.

⇓ **If Enabled is displayed**

10. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
11. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

12. All OK

Circuit/System Testing

1. Ignition OFF.

   Warning: Turn OFF the ignition before inserting fingers into the throttle bore. Unexpected movement of the throttle blade could cause personal injury.
2. Verify the conditions listed below do not exist with the Q38 Throttle Body Assembly:

   Note:
   - The rest position is defined as the actual Throttle Position percentage when the ignition is OFF or with the ignition ON for greater than 30 seconds.

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- When the ignition is OFF, spring tension should hold the throttle plate in the rest position. You should be able to open the throttle plate to wide open throttle (WOT) or push the throttle plate to the fully closed position. In each case, the throttle plate should return to the rest position without assistance.

- A throttle blade that is not in the rest position
- A throttle blade that is binding open or closed
- A throttle blade that is free to move open or closed without spring pressure

⇒ **If a condition is found**

Replace the Q38 Throttle Body.

⇓ **If a condition is not found**

Note:

- Disconnecting the throttle body harness connector may cause additional DTCs to set.
- The ignition must be OFF and the ECM completely powered down before testing each circuit.
- The Test Lamp must be connected to circuit before turning ignition on or incorrect diagnosis may occur.

3. Ignition OFF, disconnect the harness connector at the Q38 Throttle Body, ignition ON.
4. Verify that a test lamp does not illuminate continuously between each motor control circuit listed below and ground.
   - TAC Motor Control Open circuit terminal 1
   - TAC Motor Control Closed circuit terminal 2

⇒ **If the test lamp illuminates continuously**

4.1. Ignition OFF, remove the test lamp. Disconnect the harness connector at the K20 Engine Control Module, ignition ON.

4.2. Test for less than 1 V between the control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If the test lamp is always OFF**

5. Verify that a test lamp does not illuminate between each motor control circuit listed below and B+.
   - TAC Motor Control Open circuit terminal 1
   - TAC Motor Control Closed circuit terminal 2

⇒ **If the test lamp illuminates**

5.1. Ignition OFF, remove the test lamp. Disconnect the harness connector at the K20 Engine Control Module.

5.2. Test for infinite resistance between the control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the K20 Engine Control Module.

⇓ **If the test lamp does not illuminate**

6. Ignition OFF, remove the test lamp. Set the DMM to the 40 V scale or higher, select the Min/Max Recording Mode, and set the Peak Min/Max response time to 1 ms or faster.

   Note:

   - The DMM Min/Max Recording Mode and the response time of 1 ms or faster must be reset after testing each circuit or a lower voltage will be recorded.
   - The ignition must be OFF and the ECM completely powered down before testing each circuit or a lower voltage will be recorded.

7. Verify the Max voltage is within 3 V of B+ while using DMM Min/Max Recording Mode function on each control circuit listed below and ground as the ignition is turned ON.

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- TAC Motor Control Open circuit terminal 1
- TAC Motor Control Closed circuit terminal 2

⇒ **If not within 3 V of B+**

7.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

7.2. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If within 3 V of B+**

8. Replace the Q38 Throttle Body.

Repair Instructions

- Throttle Body Assembly Replacement
- Control Module References for ECM replacement, programming, and setup

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
5. Ignition ON.
6. Verify the scan tool TAC Motor parameter displays Enabled while performing the Throttle Sweep Test with a scan tool.

⇒ **If Disabled**

Replace the Q38 Throttle Body.

⇓ **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

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DTC P15AE or P15AF (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P15AE

Fuel Injector Control Module System Voltage Low

DTC P15AF

Fuel Injector Control Module System Voltage High

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Supply Voltage	P15AE	P15AE	P15AF

Circuit/System Description

The fuel injector control module monitors a circuit voltage to verify the voltage is between the normal operating range. The DTC can set for a circuit or system voltage out of range.

Conditions for Running the DTC

The ignition is ON.

Conditions for Setting the DTC

- The control module detects a circuit or system voltage is less than approximately 9 V for approximately 5 seconds.
- The control module detects a circuit or system voltage is greater than approximately 15 V for approximately 5 seconds.

Action Taken When the DTC Sets

DTCs P15AE and P15AF are Type C DTCs.

Conditions for Clearing the DTC

DTCs P15AE and P15AF are Type C DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

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Description and Operation

LPG System Description and Operation

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Electrical Center Identification Views
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition OFF.
2. Test for 12.4–12.8 V at the battery terminals and record the reading. The battery voltage should stabilize after a few minutes of turning the ignition OFF.

⇒ **If not between 12.4 V–12.8 V**

Refer to Battery Inspection/Test

⇓ **If between 12.4 V–12.8 V**

3. Engine running, accessories OFF.
4. Test for 13.4–15 V at the battery terminals and record the reading.

⇒ **If not between 13.4–15 V**

Refer to Charging System Test

⇓ **If between 13.4–15 V**

5. Verify the engine control module scan tool Ignition 1 Signal voltage parameter is within 1 V of the battery voltage.

⇒ **If not within 1 V of the battery voltage**

Refer to Circuit/System Testing.

⇓ **If within 1 V of the battery voltage**

6. All OK

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the fuel injector control module. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 10 Ω between the ground circuit terminal X1–21 and ground.

⇒ **If 10 Ω or greater**

2.1. Ignition OFF.

2.2. Test for less than 2 Ω in the ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, repair the open/high resistance in the ground connection.

⇓ **If less than 10 Ω**

3. Verify a test lamp illuminates between the B+ circuit terminal X1–22 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

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3.1. Ignition OFF.
3.2. Test for less than 2 Ω in the B+ circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

3.1. Ignition OFF.
3.2. Test for infinite resistance between the B+ circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the fuel injector control module.

⇓ **If the test lamp illuminates**

4. Test or replace the fuel injector control module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Fuel Injector Control Module Replacement

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DTC P163A

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptor

DTC P163A

Control Module Fuel Pressure Regulator 1 Control System Circuitry Performance

Circuit/System Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM).

Conditions for Running the DTC

- The engine is running or cranking.
- The ignition voltage is between 8-18 V.
- DTC P163A runs continuously when the conditions are met for greater than 500 mS.

Conditions for Setting the DTC

The engine control module detects a condition with the integrated circuits of the high pressure fuel pump actuator driver module or the ECM detects that the current used to drive the high pressure fuel pump actuator is out of range for greater than 4 s.

Action Taken When the DTC Sets

DTC P163A is a Type C DTC.

Conditions for Clearing the DTC

DTC P163A is a Type C DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Engine Control Module Description

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

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool parameters listed below do not display Malfunction when commanding the Fuel Pressure Regulator On and Off with a scan tool.
   - Fuel Pressure Regulator Control Circuit High Voltage Test Status
   - Fuel Pressure Regulator Control Circuit Open Test Status
   - Fuel Pressure Regulator Control Circuit Low Voltage Test Status
   - Fuel Pressure Regulator High Control Circuit High Voltage Test Status
   - Fuel Pressure Regulator High Control Circuit Open Test Status
   - Fuel Pressure Regulator High Control Circuit Low Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump. 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 pressure fuel pump actuator low control circuit terminal 1 and B+.

⇒ **If the test lamp illuminates**

2.1. Remove the test lamp.

2.2. Disconnect the X3 harness connector at the K20 Engine Control Module.

2.3. 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, test or replace the K20 Engine Control Module.

⇓ **If the test lamp does not illuminate**

3. Ignition ON.
4. Verify a test lamp does not illuminate between the high pressure fuel pump actuator high control terminal 2 and ground.

⇒ **If the test lamp illuminates**

4.1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module. Ignition ON.

4.2. 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.

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⇒ If less than 1 V, test or replace the K20 Engine Control Module.

⇓ **If the test lamp does not illuminate**

5. Verify the test lamp illuminates when the Fuel Pressure Regulator is commanded On with a scan tool.

⇒ **If the test lamp does not illuminate**

5.1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module.

5.2. 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, test or replace the K20 Engine Control Module.

⇓ **If the test lamp illuminates**

6. Ignition OFF, connect a test lamp between the high pressure fuel pump actuator low control circuit terminal 1 and B+. Ignition ON.
7. Verify the test lamp illuminates when the Fuel Pressure Regulator is commanded On with a scan tool.

⇒ **If the test lamp does not illuminate**

7.1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module. Ignition ON.

7.2. 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

7.3. 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, test or replace the K20 Engine Control Module.

⇓ **If the test lamp illuminates**

8. Test or replace the G18 High Pressure Fuel Pump.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.

   Note: The DMM and test leads must be calibrated to 0 Ω in order to prevent misdiagnosis.
2. Test for 0.35–0.6 Ω at 20°C (68°F) of resistance between low control circuit terminal 1 and high control circuit terminal 2.

⇒ **If not within the specified range**

Replace the G18 High Pressure Fuel Pump.

⇓ **If within the specified range**

3. Test for infinite resistance between each terminal and the high pressure fuel pump housing/case.

⇒ **If less than infinite resistance**

Replace the G18 High Pressure Fuel Pump.

⇓ **If infinite resistance**

4. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Pump Replacement for G18 High Pressure Fuel Pump replacement
- Control Module References for K20 Engine Control Module replacement, programming, and setup

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Note: Some vehicles do not support the Fuel Rail Pressure Relief Valve Reset procedure. Applications not supporting this procedure will return an error message stating "Parameter ID not supported. Check for proper vehicle selection."

- Perform the Fuel Rail Pressure Relief Valve Reset procedure.

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DTC P168E, P168F, P16B5, or P16B6

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P168E

Fuel Injector Control Module Not Programmed

DTC P168F

Fuel Injector Control Module Read Only Memory

DTC P16B5

Fuel Injector Control Module Random Access Memory

DTC P16B6

Fuel Injector Control Module Long Term Memory Performance

Circuit/System Description

This diagnostic applies to internal microprocessor integrity conditions within the fuel injector control module (FICM). This diagnostic also addresses if the FICM is not programmed.

Conditions for Running the DTC

These DTCs run when the fuel injector control module is powered up.

Conditions for Setting the DTC

The fuel injector control module has detected an internal malfunction, or incomplete programming.

Action Taken When the DTC Sets

DTC P168E, P168F, P16B5, and P16B6 are type A DTCs.

Conditions for Clearing the DTC

DTC P168E, P168F, P16B5, and P16B6 are type A DTCs.

Reference Information

Description and Operation

Fuel System Description

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

Circuit/System Verification

Note: This DTC may be stored as a history DTC without affecting the operation of the module. If stored only as a history DTC and not retrieved as a current DTC, do not replace the module.

1. Ignition ON, clear the DTC information with a scan tool.
2. Observe the scan tool DTC information. Verify that DTC P168E, P168F, P16B5, or P16B6 does not set.

   ⇒ If a DTC is set, replace the K103 fuel injector control module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Control Module References for fuel injector control module replacement, programming, and setup.

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DTC P2122, P2123, P2127, P2128, or P2138

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P2122

Accelerator Pedal Position (APP) Sensor 1 Circuit Low Voltage

DTC P2123

Accelerator Pedal Position (APP) Sensor 1 Circuit High Voltage

DTC P2127

Accelerator Pedal Position (APP) Sensor 2 Circuit Low Voltage

DTC P2128

Accelerator Pedal Position (APP) Sensor 2 Circuit High Voltage

DTC P2138

Accelerator Pedal Position (APP) Sensor 1-2 Correlation

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

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Typical Scan Tool Data

APP Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating at idle. **Parameter Normal Range:** APP Sensor 1 0.88–1.08 V			
APP Sensor 1 5 V Reference	0.00 V	0.00 V	2–3 V
APP Sensor 1 Signal	0.00 V	0.00 V	4–5 V
APP Sensor 1 Low Reference	—	4–5 V	—

APP Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating at idle. **Parameter Normal Range:** APP Sensor 2 0.39–0.59 V			
APP Sensor 2 5 V Reference	0.00 V	0.00 V	1–3 V
APP Sensor 2 Signal	0.00 V	0.00 V	2–5 V
APP Sensor 2 Low Reference	—	4–5 V	—

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Circuit/System Description

The accelerator pedal assembly contains 2 accelerator pedal position (APP) sensors. The APP sensors are mounted to the accelerator pedal assembly and are not serviceable. The APP sensors provide a signal voltage that changes relative to pedal position. The engine control module (ECM) supplies each APP sensor with a 5 V reference circuit, a low reference circuit, and a signal circuit.

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

- DTC P06A3 or P0697 are not set.
- The ignition is ON or the engine is operating.
- The ignition voltage is greater than 6 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 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

Connector End View Reference

Component Connector End Views

Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0697 or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to DTC P0641, P0651, P0697, or P06A3 for further diagnosis.

⇓ **If none of the DTCs are set**

3. Verify the APP Sensor 1 Circuit Status and APP Sensor 2 Circuit Status displays OK.

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing

⇓ **If OK is displayed**

4. Verify the scan tool APP Sensor 1 and 2 Agree/Disagree parameter displays Agree while performing the tests listed below:
   - Rapidly depress the accelerator pedal from the rest position to the wide open throttle position (WOT) and release pedal. Repeat the procedure several times.
   - Slowly depress the accelerator pedal to WOT and then slowly return the pedal to closed throttle. Repeat the procedure several times.

⇒ **If Disagree**

Refer to Circuit/System Testing

⇓ **If Agree**

5. Verify that DTC P2122, P2123, P2127, P2128, or P2138 is not set.

⇒ **If any of the DTCs are set**

Refer to Circuit/System Testing

⇓ **If none of the DTCs set**

6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

8. All OK

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B107 accelerator pedal 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.
   - Low reference circuit terminal 4 or A
   - Low reference circuit terminal 5 or D

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K20 engine control module.

2.2. Test for less than 2 Ω in the low reference circuit end to end.

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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 less than 5 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between each 5 V reference circuit terminal listed below and ground.
   - 5 V reference circuit terminal 1 or C
   - 5 V reference circuit terminal 2 or F

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the harness connector at the K20 engine control module.

4.2. Test for infinite resistance between the 5 V reference circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 engine control module.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the harness connector at the K20 engine control module, ignition ON.

4.2. Test for less than 1 V between the 5 V reference circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 engine control module.

⇓ **If between 4.8–5.2 V**

5. Verify each APP sensor voltage parameter is less than 0.2 V.

⇒ **If 0.2 V or greater**

5.1. Ignition OFF, disconnect the harness connector at the K20 engine control module, ignition ON.

5.2. Test for less than 1 V between the signal circuit terminal listed below and ground.

- APP sensor 1 signal circuit terminal 3 or E
- APP sensor 2 signal circuit terminal 6 or B

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 engine control module.

⇓ **If less than 0.2 V**

6. Install a 3 A fused jumper wire between each signal circuit terminal listed below and the 5 V reference circuit terminal 1 or C.
   - APP sensor 1 signal circuit terminal 3 or E
   - APP sensor 2 signal circuit terminal 6 or B
7. Verify the scan tool APP sensor voltage parameter is greater than 4.8 V.

⇒ **If 4.8 V or less**

7.1. Ignition OFF, disconnect the harness connector at the K20 engine control module.

7.2. Test for infinite resistance between the signal circuit terminal and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

7.3. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 engine control module.

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⇓ **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 Position Sensor Replacement
- Control Module References for ECM replacement, programming, and setup

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DTC P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, or P216F (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P2147

Injector 1 Positive Voltage Control Circuit Low Voltage

DTC P2148

Injector 1 Positive Voltage Control Circuit High Voltage

DTC P2150

Injector 2 Positive Voltage Control Circuit Low Voltage

DTC P2151

Injector 2 Positive Voltage Control Circuit High Voltage

DTC P2153

Injector 3 Positive Voltage Control Circuit Low Voltage

DTC P2154

Injector 3 Positive Voltage Control Circuit High Voltage

DTC P2156

Injector 4 Positive Voltage Control Circuit Low Voltage

DTC P2157

Injector 4 Positive Voltage Control Circuit High Voltage

DTC P216B

Injector 5 Positive Voltage Control Circuit Low Voltage

DTC P216C

Injector 5 Positive Voltage Control Circuit High Voltage

DTC P216E

Injector 6 Positive Voltage Control Circuit Low Voltage

DTC P216F

Injector 6 Positive Voltage Control Circuit High Voltage

Diagnostic Fault Information

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Supply Cylinder 1	P2147	P0201	P2148	P1248
Direct Fuel Injector High Voltage Control Cylinder 1	P0261	P0201	P0262	P1248
Direct Fuel Injector High Voltage Supply Cylinder 2	P2150	P0202	P2151	P1249
Direct Fuel Injector High Voltage Control Cylinder 2	P0264	P0202	P0265	P1249
Direct Fuel Injector High Voltage Supply Cylinder 3	P2153	P0203	P2154	P124A
Direct Fuel Injector High Voltage Control Cylinder 3	P0267	P0203	P0268	P124A
Direct Fuel Injector High Voltage Supply Cylinder 4	P2156	P0204	P2157	P124B
Direct Fuel Injector High Voltage Control Cylinder 4	P0270	P0204	P0271	P124B
Direct Fuel Injector High Voltage Supply Cylinder 5	P216B	P0205	P216C	P124C
Direct Fuel Injector High Voltage Control Cylinder 5	P0273	P0205	P0274	P124C
Direct Fuel Injector High Voltage Supply Cylinder 6	P216E	P0206	P216F	P124D
Direct Fuel Injector High Voltage Control Cylinder 6	P0276	P0206	P0277	P124D

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Circuit/System Description

The engine control module (ECM) supplies voltage to each fuel injector on the injector high voltage supply circuits. The ECM energizes each fuel injector by grounding the high voltage control circuit of the fuel injector. The ECM monitors the status of the injector high voltage supply circuits and the fuel injector high voltage control circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- DTC P062B is not set.
- The engine is running.
- The ignition voltage is greater than 11 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P2147, P2150, P2153, P2156, P216B, or P216E

The ECM detects the injector high voltage supply circuit is shorted to ground for greater than 2 s.

P2148, P2151, P2154, P2157, P216C, or P216F

The ECM detects the injector high voltage supply circuit is shorted to voltage for greater than 2 s.

Action Taken When the DTC Sets

DTCs P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, and P216F are Type A DTCs.

Conditions for Clearing the DTC

DTCs P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, and P216F are Type A DTCs.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to Fuel Injector Solenoid Coil Test.
- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Injector Circuit Status parameters. An Injector Circuit Status parameter will change from OK or Not Running to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG 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 DTC P0685 or P1682 are not set.

⇒ **If DTC P0685 or P1682 are set**

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Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If DTC P0685 or P1682 are not set**

3. Engine operating.
4. Verify DTC P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, or P216F are not set.

⇒ **If any of the specified DTCs are set**

Refer to Circuit/System Testing

⇓ **If none of the specified DTCs are set**

5. Ignition ON.
6. Verify the scan tool Cylinder 1–6 Injector Circuit Status parameters display OK.

⇒ **If the Cylinder 1–6 Injector Circuit Status parameters do not display OK**

Refer to Circuit/System Testing

⇓ **If the Cylinder 1–6 Injector Circuit Status parameters display OK**

7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
8. Verify DTC P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, or P216F are not set.

⇒ **If any of the specified DTCs are set**

Refer to Circuit/System Testing

⇓ **If none of the specified DTCs are set**

9. All OK

Circuit/System Testing

1. Ignition OFF, disconnect the X160 engine harness to fuel injector harness connector. Ignition ON.
2. Verify the appropriate scan tool Cylinder 1–6 Injector Circuit Status parameter displays Open.

⇒ **If the appropriate scan tool Cylinder 1–6 Injector Circuit Status parameter does not display Open.**

2.1. Ignition OFF, disconnect the X3 harness connector at the K20 engine control module.

2.2. Test for infinite resistance between the appropriate high voltage supply circuit, ECM side and ground.

⇒ If less than infinite, repair the short to ground on the circuit.

⇓ If infinite resistance

2.3. Ignition ON.

2.4. Test for less than 1 V between the appropriate high voltage control circuit, ECM side 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 appropriate scan tool Cylinder 1–6 Injector Circuit Status parameter displays Open.**

3. Ignition ON, connect a test lamp between the appropriate high voltage supply circuit and the high voltage control circuit.
4. Verify the Injector Circuit Status parameter transitions from Open to OK.

⇓ **If the Injector Circuit Status parameter does not transition from Open to OK.**

4.1. Ignition OFF, disconnect the X3 harness connector at the K20 engine control module.

4.2. Test for infinite resistance between the appropriate high voltage supply circuit, ECM side and ground.

⇒ If less than infinite, repair the short to ground on the circuit.

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⇓ If infinite resistance

4.3. Test for less than 2 Ω on the appropriate high voltage supply circuit, ECM side end to end.

⇒ If 2 Ω or greater, repair open/high resistance in the circuit.

⇓ If less than 2 Ω

4.4. Test for infinite resistance between the appropriate high voltage control circuit, ECM side and ground.

⇒ If less than infinite, repair the short to ground on the circuit.

⇓ If infinite resistance

4.5. Test for less than 2 Ω on the appropriate high voltage control circuit, ECM side end to end.

⇒ If 2 Ω or greater, repair open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 engine control module.

⇓ **If the Injector Circuit Status parameter transitions from Open to OK.**

Note: Testing for the following steps is performed on the fuel injector side of the multi-way harness connector. It may be necessary to remove the intake manifold to isolate the condition.

5. Ignition OFF.
6. Test for infinite resistance between the appropriate high voltage supply circuit and ground.

⇒ **If less than infinite resistance**

6.1. Disconnect the harness connector at the appropriate Q17 fuel injector.

6.2. Test for infinite resistance between the appropriate high voltage supply circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

6.3. Test for infinite resistance between the appropriate high voltage control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, test or replace the appropriate Q17 fuel injector.

⇓ **If infinite resistance**

7. Test for 1.5-2.5 Ω between the appropriate high voltage supply circuit and high voltage control circuit.

⇒ **If less than the specified range**

7.1. Disconnect the harness connector at the appropriate Q17 fuel injector.

7.2. Test for infinite resistance between the appropriate high voltage supply circuit and high voltage control circuit.

⇒ If less than infinite resistance, repair the short on the circuits.

⇒ If infinite resistance, replace the appropriate Q17 fuel injector.

⇒ **If greater than the specified range**

7.1. Disconnect the harness connector at the appropriate Q17 fuel injector.

7.2. Test for less than 2 Ω on appropriate high voltage supply circuit end to end

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit

⇓ If less than 2 Ω

7.3. Test for less than 2 Ω on appropriate high voltage 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 appropriate Q17 fuel injector.

⇓ **If within the specified range**

8. Preform the Fuel Injector Solenoid Coil Test.

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Component Testing

Fuel Injector Solenoid Coil Test

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel Injector and Fuel Rail Replacement
- Control Module References for engine control mosule replacement, programming, and setup.

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DTC P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, or P216F (LFW, LFX)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P2147

Injector 1 Positive Voltage Control Circuit Low Voltage

DTC P2148

Injector 1 Positive Voltage Control Circuit High Voltage

DTC P2150

Injector 2 Positive Voltage Control Circuit Low Voltage

DTC P2151

Injector 2 Positive Voltage Control Circuit High Voltage

DTC P2153

Injector 3 Positive Voltage Control Circuit Low Voltage

DTC P2154

Injector 3 Positive Voltage Control Circuit High Voltage

DTC P2156

Injector 4 Positive Voltage Control Circuit Low Voltage

DTC P2157

Injector 4 Positive Voltage Control Circuit High Voltage

DTC P216B

Injector 5 Positive Voltage Control Circuit Low Voltage

DTC P216C

Injector 5 Positive Voltage Control Circuit High Voltage

DTC P216E

Injector 6 Positive Voltage Control Circuit Low Voltage

DTC P216F

Injector 6 Positive Voltage Control Circuit High Voltage

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Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Supply Cylinder 1	P2147	P0201	P2148	P1248
Direct Fuel Injector High Voltage Control Cylinder 1	P0261	P0201	P0262	P1248
Direct Fuel Injector High Voltage Supply Cylinder 2	P2150	P0202	P2151	P1249
Direct Fuel Injector High Voltage Control Cylinder 2	P0264	P0202	P0265	P1249
Direct Fuel Injector High Voltage Supply Cylinder 3	P2153	P0203	P2154	P124A
Direct Fuel Injector High Voltage Control Cylinder 3	P0267	P0203	P0268	P124A
Direct Fuel Injector High Voltage Supply Cylinder 4	P2156	P0204	P0270, P2157	P124B
Direct Fuel Injector High Voltage Control Cylinder 4	P0270, P2156	P0204	P0271, P2157	P124B
Direct Fuel Injector High Voltage Supply Cylinder 5	P216B	P0205	P216C	P124C
Direct Fuel Injector High Voltage Control Cylinder 5	P0273	P0205	P0274	P124C
Direct Fuel Injector High Voltage Supply Cylinder 6	P216E	P0206	P216F	P124D
Direct Fuel Injector High Voltage Control Cylinder 6	P0276	P0206	P0277	P124D

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Circuit/System Description

The engine control module (ECM) supplies voltage to each fuel injector on the injector high voltage supply circuits. The ECM energizes each fuel injector by grounding the high voltage control circuit of the fuel injector. The ECM monitors the status of the injector high voltage supply circuits and the fuel injector high voltage control circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- The engine is running.
- The ignition voltage is between 11–18 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P2147, P2150, P2153, P2156, P216B, or P216E

The engine control module detects the fuel injector high voltage supply circuit is shorted to ground for greater than 2 s.

P2148, P2151, P2154, P2157, P216C, or P216F

The engine control module detects the fuel injector voltage supply circuit is shorted to voltage for greater than 2 s.

Action Taken When the DTC Sets

DTCs P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, and P216F are Type A DTCs.

Conditions for Clearing the DTC

DTCs P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, and P216F are Type A DTCs.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to Fuel Injector Solenoid Coil Test.
- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Cylinder 1–6 Injector Circuit Status parameters. An Injector Circuit Status parameter will change from OK or Not Run to Fault if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0685 or P1682 is not set.

⇒ **If DTC P0685 or P1682 is set**

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Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If DTC P0685 or P1682 is not set**

3. Engine idling.
4. Verify the scan tool Cylinder 1–6 Injector Control Circuit Status parameters display OK.

⇒ **If any parameters do not display OK**

Refer to Circuit/System Testing.

⇓ **If all parameters display OK**

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 P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, or P216F does not set.

⇒ **If any DTC sets**

Refer to Circuit/System Testing.

⇓ **If no DTC sets**

7. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the appropriate multi-way harness connector X160 or X161, at the rear of the intake manifold, ignition ON. It may take up to 2 min for all vehicle systems to power down.
2. Verify the scan tool Cylinder 1–6 Injector Control Circuit Status parameters display Open.

⇒ **If Open is not displayed**

2.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

Note: Test on the engine control module side of the multi-way harness connector.

2.2. Test for infinite resistance between the appropriate Q17 Fuel Injector control circuit and ground.

⇒ If less than infinite, repair the short to ground on the circuit.

⇓ If infinite resistance

2.3. Ignition ON.

2.4. Test for less than 1 V between the appropriate 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, test or replace the K20 Engine Control Module.

⇓ **If Open is displayed**

3. Ignition ON, connect a test lamp between the appropriate Q17 Fuel Injector high voltage supply circuit and control circuits.
4. Verify the appropriate Cylinder 1–6 Injector Control Circuit Status transitions from Open to OK.

⇒ **If the parameter does not transition**

4.1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module.

4.2. Test for less than 2 Ω on the appropriate Q17 Fuel Injector high voltage supply circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ If less than 2 Ω

4.3. Test for less than 2 Ω on the appropriate Q17 Fuel Injector low control 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, test or replace the K20 Engine Control Module.

⇓ **If the parameter transitions**

Note: Testing for the following steps is performed on the fuel injector side of the multi-way harness connector. It may be necessary to remove the intake manifold to isolate the condition.

5. Test for 2-3 Ω between the appropriate Q17 Fuel Injector high voltage supply circuit and control circuit.

⇒ **If less than 2 Ω**

5.1. Disconnect the harness connector at the appropriate Q17 Fuel Injector.

5.2. Test for infinite resistance between the appropriate Q17 Fuel Injector high voltage supply circuit and control circuit.

⇒ If less than infinite, repair the short between the circuits.

⇒ If infinite resistance, test or replace the Q17 Fuel Injector.

⇒ **If greater than 3 Ω**

5.1. Disconnect the harness connector at the appropriate Q17 Fuel Injector.

5.2. Test for less the 2 Ω in the appropriate Q17 Fuel Injector high voltage supply circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ If less than 2 Ω

5.3. Test for less the 2 Ω in the appropriate Q17 Fuel Injector control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, test or replace the Q17 Fuel Injector.

⇓ **If between 2-3 Ω**

6. Test for infinite resistance between the appropriate Q17 Fuel Injector control circuit and ground.

⇒ **If less than infinite resistance**

6.1. Disconnect the harness connector at the appropriate Q17 Fuel Injector.

6.2. Test for infinite resistance between the appropriate Q17 Fuel Injector high voltage supply circuit and ground.

⇒ If less than infinite, repair the short to ground on the circuit.

⇓ If infinite resistance

6.3. Test for infinite resistance between the appropriate Q17 Fuel Injector control circuit and ground.

⇒ If less than infinite, repair the short to ground on the circuit.

⇒ If infinite resistance, test or replace the Q17 Fuel Injector.

⇓ **If infinite resistance**

7. Ignition ON.

8. Test for less than 1 V between the appropriate 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**

9. All OK.

Component Testing

- Fuel Injector Solenoid Coil Test
- Fuel Injector Balance Test

Repair Instructions

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Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Injection Fuel Rail Assembly Replacement - Bank 1
- Fuel Injection Fuel Rail Assembly Replacement - Bank 2
- Control Module References for K20 Engine Control Module replacement, programming, and setup.

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DTC P2199

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptor

DTC P2199

Intake Air Temperature (IAT) Sensors 1-2 Not Plausible

Diagnostic Fault Information

IAT 1 Sensor

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, P2227, P2228, P2229	P0113*, P0114**, P2199, P2227, P2229	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199	P0096, P0097, P00F4, P0101, P0102, P2199	P0690	P0096, P0101, P0103
Signal	P0096, P0097, P00F5, P2199	P0096, P0097, P00F3, P2199	P0096*, P0097, P00F3, P2199	P0096
Ground	—	P0096, P0097,	—	P0096, P0102

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
		P00F3, P0102, P0178, P2199, P2230		
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT 1 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	150°C (302°F)	−40°C (−40°F)	−40°C (−40°F)*
Low Reference	—	−40°C (−40°F)	−40°C (−40°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

IAT Sensor 2

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Ignition Voltage	−40°C (−40°F) 10 Hz	−40°C (−40°F) 10 Hz	—
Signal	−40°C (−40°F) 10 Hz	−40°C (−40°F) 10 Hz	−40°C (−40°F)* 10 Hz
Ground	—	−40°C (−40°F) 10 Hz	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

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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 °C (°F). The IAT sensor 2 and the humidity sensor share the same circuit. The IAT sensor 2 signal is displayed by the scan tool as Hertz (Hz) and °C (°F).

The sensors listed below share an ECM supplied 5 V reference circuit:

- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

The sensors listed below share an ECM supplied low reference circuit:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

IAT Sensor 1 — Temperature, Resistance, Voltage Table

IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage
Cold	High	High
Warm	Low	Low

IAT Sensor 2 — Temperature, Frequency Table

IAT Sensor 2	IAT Sensor 2 Frequency	IAT Sensor 2 Temperature
Cold	45 Hz	−40°C (−40°F)
Warm	302 Hz	104°C (219°F)

Conditions for Running the DTC

- DTC P1682 is not set.
- The ignition is ON.
- Ignition voltage is at least 11 V.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

The ECM detects that the absolute difference between the IAT sensor 1 and the IAT sensor 2 temperatures is greater than 55°C (99°F) for longer than 5 s.

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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 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; −40°C (−40°F), and there are Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to Special 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 for further diagnosis.

⇓ **If none of the DTCs are set**

Note: To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 3 and 4of this verification procedure only if the ignition has been OFF for 8 hours or more.

3. Ignition ON.
4. Verify the following scan tool parameters are within 10°C (18°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2

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- Start-Up ECT

⇒ **If not within 10°C (18°F)**

Refer to Circuit/System Testing.

⇓ **If within 10°C (18°F)**

5. Engine idling, verify the following scan tool parameters are between: −38 and +149°C (−36 and +300°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - ECT Sensor

⇒ **If not between: −38 and +149°C (−36 and +300°F)**

Refer to Circuit/System Testing.

⇓ **If between: −38 and +149°C (−36 and +300°F)**

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. Verify none of the following conditions exist:
   - A restricted or collapsed air intake duct
   - An intake manifold leak
   - A MAP sensor seal that is leaking, missing, or damaged
   - A restricted or collapsed air intake duct
   - A misaligned or damaged air intake duct
   - Any water intrusion in the induction system
   - An Intake Manifold Resonator with a leaking seal, or a cracked or broken housing

⇒ **If a condition exists**

Repair or replace component as appropriate.

⇓ **If no condition exists**

2. Ignition OFF, and all vehicle systems OFF, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air sensor.
3. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.

⇒ **If 2 Ω or greater**

3.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

3.2. Test for less than 2 Ω in the low reference circuit end to end.

⇒ If 2 Ω or greater, repair the open or high resistance in the circuit.

⇒ If less than 2 Ω replace the K20 Engine Control Module.

⇓ **If less than 2 Ω**

4. Ignition OFF, test for less than 2 Ω between the ground circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

4.1. Ignition OFF. Disconnect the sensor chassis ground.

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4.2. 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**

5.1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.

5.2. 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**

5.1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.

5.2. 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

5.3. 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**

6. Ignition ON, test for 4.8–5.2 V between the intake air temperature signal 1 circuit terminal 1 and ground.

⇒ **If less than 4.8 V**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

6.2. Test for infinite resistance between the signal circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

6.3. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 5.2 V**

Note: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

6.2. Ignition ON, test for less than 1 V between the signal circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If between 4.8–5.2 V**

7. Ignition ON, verify the scan tool IAT Sensor 1 parameter is colder than −39°C (−38°F).

⇒ **If not colder than −39°C (−38°F).**

Replace the engine control module.

⇓ **If colder than −39°C (−38°F).**

8. Ignition OFF. Install a 3 A fused jumper wire between the signal circuit terminal 1 and low reference circuit terminal 3.

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9. Ignition ON. Verify the scan tool IAT Sensor 1 parameter is warmer than 149°C (300°F).

⇒ **If not warmer than 149°C (300°F).**

Replace the K20 Engine Control Module.

⇓ **If warmer than 149°C (300°F).**

10. Ignition ON, 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**

10.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

10.2. 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

10.3. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 5.2 V**

Note: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

10.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

10.2. Ignition ON, test for less than 1 V between the signal circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If between 4.8–5.2 V**

11. Determine if *EL-38522-A* Variable Signal Generator or equivalent is available.

⇒ **EL-38522-A, Variable Signal Generator; or equivalent is not available**

11.1. Replace the K20 Engine Control Module.

11.2. 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.

11.3. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to step 15.

⇓ **If the DTC does not set**

11.4. All OK.

⇓ **EL-38522-A, Variable Signal Generator; or equivalent is available**

12. Ignition OFF, connect the leads of the *EL-38522-A* Variable Signal Generator as follows:
    - Red lead to the signal circuit terminal 8 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
13. Set the *EL-38522-A* Variable Signal Generator to the following specifications.
    - Signal switch to 5 V
    - Duty Cycle switch to 50 % (Normal)
    - Frequency switch to 30 Hz
14. Ignition ON, verify the scan tool IAT Sensor 2 parameter is between 28–32 Hz.

⇒ **If not between 28–32 Hz**

Replace the K20 Engine Control Module.

⇓ **If between 28–32 Hz**

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15. Test or replace the appropriate temperature sensor.

Component Testing

Multifunction Intake Air Sensor

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.

   Note: A thermometer can be used to test the sensor off the vehicle.
2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the Temperature Versus Resistance - Intake Air Temperature Sensor table for Hitachi Sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range**

3. All OK

Multifunction Intake Air Sensor

1. Test the IAT Sensor 2 by varying the sensor temperature while monitoring the air temperature with a thermometer. Compare the readings with the scan tool IAT Sensor 2 parameter. The values should be within 5%.

⇒ **If not within the specified range**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range**

2. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Mass Airflow Sensor with Intake Air Temperature Sensor Replacement for multifunction intake air sensor replacement.
- Control Module References for engine control module replacement, programming, and setup

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DTC P2227-P2230 (LFW, LFX)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P2227

Barometric Pressure (BARO) Sensor Performance

DTC P2228

Barometric Pressure (BARO) Sensor Circuit Low Voltage

DTC P2229

Barometric Pressure (BARO) Sensor Circuit High Voltage

DTC P2230

Barometric Pressure (BARO) Sensor Circuit Erratic

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0641, P2227, P2228	P2227, P2228	P0193, P0641, P2227, P2229	P2227
Signal	P2227, P2228	P2227, P2228	P2227, P2229	P2227
Low Reference	—	P0113, P2199, P2227, P2228, P2229	—	P2227

Typical Scan Tool Data

BARO

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition On, Engine Off **Parameter Normal Range:** 56–105 kPa (8.1–15.2 psi), varies with altitude			
5 V Reference			

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Circuit	Short to Ground	Open	Short to Voltage
	0 kPa (0 psi)	0 kPa (0 psi)	128 kPa (18.6 psi)
Signal	0 kPa (0 psi)	0 kPa (0 psi)	128 kPa (18.6 psi)
Low Reference	—	128 kPa (18.6 psi)	—

Circuit/System Description

The barometric pressure (BARO) sensor is integral to the multifunction intake air sensor and responds to changes in altitude and atmospheric conditions. This gives the ECM an indication of barometric pressure. The ECM uses this information to calculate fuel delivery. The BARO sensor provides a voltage signal to the ECM relative to the atmospheric pressure changes. The ECM monitors the BARO sensor signal for a voltage outside of the normal range.

Conditions for Running the DTC

P2227

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P2101, P2135, P2228, or P2229 is not set.
- The engine is running.

  OR
- DTC P0106, P0107, P0108, P2228, P2229, P2230, or P2610 is not set and P0107, P0108, P2228, or P2229 is not pending.
- Ignition On, engine Off
- The time between the current ignition cycle and the last time the engine was running is greater than 7 min.
- DTC P2227 runs continuously when the above conditions are met.

P2228 or P2229

- The engine is running.
- The DTCs run continuously when the above condition is met .

P2230

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P2101, P2135, P2228, or P2229 is not set.
- The ignition is On.
- DTC P2230 runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2227

- The engine is running.
- The ECM detects that the difference between the BARO signal and the calculated BARO is greater than 15 kPa (2.2 psi) if the vehicle has traveled at most 2.0 km (1.2 mi) since the last calculated BARO update, or the ECM detects that the difference between the BARO signal and the calculated BARO is greater than 20 kPa (2.9 psi) if the vehicle has traveled greater than 2.0 km (1.2 mi) since the last calculated BARO update.

  OR

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- Ignition On, engine Off
- The ECM detects that the BARO pressure is less than 50 kPa (7.3 psi) or greater than 115 kPa (16.7 psi).

P2228

The ECM detects that the BARO sensor voltage is less than 2.0 V for greater than 4 s.

P2229

The ECM detects that the BARO sensor voltage is greater than 4.5 V for greater than 4 s.

P2230

The ECM detects that the cumulative difference between BARO sensor readings, over a specific length of time, is greater than a calibrated threshold.

Action Taken When the DTC Sets

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Diagnostic Aids

Inspect the inlet port on the BARO sensor for moisture or debris and attempt to dry or clean the inlet, if contaminated.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition On.
2. Verify DTC P0106, P0107, P0108, or P0697 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 MAP Sensor parameter is within the range specified in the Altitude Versus Barometric Pressure table.

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⇒ **If not within the specified range**

Refer to DTC P0106.

⇓ **If within the specified range**

4. Verify the scan tool BARO pressure parameter is within the range specified in the Altitude Versus Barometric Pressure table.

⇒ **If not within the specified range**

Refer to Circuit/System Testing.

⇓ **If within the specified range**

5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in 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. Verify the conditions listed below do not exist with the B75C Multifunction Intake Air Sensor:
   - Damage
   - Restrictions in the inlet port

⇒ **If a condition exists**

Repair or replace the B75C Multifunction Intake Air Sensor as necessary.

⇓ **If none of the conditions exist**

2. Ignition Off, and all vehicle systems Off, it may take up to 2 minutes for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
3. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.

⇒ **If 5 Ω or greater**

3.1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.

3.2. Test for less than 2 Ω in the low reference circuit end to end.

⇒ If greater than the specified value, repair the open or high resistance in the circuit.

⇒ If 2 Ω or less replace the K20 Engine Control Module.

⇓ **If less than 5 Ω**

4. Ignition On.
5. Test for 4.8–5.2 V between the 5 V reference circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.

5.2. Test for infinite resistance between the 5 V reference circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

5.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 5.2 V**

5.1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.

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5.2. Test for less than 1 V between the 5 V reference circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If between 4.8–5.2 V**

6. Verify the scan tool BARO Sensor parameter is less than 0.2 V.

⇒ **If 0.2 V or greater**

6.1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.

6.2. Test for less than 1 V between the signal circuit terminal 4 and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If less than 0.2 V**

7. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 2.

8. Verify the scan tool BARO Sensor parameter is greater than 4.5 V.

⇒ **If 4.5 V or less**

8.1. Ignition Off, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.

8.2. Test for infinite resistance between the signal circuit terminal 4 and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

8.3. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If greater than 4.5 V**

9. Test or replace the B75C Multifunction Intake Air Sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Mass Airflow Sensor with Intake Air Temperature Sensor Replacement for multifunction intake air sensor replacement
- Control Module References for engine control module replacement, programming, and setup

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DTC P2227-P2230 (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P2227

Barometric Pressure (BARO) Sensor Performance

DTC P2228

Barometric Pressure (BARO) Sensor Circuit Low Voltage

DTC P2229

Barometric Pressure (BARO) Sensor Circuit High Voltage

DTC P2230

Barometric Pressure (BARO) Sensor Circuit Erratic

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0651, P2227, P2228	P2228	P0651, P2229	P2227
Signal	P2227, P2228	P2227, P2228	P2227, P2229	P2227
Low Reference	—	P2227, P2229	—	P2227

Typical Scan Tool Data

BARO

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON, Engine OFF **Parameter Normal Range:** 56–105 kPa (8.1–15.2 psi), varies with altitude			
5 V Reference	0 kPa (0 psi)	0 kPa (0 psi)	127 kPa (18.4 psi)
Signal	0 kPa (0 psi)	0 kPa (0 psi)	127 kPa (18.4 psi)

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Circuit	Short to Ground	Open	Short to Voltage
Low Reference	—	127 kPa (18.4 psi)	—

Circuit/System Description

The barometric pressure (BARO) sensor is integral to the throttle inlet absolute pressure sensor and responds to changes in altitude and atmospheric conditions. This gives the engine control module (ECM) an indication of barometric pressure. The ECM uses this information to calculate fuel delivery. The BARO sensor provides a voltage signal to the ECM relative to the atmospheric pressure changes. The ECM monitors the BARO sensor signal for a voltage outside of the normal range.

Conditions for Running the DTC

P2227

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P1516, P2135, P2228, or P2229 is not set.
- The engine is running.
  OR
- DTC P0106, P0107, P0108, P2228, P2229, P2230, or P2610 is not set or pending.
- Ignition ON, engine OFF
- DTC P2227 runs continuously when the above conditions are met.

P2228 or P2229

- The engine is running.
- The DTCs run continuously when the above condition is met .

P2230

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P1516, P2135, P2228, or P2229 is not set.
- The engine is running.
- DTC P2230 runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2227

- The ECM detects that the difference between the BARO signal and the calculated BARO is greater than 15 kPa (2.2 psi) if the vehicle has traveled at most 2 km (1.24 mi) since the last calculated BARO update, or the ECM detects that the difference between the BARO signal and the calculated BARO is greater than 20 kPa (2.9 psi) if the vehicle has traveled greater than 2 km (1.24 mi) since the last calculated BARO update.
  OR
- The ECM detects that the BARO pressure is less than 44 kPa (6.4 psi) or greater than 115 kPa (16.7 psi).

P2228

The ECM detects that the BARO sensor voltage is less than 1.7 V for greater than 5 s.

P2229

The ECM detects that the BARO sensor voltage is greater than 4.5 V for greater than 5 s.

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P2230

The ECM detects that the cumulative difference between BARO sensor readings, over a specific length of time, is greater than a calibrated threshold.

Action Taken When the DTC Sets

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0641 is not set.

⇒ **If the DTC is set**
Refer to DTC P0641, P0651, P0697, or P06A3.

⇓ **If the DTC is not set**

3. Verify the scan tool BARO parameter is within range specified in the Altitude Versus Barometric Pressure table.

⇒ **If the BARO is not within the specified range**
Refer to Circuit/System Testing.

⇓ **If the BARO is within the specified range**

4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.

⇒ **If the DTC sets**
Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

6. All OK.

Circuit/System Testing

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1. Verify the conditions listed below do not exist with the B192 Throttle Inlet Absolute Pressure sensor:
    - Damage
    - Restrictions in the inlet port

⇒ **If a condition is found**

Repair or replace as necessary.

⇓ **If no condition is found**

2. Ignition OFF, and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down. Disconnect the harness connector at the B192 Throttle Inlet Absolute Pressure sensor.
3. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 5 Ω or greater**

3.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

3.2. Test for less than 2 Ω in the low reference circuit end to end.

⇒ If greater than the specified value, repair the open or high resistance in the circuit.

⇒ If 2 Ω or less replace the K20 Engine Control Module.

⇓ **If less than 5 Ω**

4. Ignition ON.
5. Test for 4.8–5.2 V between the 5 V reference circuit terminal 1 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. Test for infinite resistance between the 5 V reference circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

5.3. Test for less than 2 Ω in the 5 V reference circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 5.2 V**

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.

5.2. Test for less than 1 V between the 5 V reference circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If between 4.8–5.2 V**

6. Verify the scan tool BARO Sensor parameter is less than 0.2 V.

⇒ **If 0.2 V or greater**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.

6.2. 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, replace the K20 Engine Control Module.

⇓ **If less than 0.2 V**

7. Install a 3 A fused jumper wire between the signal circuit terminal 3 and the 5 V reference circuit terminal 1.
8. Verify the scan tool BARO Sensor parameter is greater than 4.5 V.

⇒ **If 4.5 V or less**

8.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

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8.2. 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

8.3. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open or high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If greater than 4.5 V**

9. Test or replace the B192 Throttle Inlet Absolute Pressure sensor.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Throttle Inlet Absolute Pressure Sensor Replacement
- Control Module References for engine control module replacement, programming and setup

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DTC P2269

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P2269

Water in Fuel

Circuit/System Description

Alcohol content information is supplied to the Engine Control Module from the Fuel Composition Sensor. The Fuel Composition Sensor has a battery positive circuit, a signal circuit, and a ground circuit. The Fuel Composition Sensor uses a microprocessor inside the sensor to measure the ethanol percentage and changes the output signal accordingly. The signal circuit carries the ethanol percentage via the frequency signal. The ECM provides an internal pull up to 5 V on the signal circuit, and the Fuel Composition Sensor pulls the 5 V to ground in pulses. The normal range of operating frequency is between 50–150 Hz. The microprocessor inside the sensor is capable of a certain amount of self-diagnosis. An output frequency between 180 Hz and 190 Hz indicates that the fuel is contaminated.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The Engine Control Module detects that the Fuel Composition Sensor output frequency is greater than 185 Hz for greater than 6 s.

Action Taken When the DTC Sets

DTC P2269 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P2269 is a Type B DTC.

Diagnostic Aids

A momentary slug of water in the fuel system may set this DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

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

Special Tools

- *J 38522* Variable Signal Generator
- *J 44175–A* Fuel Composition Tester

For equivalent regional tools, refer to Special Tools.

Circuit/System Verification

1. Engine running, verify the scan tool Fuel Composition Sensor parameter is between 50–150 Hz.

⇒ **If not within the specified range**

Refer to Circuit/System Testing.

⇓ **If within the specified range**

2. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

⇒ **If DTC is set**

Refer to Circuit/System Testing.

⇓ **If DTC is not set**

3. All OK.

Circuit/System Testing

1. Verify that there are no contaminants, water, or too high of a concentration of ethanol in the fuel. Refer to Alcohol/Contaminants-in-Fuel Diagnosis and the *CH 44175–A* Instruction Manual.

⇒ **If the fuel tested is not within acceptable levels**

Refer to Fuel System Cleaning

⇓ **If the fuel tested is within acceptable levels**

2. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B198 Fuel Composition Sensor. It may take up to 2 minutes for all vehicle systems to power down.
3. Test for less than 5 Ω between the ground circuit terminal 2 and ground.

⇒ **If 5 Ω or greater**

3.1. Ignition OFF.

3.2. Test for less than 2 Ω in the ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, repair the ground connection.

⇓ **If less than 5 Ω**

4. Ignition ON, verify that a test lamp illuminates between the B+ circuit terminal 1 and ground.

⇒ **If the test lamp does not illuminate and the fuse is not opened**

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4.1. Ignition OFF, remove the test lamp.

4.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is good and voltage is supplied to the fuse.

⇒ **If the test lamp does not illuminate and the fuse is opened**

4.1. Ignition OFF, remove the test lamp.

4.2. Test for infinite resistance between the B+ circuit and ground

⇒ If less than infinite, repair the short to ground in the circuit.

⇒ If infinite, test all the components connected to the circuit, and repair or replace as necessary.

⇓ **If the test lamp illuminates**

5. Ignition ON, test for 4.8–5.2 V between the signal circuit terminal 3 and ground.

⇒ **If less than the specified range**

5.1. Ignition OFF, disconnect the harness connector X1 at the K20 Engine Control Module.

5.2. 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, test or replace the K20 Engine Control Module.

⇒ **If greater than the specified range**

5.1. Ignition OFF, disconnect the harness connector X1 at the K20 Engine Control Module, ignition ON.

5.2. Test for less than 1 V between the signal circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, test or replace the K20 Engine Control Module.

⇓ **If within the specified range**

6. Ignition OFF, connect the red lead of the *EL 38522–A* Variable Signal Generator to the signal circuit terminal 3 at the B198 Fuel Composition Sensor harness connector. Connect the battery voltage supply to B+, and the black lead to ground.
7. Set the *EL 38522–A* Variable Signal Generator Signal to 5 V, the Frequency to 60 Hz, and the Duty Cycle to Normal.
8. Ignition ON, verify the scan tool Fuel Composition Sensor parameter is at 60 Hz.

⇒ **If not the specified value**

Test or replace the K20 Engine Control Module.

⇓ **If the specified value**

9. Test or replace the B198 Fuel Composition Sensor.

Component Testing

1. Test the fuel composition using the *CH 44175–A* Alcohol Tester Kit and the CH 44175–A Instruction Manual. Record the frequency.
2. Compare the special tool test frequency and the scan tool Fuel Composition Sensor frequency parameter.
3. Verify the difference between the tool and the sensor is 12 Hz or less.

⇒ **If greater than the specified value**

Replace the B198 Fuel Composition Sensor.

⇓ **If less than the specified value**

4. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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- Flexible Fuel Sensor Replacement
- Fuel System Cleaning
- Control Module References for K20 Engine Control Module programming, replacement, and setup.

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DTC P2269 (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 P2269

Fuel Conductivity Out Of Range

Circuit/System Description

When Warm Up Mode is activated, the fuel injector control module will vary the requested torque signal sent to the engine control module (ECM) requesting a reduction in engine torque. The requested torque signal has a square wave 50% duty cycle. The frequency of the signal will vary from 50 Hz to 150 Hz. The ECM provides an internal pull up to 5 V on the signal circuit, and the fuel injector control module pulls the 5 V to ground in pulses.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects that the requested torque signal output frequency is greater than 155 Hz for greater than 6 s.

Action Taken When the DTC Sets

DTC P2269 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P2269 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG System Description and Operation

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- 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

Special Tools

J 38522 Variable Signal Generator

For equivalent regional tools, refer to Special Tools.

Circuit/System Verification

1. Engine running.
2. Verify the scan tool Fuel Injector Control Module Requested Torque parameter is between 50–150 Hz.

⇒ **If not between 50–150 Hz**

Refer to Circuit/System Testing

⇓ **If between 50–150 Hz**

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. It may take up to 2 minutes for all vehicle systems to power down. Disconnect the harness connector at the A714 fuel injector control module.
2. Test for less than 5 Ω between the ground circuit terminal X1–21 and ground.

⇓ **If 5 Ω or greater**

2.1. Ignition OFF.

2.2. Test for less than 2 Ω in the ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit

⇒ If less than 2 Ω, repair the open/high resistance in the ground connection.

3. Ignition ON.
4. Verify that a test lamp illuminates between the B+ circuit terminal X1–22 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is OK**

4.1. Ignition OFF.

4.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit

⇒ If less than 2 Ω, verify the fuse is OK and there is voltage at the fuse.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

4.1. Ignition OFF.

4.2. Test for infinite resistance between the B+ circuit and ground.

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⇒ If less than infinite resistance, repair the short to ground in the circuit.

⇒ If infinite resistance, replace the A714 fuel injector control module.

⇓ **If the test lamp illuminates**

5. Ignition ON.
6. Test for 4.8–5.2 V between the signal circuit terminal X2–1 and ground.

⇒ **If less than 4.8 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.

6.2. Test for infinite resistance between the signal circuit and ground.

⇒ If less than infinite resistance, repair the short to ground in the circuit.

⇓ If infinite resistance

6.3. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 engine control module.

⇒ **If greater than 5.2 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.

6.2. Ignition ON.

6.3. 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, replace the K20 engine control module.

⇓ **If between 4.8–5.2 V**

7. Ignition OFF, connect the red lead of the *J 38522* Variable Signal Generator to the signal circuit terminal X2–1 at the A714 fuel injector control module harness connector.
8. Connect the battery voltage supply to B+, and the black lead to ground.
9. Set the *J 38522* Variable Signal Generator Signal to 5 V, the Frequency to 60 Hz, and the Duty Cycle to Normal.
10. Ignition ON.
11. Verify the scan tool Fuel Injector Control Module Requested Torque parameter is at 60 Hz.

⇒ **If not at the specified value**

Replace the K20 engine control module.

⇓ **If the specified value**

12. Test or replace the A714 fuel injector control module.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Control Module References for engine control module or fuel injector control module programming, replacement, and setup.

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DTC P2544

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for a overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptors

DTC P2544

Transmission Torque Request Signal Message Counter Incorrect

Circuit/System Description

To improve shift feel, the transmission control module (TCM) is constantly sending the engine control module (ECM) serial data messages with 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

- 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.

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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

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DTC P2635

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

DTC Descriptor

DTC P2635

Fuel Pump Flow Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0231	P023F	P0232	P023F, P2635
Low Reference	—	P023F	—	P023F, P2635

Circuit/System Description

The engine control module (ECM) supplies voltage to the chassis control module when the ECM detects that the ignition is on. The voltage from the ECM to the chassis control module remains active for two seconds, unless the engine is in crank or run. While this voltage is being received, the chassis control module closes the ground switch of the fuel pump and also supplies a varying voltage to the fuel tank pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

- DTC P018B, P018C, P018D, P0231, P0232, P023F, P064A, P1255 or P06A6 are not active.
- DTC P0641 has not failed this ignition cycle.
- Fuel pump control is enabled and the fuel pump control state is normal.
- The system voltage is greater than 11 V.
- The engine has been running for more than 30 seconds.
- Low fuel level warning not present.

Conditions for Setting the DTC

This DTC sets when the chassis control module detects a predetermined fuel pressure performance degradation between the desired fuel pressure and the current fuel pressure.

Action Taken When the DTC Sets

DTC P2635 is a Type B DTC.

Conditions for Clearing the DTC

DTC P2635 is a Type B DTC.

Diagnostic Aids

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Using the failure records data may help locate an intermittent condition. If you cannot duplicate the DTC, the information in the failure records can help determine how many miles since the DTC set. The fail counter and pass counter can help determine how many ignition cycles that the diagnostic test reported a pass and/or a fail.

On vehicles equipped with a high pressure mechanical pump on direct injection engines, the vehicle may continue to run even though the pump in the fuel tank is not operating.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

Note: Do not replace the chassis control module based on a history DTC P2635. The DTC P2635 may be stored but that does not indicate a failure of the chassis control module. Refer to Strategy Based Diagnosis for further history DTC diagnostics.

1. Ignition ON.
2. Verify DTC U18A2 is not set or stored in history.

⇒ **If DTC U18A2 is set or stored in history**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If DTC U18A2 is not set or stored in history**

3. Verify DTC P018B, P018C, P018D, P0231, P0232 or P023F is not set.

⇒ **If any of the DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If none of the DTCs are set**

4. Verify the proper fuel system pressure. Perform the fuel system pressure test, refer to Fuel System Diagnosis.

⇒ **If the fuel system pressure test is not normal**

Replace the A7 Fuel Pump and Level Sensor Assembly.

⇓ **If the fuel system pressure test is normal**

5. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the A7 Fuel Pump and Level Sensor Assembly. It may take up to 2 minutes for all vehicle systems to power down.

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6. Test for less than 10 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 10 Ω or greater**

6.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module.

6.2. Test for less than 2 Ω in the low reference circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K38 Chassis Control Module.

⇓ **If less than 10 Ω**

7. Connect a test lamp between the control circuit terminal 1 and the low reference circuit terminal 2.
8. Ignition ON.
9. Verify the test lamp turns ON and OFF when commanding the fuel pump ON and OFF using the scan tool ECM fuel pump enable control function.

⇒ **If the test lamp is always OFF**

9.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module.

9.2. 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

9.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K38 Chassis Control Module.

⇒ **If the test lamp is always ON**

9.1. Ignition OFF, disconnect the harness connector at the K38 Chassis Control Module, ignition ON.

9.2. Test for less than 1 V between the control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K38 Chassis Control Module.

⇓ **If the test lamp turns ON and OFF**

10. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Control Module References for K38 Chassis Control Module replacement, programming, and setup.

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Symptoms - Engine Controls (Except LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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.

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.

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Lack of Power, Sluggishness, or Sponginess

The engine delivers less than expected power. Little or no increase in vehicle speed when the accelerator pedal is pushed down part way.

Poor Fuel Economy

Fuel economy, as measured by an actual road test, is noticeably lower than expected. Also, the fuel economy is noticeably lower than it was on this vehicle at one time, as previously shown by an actual road test.

Rough, Unstable, or Incorrect Idle and Stalling

The engine runs unevenly at idle. If severe, the engine or the vehicle may shake. Engine idle speed may vary. Either condition may be severe enough to stall the engine.

Surges/Chuggles

An engine power variation under steady throttle or cruise. Feels like the vehicle speeds up and slows down with no change in the accelerator pedal position.

Symptoms Verification

Before using the Symptom tables, perform the following inspections:

- Verify the malfunction indicator lamp (MIL) is operating correctly. Use the scan tool to command the lamp ON and OFF.
- Verify there are no DTCs that are stored.
- Verify the scan tool data is within a normal operating range. Refer to Control Module References for scan tool information.
- Verify the customer concern.
- Perform the Visual/Physical Inspection in this section. The visual/physical inspection is extremely important, and can lead to correcting a condition without additional testing. It may also help reveal the cause of an intermittent condition.

Identifying Intermittent Conditions

Many intermittent conditions occur with harness or connector movement due to engine torque, rough pavement, vibration or physical movements of a component. Refer to the following for a list of issues that may cause an intermittent condition:

- Moisture and water intrusion in connectors, terminals, and components
- Incomplete connector mating
- Poor terminal contact
- High circuit or component resistance—High resistance can include any resistance, regardless of the amount, which can interrupt the operation of the component.
- Harness that is too short or tight
- Wire insulation that is chaffed or cut
- High or low ambient temperature
- High or low engine coolant temperatures
- High underhood temperatures
- Heat build up in component or circuit due to circuit resistance, poor terminal contact, or high electrical load
- High or low system voltage
- High vehicle load conditions
- Rough road surfaces
- Electro-magnetic interference (EMI)/circuit interference from relays, solenoids or other electrical surge

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- Incorrect installation of aftermarket, add on accessories

Visual/Physical Check

- Verify the control module grounds are clean, tight, and correctly located.
- Verify the vacuum hoses are not split or kinked, and are properly connected.
- Verify the air filter is clean and free from restrictions.
- Verify there is no water intrusion in connectors terminals and components.
- Inspect the air intake ducts for the following conditions:
  - Collapsed
  - Damaged areas
  - Looseness
  - Incorrect installation
  - Leaking
- Inspect for air leaks at the throttle body mounting area, the mass air flow (MAF) sensor and intake manifold sealing surfaces.
- Inspect the wiring harness for the following conditions:
  - Poor connections
  - Pinches
  - Cuts
- Inspect for loose, damaged, unseated, or missing sensors/components.
- Inspect the terminals for corrosion and correct contact.

Symptoms Testing

Backfire, Cuts Out/Misses, Detonation/Spark Knock, Dieseling/Run-On, Engine Control Module Commanded Reduced Engine Power, Hard Start, Hesitation/Sag/Stumble, Lack of Power/Sluggishness/Sponginess, Poor Fuel Economy, Rough, Unstable, or Incorrect Idle and Stalling, or Surges/Chuggles

- Test the fuel system for the following:
  - Incorrect fuel system operation and pressure—Refer to Fuel System Diagnosis.
  - Improperly operating fuel injectors—Refer to Fuel Injector Solenoid Coil Test.
  - Poor fuel quality condition—Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
- Test the ignition system for the following:
  - Spark plugs with incorrect heat range or an abnormal condition—Refer to Spark Plug Inspection and Ignition System Specifications.
  - Coolant or oil fouled spark plugs—For diagnosis, refer to Coolant in Combustion Chamber or Oil Consumption Diagnosis.
  - Secondary ignition system susceptible to water. Engine running, wet down the secondary ignition system with water from a spray bottle to help locate damaged or deteriorated components. Look/listen for arcing or misfiring as the water is applied.
  - Weak spark using the *J 26792* HEI spark tester—Refer to Electronic Ignition System Diagnosis.
- Inspect for the following conditions:
  - Improper operation of the transmission torque converter clutch (TCC) — The scan tool should indicate an engine speed drop when the TCC is commanded ON. Refer to Torque Converter Diagnosis.
  - Improper operation of the 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 heated oxygen sensors should respond quickly to different throttle positions.

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Caution: Refer to Heated Oxygen and Oxygen Sensor Caution
- Water intrusion in the heated oxygen sensor connectors.

Note: The embossed arrows on the mass air flow (MAF) sensor indicate the direction of the intake air flow. The arrows must point toward the engine.
- Improper mass air flow sensor installation. A mass air flow sensor that is incorrectly installed may cause a hard start. Install the mass air flow sensor in the proper direction. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Improper mass air flow sensor connections.
- Engine oil contaminated by fuel
- Split or kinked vacuum hoses—Verify that the routing and connections are correct.
- Excessive knock sensor system spark retard activity—Observe the scan tool Knock Retard parameter for activity greater than 0°.

- Inspect the exhaust system components for the following:
  - Physical damage or possible internal failure
  - Restricted three-way catalytic converters

  For more information, refer to Symptoms - Engine Exhaust.
- Inspect for electromagnetic interference (EMI) on a reference circuit, which can cause a misfire condition. You can usually detect electromagnetic interference with a scan tool by monitoring the engine speed parameter. A sudden increase in the engine speed parameter with little change in actual engine speed indicates that electromagnetic interference is present. Inspect the high voltage components near the ignition control circuit if a condition exists.
- Inspect for an improperly operating crankcase ventilation valve—Refer to Crankcase Ventilation System Inspection/Diagnosis.
- Inspect for a stuck open evaporative emission (EVAP) canister purge solenoid
- Inspect the engine cooling system for the following conditions:
  - A thermostat with an incorrect heat range—Refer to Thermostat Diagnosis.
  - Improper engine coolant level—If the level is low, refer to Loss of Coolant.
- Inspect the crankshaft position sensor for an intermittent condition—Observe the scan tool CKP 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 engine control module
- Inspect the engine for the following mechanical failures:

  Refer to Symptoms - Engine Mechanical.
  - Excessive oil in the combustion chamber or leaking valve seals
  - Oil consumption
  - Incorrect cylinder compression
  - Sticking or leaking valves
  - Worn camshaft lobes
  - Incorrect valve timing
  - Worn rocker arms
  - Broken valve springs
  - Excessive carbon buildup in the combustion chambers—Clean the chambers with top engine cleaner, if necessary. Follow the instructions on the can.
  - Incorrect engine parts
- If the above conditions do not address the symptom, refer to the additional symptoms tests.

Additional Symptoms Tests

Detonation/Spark Knock

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- Test for an engine overheating condition. Refer to Engine Overheating.
- Verify that the engine coolant temperature sensor has not shifted in value. Allow the engine to run and reach operating temperature. Observe the ECT Sensor parameter with a scan tool and compare the reading to that parameter listed on the K20 Engine Control Module: Scan Tool Information list. If the reading is not in the range specified in the list, test the resistance of the engine coolant temperature sensor. Refer to Temperature Versus Resistance - Engine Coolant Temperature Sensor for resistance specifications. Replace the engine coolant temperature sensor if the resistance is not within specification. Refer to Engine Coolant Temperature Sensor Replacement. If the sensor is within the specification, test the engine coolant temperature sensor circuits for high resistance.
- Inspect for excessive carbon buildup in the combustion chambers. Clean the chambers with Top Engine Cleaner, if necessary. Follow the instructions on the can.
- If there are no engine mechanical faults, fill the fuel tank with a known high quality fuel that meets the vehicle minimum octane requirements.

Engine Control Module Commanded Reduced Engine Power

Under certain conditions the engine control module may limit engine power by reducing engine torque and, for some vehicles, fuel pressure as well. For most, but not all of the conditions, the engine control module will illuminate the reduced engine power lamp on the instrument cluster. If equipped with the driver information center feature, a reduced engine power message may be displayed as well. 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 engine control module to reduce engine power. Refer to Cooling Fan Description and Operation and Cooling System Description and Operation to verify correct operation of the cooling fan.
- A condition with the throttle actuator control (TAC) system. Refer to DTC P1516, P2101, P2119, or P2176 and Throttle Actuator Control (TAC) System Description for further diagnosis.

Fuel Odor

- Inspect for a saturated EVAP canister—Refer to Evaporative Emission Control System Description.
- Inspect for leaking, damaged, or deteriorated fuel lines.
- Inspect for a condition with the internal components of the fuel tank assembly—Refer to Fuel System Description.

Hard Start

- Observe the TB Idle Airflow Compensation parameter with a scan tool. A value of 90 % may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to Throttle Body Inspection and Cleaning.
- Test the engine coolant temperature (ECT) sensor. Compare the scan tool ECT Sensor value to the scan tool intake air temperature (IAT) sensor value on a cold engine. The ECT and IAT Sensor values should be within ± 3°C (5°F). If the engine coolant

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temperature sensor is out of range with the intake air temperature sensor, test the resistance of the engine coolant temperature sensor. Refer to Temperature Versus Resistance - Engine Coolant Temperature Sensor for resistance specifications. Replace the engine coolant temperature sensor if the resistance is not within specification. Refer to Engine Coolant Temperature Sensor Replacement. If the sensor is within the specification, test the engine coolant temperature sensor circuits for high resistance.

- Verify that the fuel system has adequate pressure for engine start-up. With a scan tool, compare the Fuel Pressure Sensor parameter value to the Desired Fuel Pressure parameter value when the ignition key is first turned to ON. Refer to Fuel System Diagnosis.
- Inspect for excessive crankshaft endplay that will cause the crankshaft position sensor reluctor wheel to move out of alignment with the crankshaft position sensor. Refer to Crankshaft and Bearing Cleaning and Inspection and Engine Mechanical Specifications.

Hesitation, Sag, Stumble

- Test the fuel pressure. Refer to Fuel System Diagnosis.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Test the generator. Refer to Symptoms - Engine Electrical. Repair the charging system if the generator output voltage is less than 9 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 and Engine Mechanical Specifications.

  Note: The following actions may need to be repeated in order to verify an intermittent intake or exhaust camshaft actuator condition.
- Engine warm and idling, verify the correct operation of the camshaft actuator system. Command the intake and exhaust camshaft actuators for each cylinder bank from 0 degrees to 20 degrees and back to zero while observing the appropriate scan tool Int. CMP Variance and Exh. CMP Variance parameters. Each parameter should be less than 2 degrees in each of the commanded states.

  ⇒ If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to Camshaft Timing Drive Components Cleaning and Inspection and Camshaft Actuator System Description for additional information.

Lack of Power, Sluggishness, or Sponginess

- Inspect the engine electrical system for correct operation. Refer to Symptoms - Engine Electrical.
- Verify that each injector harness is connected to the correct injector.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.

  Note: The following actions may need to be repeated in order to verify an intermittent intake or exhaust camshaft actuator condition.
- Engine warm and idling, verify the correct operation of the camshaft actuator system. Command the intake and exhaust camshaft actuators for each cylinder bank from 0 degrees to 20 degrees and back to zero while observing the appropriate scan tool Int. CMP Variance and Exh. CMP Variance parameters. Each parameter should be less than 2 degrees in each of the commanded states.

  ⇒ If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to Camshaft Timing Drive Components Cleaning and Inspection and Camshaft Actuator System Description for additional information.

Poor Fuel Economy

- Inspect for heavy loads being carried or towed
- Inspect for acceleration rate too much or too often

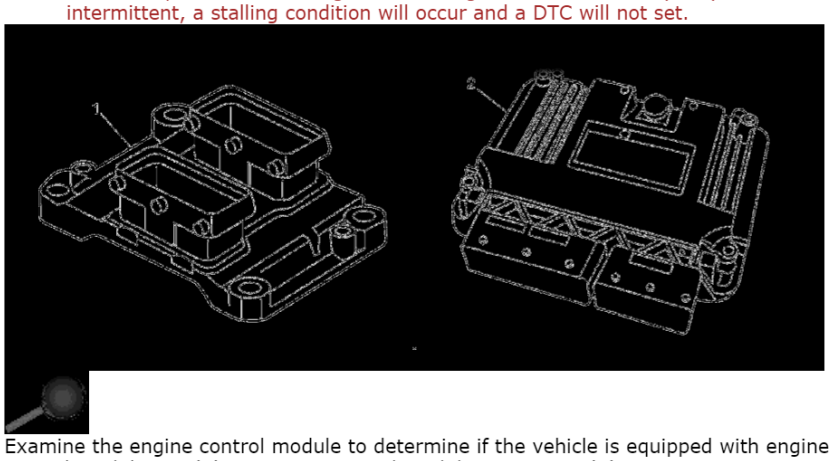
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- Inspect for incorrect operation of the speedometer.
- Verify that the engine coolant temperature (ECT) has not shifted in value. Allow the engine to run and reach operating temperature. Observe the ECT Sensor parameter with a scan tool and compare the reading to the parameter listed in the K20 Engine Control Module: Scan Tool Information list. If the reading is not in the range specified in the list, test the resistance of the engine coolant temperature sensor. Refer to Temperature Versus Resistance - Engine Coolant Temperature Sensor for resistance specifications. Replace the engine coolant temperature sensor if the resistance is not within specification. Refer to Engine Coolant Temperature Sensor Replacement. If the sensor is within the specification, test the engine coolant temperature sensor circuits for high resistance.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Observe the TB Idle Airflow Compensation parameter with a scan tool. A value of 90 % may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to Throttle Body Inspection and Cleaning.
- Inspect the brake system for brake drag.

Rough, Unstable, or Incorrect Idle and Stalling

- Observe the TB Idle Airflow Compensation parameter with a scan tool. A value of 90 % may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to Throttle Body Inspection and Cleaning.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Inspect the engine mounts. Refer to Engine Mount Inspection.

  Note: The engine control module (ECM) uses either the bank 1 intake camshaft position sensor, or the bank 1 exhaust camshaft position sensor to determine injector and ignition system synchronization, as well as to determine camshaft to crankshaft relationship. If the sensor signal to the engine control module (ECM) is intermittent, a stalling condition will occur and a DTC will not set.



- Examine the engine control module to determine if the vehicle is equipped with engine control module E55 (1), or engine control module E69 or E77 (2).
  - ⇒ If the vehicle is equipped with engine control module E55, E69, or E77, inspect the bank 1 intake camshaft position sensor wiring and connectors for poor connections—Refer to Inducing Intermittent Fault Conditions for further diagnosis.
  - ⇒ If the vehicle is NOT equipped with engine control module E55, E69, or E77, inspect the bank 1 exhaust camshaft position sensor wiring and connectors for poor connections—Refer to Inducing Intermittent Fault Conditions for further diagnosis.

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- Inspect the intake and exhaust manifolds for casting flash.
- An excessively high idle may be due to the floor mat interfering with the accelerator pedal. With this condition present, it may not be possible to shift the transmission into gear. Inspect the accelerator pedal for binding and verify that the floor mat is not interfering with the accelerator pedal movement.

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.
- Inspect for slow responding heated oxygen sensors (HO2S). The heated oxygen sensors should respond quickly to a change in throttle position. If the heated oxygen sensors do not respond to different throttle positions, inspect for contamination from fuel, silicon, or the incorrect use of 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 engine control module reduces the amount of fuel delivered to the engine, causing a driveability condition.
- Verify that each fuel injector harness is connected to the correct fuel injector.

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Symptoms - Engine Controls (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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.

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.

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Lack of Power, Sluggishness, or Sponginess

The engine delivers less than expected power. Little or no increase in vehicle speed when the accelerator pedal is pushed down part way.

Poor Fuel Economy

Fuel economy, as measured by an actual road test, is noticeably lower than expected. Also, the fuel economy is noticeably lower than it was on this vehicle at one time, as previously shown by an actual road test.

Rough, Unstable, or Incorrect Idle and Stalling

The engine runs unevenly at idle. If severe, the engine or the vehicle may shake. Engine idle speed may vary. Either condition may be severe enough to stall the engine.

Surges/Chuggles

An engine power variation under steady throttle or cruise. Feels like the vehicle speeds up and slows down with no change in the accelerator pedal position.

Symptoms Verification

Before using the Symptom tables, perform the following inspections:

- Verify the malfunction indicator lamp (MIL) is operating correctly. Use the scan tool to command the lamp ON and OFF.
- Verify there are no DTCs that are stored.
- Verify the scan tool data is within a normal operating range. Refer to Control Module References for scan tool information.
- Verify the customer concern.
- Perform the Visual/Physical Inspection in this section. The visual/physical inspection is extremely important, and can lead to correcting a condition without additional testing. It may also help reveal the cause of an intermittent condition.

Identifying Intermittent Conditions

Many intermittent conditions occur with harness or connector movement due to engine torque, rough pavement, vibration or physical movements of a component. Refer to the following for a list of issues that may cause an intermittent condition:

- Moisture and water intrusion in connectors, terminals, and components
- Incomplete connector mating
- Poor terminal contact
- High circuit or component resistance—High resistance can include any resistance, regardless of the amount, which can interrupt the operation of the component.
- Harness that is too short or tight
- Wire insulation that is chaffed or cut
- High or low ambient temperature
- High or low engine coolant temperatures
- High underhood temperatures
- Heat build up in component or circuit due to circuit resistance, poor terminal contact, or high electrical load
- High or low system voltage
- High vehicle load conditions
- Rough road surfaces
- Electro-magnetic interference (EMI)/circuit interference from relays, solenoids or other electrical surge

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- Incorrect installation of aftermarket, add on accessories

Visual/Physical Check

- Verify the control module grounds are clean, tight, and correctly located.
- Verify the vacuum hoses are not split or kinked, and are properly connected.
- Verify the air filter is clean and free from restrictions.
- Verify there is no water intrusion in connectors terminals and components.
- Verify that the liquid propane gas (LPG) manual shut-off valve is fully open.
- Inspect the air intake ducts for the following conditions:
  - Collapsed
  - Damaged areas
  - Looseness
  - Incorrect installation
  - Leaking
- Inspect for air leaks at the throttle body mounting area, the mass air flow (MAF) sensor and intake manifold sealing surfaces.
- Inspect for leaking, damaged, or deteriorated liquid propane gas (LPG) fuel lines and components.
- Inspect the wiring harness for the following conditions:
  - Poor connections
  - Pinches
  - Cuts
- Inspect for loose, damaged, unseated, or missing sensors/components.
- Inspect the terminals for corrosion and correct contact.

Symptoms Testing

Backfire, Cuts Out/Misses, Detonation/Spark Knock, Dieseling/Run-On, ECM Commanded Reduced Engine Power, Hard Start, Hesitation/Sag/Stumble, Lack of Power/Sluggishness/Sponginess, Poor Fuel Economy, Rough, Unstable, or Incorrect Idle and Stalling, or Surges/Chuggles

- Test the fuel system for the following:
  - Incorrect liquid propane gas (LPG) fuel system operation and pressure—Refer to Fuel System Diagnosis.
  - Improperly operating liquid propane gas (LPG) fuel injectors. Refer to Fuel Injector Solenoid Coil Test and Fuel System Diagnosis
- Test the ignition system for the following:
  - Spark plugs with incorrect heat range or an abnormal condition—Refer to Spark Plug Inspection and Ignition System Specifications.
  - Coolant or oil fouled spark plugs—For diagnosis, refer to Coolant in Combustion Chamber or Oil Consumption Diagnosis.
  - Secondary ignition system susceptible to water. Engine running, wet down the secondary ignition system with water from a spray bottle to help locate damaged or deteriorated components. Look/listen for arcing or misfiring as the water is applied.
  - Weak spark using the *J 26792* HEI spark tester—Refer to Electronic Ignition System Diagnosis.
- Inspect for the following conditions:
  - Improper operation of the transmission torque converter clutch (TCC) — The scan tool should indicate an engine speed drop when the transmission torque converter clutch is commanded ON. Refer to Torque Converter Diagnosis.
  - Improper operation of the A/C compressor

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- An engine that runs lean or rich—Observe the Fuel Trim parameters with a scan tool.
- Slow responding heated oxygen sensors (HO2S)—The heated oxygen sensors should respond quickly to different throttle positions.

  Caution: Refer to Heated Oxygen and Oxygen Sensor Caution
- Water intrusion in the heated oxygen sensor connectors.

  Note: *The* embossed arrows on the mass air flow (MAF) sensor indicate the direction of the intake air flow. The arrows must point toward the engine.
- Improper mass air flow sensor installation. A mass air flow sensor that is incorrectly installed may cause a hard start. Install the mass air flow sensor in the proper direction. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Improper mass air flow sensor connections.
- Split or kinked vacuum hoses—Verify that the routing and connections are correct.
- Excessive knock sensor system spark retard activity—Observe the scan tool Knock Retard parameter for activity greater than 0°.

- Inspect the exhaust system components for the following:
  - Physical damage or possible internal failure
  - Restricted three-way catalytic converters

  For more information, refer to Symptoms - Engine Exhaust.
- Inspect for electromagnetic interference (EMI) on a reference circuit, which can cause a misfire condition. You can usually detect electromagnetic interference with a scan tool by monitoring the engine speed parameter. A sudden increase in the engine speed parameter with little change in actual engine speed indicates that electromagnetic interference is present. Inspect the high voltage components near the ignition control circuit if a condition exists.
- Inspect for an improperly operating crankcase ventilation valve—Refer to Crankcase Ventilation System Inspection/Diagnosis.
- Inspect for a stuck open evaporative emission (EVAP) canister purge solenoid
- Inspect the engine cooling system for the following conditions:
  - A thermostat with an incorrect heat range—Refer to Thermostat Diagnosis.
  - Improper engine coolant level—If the level is low, refer to Loss of Coolant.
- Inspect the crankshaft position sensor for an intermittent condition—Observe the scan tool CKP Resync Counter parameter. The Resync Counter parameter should remain at 0 during all operating conditions, and when moving the related harnesses and connectors between the crankshaft position sensor and the ECM.
- Inspect the engine for the following mechanical failures:

  Refer to Symptoms - Engine Mechanical.
  - Excessive oil in the combustion chamber or leaking valve seals
  - Oil consumption
  - Incorrect cylinder compression
  - Sticking or leaking valves
  - Worn camshaft lobes
  - Incorrect valve timing
  - Worn rocker arms
  - Broken valve springs
  - Excessive carbon buildup in the combustion chambers—Clean the chambers with top engine cleaner, if necessary. Follow the instructions on the can.
  - Incorrect engine parts
- If the above conditions do not address the symptom, refer to the additional symptoms tests.

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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 engine coolant temperature sensor. Refer to Temperature Versus Resistance - Engine Coolant Temperature Sensor for resistance specifications. Replace the engine coolant temperature sensor if the resistance is not within specification. Refer to Engine Coolant Temperature Sensor Replacement. If the sensor is within the specification, test the engine coolant temperature sensor circuits for high resistance.
- Inspect for excessive carbon buildup in the combustion chambers. Clean the chambers with Top Engine Cleaner, if necessary. Follow the instructions on the can.

Engine Control Module Commanded Reduced Engine Power

Under certain conditions the engine control module may limit engine power by reducing engine torque and, for some vehicles, fuel pressure as well. For most, but not all of the conditions, the engine control module will illuminate the reduced engine power lamp on the instrument cluster. If equipped with the driver information center feature, a reduced engine power message may be displayed as well. 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 engine control module to reduce engine power. Refer to Cooling Fan Description and Operation and Cooling System Description and Operation to verify correct operation of the cooling fan.
- A condition with the throttle actuator control (TAC). Refer to DTC P1516, P2101, P2119, or P2176 and Throttle Actuator Control (TAC) System Description for further diagnosis.

Fuel Odor

Note: When the vehicle is switched OFF, shortly after starting in cold temperatures, a small quantity of LPG may be released from the LPG vaporizer, located behind the right front wheel. An odor may be detected. This is normal and does not indicate a leak, if it does not persist.

Inspect for leaking, damaged, or deteriorated liquid propane gas (LPG) fuel lines and components.—Refer to LPG Leak Testing

Hard Start

- Observe the TB Idle Airflow Compensation parameter with a scan tool. A value of 90 % may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to Throttle Body Inspection and Cleaning.
- Test the engine coolant temperature (ECT) sensor. Compare the ECT sensor value to the intake air temperature (IAT) sensor value on a cold engine. The ECT and IAT sensor

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values should be within ± 3°C (5°F). If the ECT sensor is out of range with the IAT sensor, test the resistance of the ECT sensor. Refer to Temperature Versus Resistance - 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 liquid propane gas (LPG) manual shut-off valve is fully open.
- Test for correct liquid propane gas (LPG) fuel system pressure and operation. Refer to Fuel System Diagnosis.
- Inspect for a restricted liquid propane gas (LPG) filter. Refer to LPG Fuel Filter Replacement.
- Verify correct operation of the liquid propane gas (LPG) shutoff solenoid valves and relays. You should hear the fuel shutoff valve relay 1 click when commanding the Fuel Pump ON and OFF with a scan tool, and you should hear the fuel shutoff valve relay 2 click when commanding the Fuel Shutoff Solenoid Valves ON and OFF with a scan tool. Refer to Fuel Shutoff Solenoid Valve Diagnosis and LPG System Description and Operation for further diagnosis.
- Inspect for excessive crankshaft endplay that will cause the crankshaft position sensor reluctor wheel to move out of alignment with the crankshaft position sensor. Refer to Crankshaft and Bearing Cleaning and Inspection and Engine Mechanical Specifications.

Hesitation, Sag, Stumble

- Test for correct liquid propane gas (LPG) fuel system pressure and operation. Refer to Fuel System Diagnosis.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Test the generator. Refer to Symptoms - Engine Electrical. Repair the charging system if the generator output voltage is less than 9 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 and Engine Mechanical Specifications.

  Note: The following actions may need to be repeated in order to verify an intermittent intake or exhaust camshaft actuator condition.
- Engine warm and idling, verify the correct operation of the camshaft actuator system. Command the intake and exhaust camshaft actuators for each cylinder bank from 0 degrees to 20 degrees and back to zero while observing the appropriate scan tool Int. CMP Variance and Exh. CMP Variance parameters. Each parameter should be less than 2 degrees in each of the commanded states.

  ⇒ If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to Camshaft Timing Drive Components Cleaning and Inspection and Camshaft Actuator System Description for additional information.

Lack of Power, Sluggishness, or Sponginess

- Inspect the engine electrical system for correct operation. Refer to Symptoms - Engine Electrical.
- Verify that each fuel injector harness is connected to the correct fuel injector.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Test for correct liquid propane gas (LPG) fuel system pressure and operation. Refer to Fuel System Diagnosis.

  Note: The following actions may need to be repeated in order to verify an intermittent intake or exhaust camshaft actuator condition.
- Engine warm and idling, verify the correct operation of the camshaft actuator system. Command the intake and exhaust camshaft actuators for each cylinder bank from 0 degrees to 20 degrees and back to zero while observing the appropriate scan tool Int.

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CMP Variance and Exh. CMP Variance parameters. Each parameter should be less than 2 degrees in each of the commanded states.

⇒ If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to Camshaft Timing Drive Components Cleaning and Inspection and Camshaft Actuator System Description for additional information.

Poor Fuel Economy

- Inspect for heavy loads being carried or towed
- Inspect for acceleration rate too much or too often
- Inspect for incorrect operation of the speedometer.
- Verify that the engine coolant temperature (ECT) sensor 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 the parameter listed in the K20 Engine Control Module: Scan Tool Information list. If the reading is not in the range specified in the list, test the resistance of the engine coolant temperature sensor. Refer to Temperature Versus Resistance - Engine Coolant Temperature Sensor for resistance specifications. Replace the engine coolant temperature sensor if the resistance is not within specification. Refer to Engine Coolant Temperature Sensor Replacement. If the sensor is within the specification, test the engine coolant temperature sensor circuits for high resistance.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Observe the TB Idle Airflow Compensation parameter with a scan tool. A value of 90 % may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to Throttle Body Inspection and Cleaning.
- Inspect the brake system for brake drag.

Poor Fuel Fill Quality

LPG fill times may vary depending on factors such as, the type of LPG fuel dispenser being used, the temperature and composition of the fuel already in the vehicle, and the temperature and composition of the fuel being put into the vehicle.

- Verify that the liquid propane gas (LPG) fill line shutoff valve, if equipped, is fully open.

  Note: A service interval is not specified for the fill valve filter. Its condition depends on the fuel quality. Use of LPG with excessive amounts of contaminants will increase the frequency of servicing the fill valve filter.
- Inspect for a contaminated or restricted fill valve filter. Service the fill valve filter, if necessary.
- Inspect for a restricted or incorrectly installed fill line union check valve. The check valve flow direction arrow should point towards the fuel tank.
- Inspect for an incorrectly operating automatic fill limiter. Refer to Australian Standards ASC-1425 for more information.

Rough, Unstable, or Incorrect Idle and Stalling

- Observe the TB Idle Airflow Compensation parameter with a scan tool. A value of 90 % may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to Throttle Body Inspection and Cleaning.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Inspect the engine mounts. Refer to Engine Mount Inspection.
- Test for correct liquid propane gas (LPG) fuel system pressure and operation. Refer to Fuel System Diagnosis.

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- Inspect the intake and exhaust manifolds for casting flash.

  Note: The engine control module (ECM) uses the bank 1 exhaust camshaft position sensor to determine injector and ignition system synchronization, as well as to determine camshaft to crankshaft relationship. If the sensor signal to the engine control module (ECM) is intermittent, a stalling condition may occur without setting a DTC.
- Inspect the bank 1 exhaust camshaft position sensor wiring and connectors for poor connections—Refer to Inducing Intermittent Fault Conditions for further diagnosis.
- An excessively high idle may be due to the floor mat interfering with the accelerator pedal. With this condition present, it may not be possible to shift the transmission into gear. Inspect the accelerator pedal for binding and verify that the floor mat is not interfering with the aceclerator pedal movement.

Surges/Chuggles

- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
- Inspect for slow responding heated oxygen sensors (HO2S). The heated oxygen sensors 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.

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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
- Instrument Cluster Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

Note: Any MIL requesting DTCs that may be set should be diagnosed first.

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
    - The MIL Control Circuit Low Voltage Test Status
    - The MIL Control Circuit Open Test Status
    - The MIL Control Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

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Refer to Circuit/System Testing

⇓ **If Malfunction is not displayed**

3. Engine running.
4. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open Test Status
   - The MIL Control Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing

⇓ **If Malfunction is not displayed**

5. Verify the malfunction indicator lamp turns ON and OFF when commanding the Malfunction Indicator Lamp On and Off with a scan tool.

⇒ **If the malfunction indicator lamp does not turn ON and OFF**

Refer to Circuit/System Testing

⇓ **If the malfunction indicator lamp turns ON and OFF**

6. All OK.

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON, verify the malfunction indicator lamp does not illuminate.

⇒ **If the malfunction indicator lamp illuminates**

3.1. Test for infinite resistance between the control circuit terminal X1 46 and ground.

⇒ If less than infinite resistance, repair the short to ground in the circuit.

⇒ If infinite resistance, replace the P16 Instrument Cluster.

⇓ **If the malfunction indicator lamp does not illuminate**

4. Connect a 3 A fused jumper wire between the control circuit terminal X1 46 and ground.
5. Verify the malfunction indicator lamp illuminates.

⇒ **If the malfunction indicator lamp illuminates**

Replace the K20 Engine Control Module.

⇒ **If the malfunction indicator lamp does not illuminate**

5.1. Test for less than 1 V between the control circuit terminal X1 46 and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇓ If less than 1 V

5.2. Ignition OFF.

5.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ If less than 2 Ω.

6. Ignition OFF, disconnect the harness connector at the instrument cluster.
7. Ignition ON, verify a test lamp illuminates between the ignition voltage circuit terminal 10 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is open**

7.1. Ignition OFF.

7.2. Test for infinite resistance between the ignition voltage circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

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⇒ **If the test lamp does not illuminate and the circuit fuse is good**

7.1. Ignition OFF.

7.2. Test for less than 2 Ω in the ignition voltage circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ **If the test lamp illuminates**

8. Replace the P16 Instrument Cluster.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Instrument Cluster Replacement
- Control Module References for control module replacement. programming, and setup

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LPG Leak Testing

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

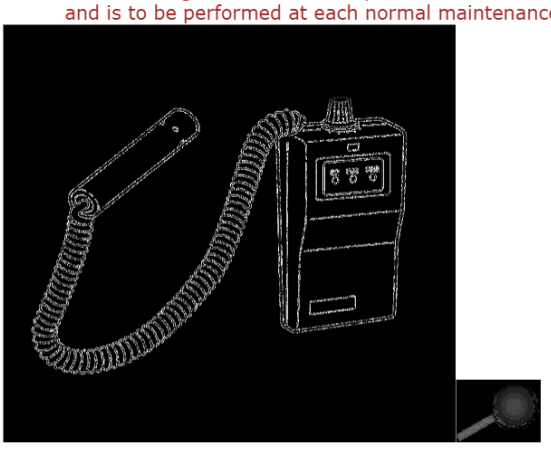
The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Warning: Refer to Safety Glasses Warning.

Note: The following leak test is to be performed on the LPG system high-pressure components and is to be performed at each normal maintenance schedule.

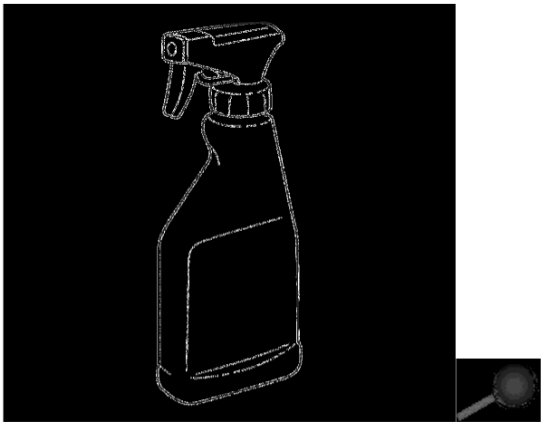


Note: LPG is heavier than air so test thoroughly below all components and fittings.

1. If a combustible gas detector is to be used for leak testing of the LPG system, the combustible gas detector should be capable of detecting 25 parts per million (PPM) of LPG in air.
2. It is important to follow the manufacturer's instructions in regard to adjustment and setting the instrument prior to conducting the test.
3. If a leak is present, a detector will signal its existence but not its size, and will indicate its general location, but may not be able to locate it exactly. A proving or follow up check with foam is often desirable.

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Note: LPG is heavier than air so test thoroughly below all components and fittings.

4. If foam is to be used, the foaming agent should be a propriety leak test solution, formulated specifically for the purpose, such as Gameco Leak Check.
5. The leak test is performed by directing a spray of solution at each of the possible leak points in the high-pressure side of the system.
6. A leak is indicated by the presence of gas bubbles (foaming) in the solution at the leak source.

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Engine Cranks But Does Not Run (Except LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 following conditions:

- The engine control module (ECM) uses the camshaft position sensors to determine engine speed and position when there is a crankshaft position sensor condition.
- 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. With a crankshaft position sensor condition in the signal circuit, the engine will go into a limp home mode after a hard restart. The ECM then calculates engine speed from one of the camshaft position sensors.
- The fuel pump control module controls and monitors the operation of the in-tank fuel pump. If the fuel pump control module detects a fault, a DTC sets in the fuel pump control module. The fuel pump control module will then send a serial data message to the engine control module (ECM) requesting the illumination of the malfunction indicator lamp (MIL).
- The fuel injectors are calibrated to begin operating when the fuel rail pressure reaches 2 MPa (290 psi) at 20–32°C (68–90°F). This specification will vary when the temperature is outside of this range.
- Insufficient fuel can cause a no start condition. Thoroughly inspect the fuel delivery system for sufficient fuel volume to the fuel injectors. Inspect the fuel supply components for partial blockage or restrictions.
- Fuel injectors with partially blocked and restricted nozzles, or a malfunctioning solenoid, can cause a no start condition. Refer to Fuel Injector Solenoid Coil Test.
- There may be fuel spray at the fuel injectors and the indicated fuel pressure may be correct, yet there may not be enough fuel to start the engine. If the fuel injectors and the injector circuit are OK, and fuel spray is detected, the fuel injector ON time may be inadequate. If the engine control module (ECM) receives incorrect inputs from the various information sensors, the fuel delivered by the fuel injectors may be inadequate to start the engine. Check all the engine data parameters with a scan tool and compare the values indicated with the expected values or the values from a known good vehicle.
- Inspect the engine for good secure electrical grounds.
- Water or foreign material in the fuel can cause a no start or engine will not stay running condition. During freezing weather water can freeze inside the fuel system. The engine may start after 30 min in a heated repair shop. The malfunction may not recur until parked overnight in freezing temperatures. Extreme weather conditions can cause contaminated fuel to prevent the vehicle from starting.
- A vehicle that starts and runs after being brought to the repair shop for a no start condition, may have an ignition system that is susceptible to moisture. Spray water on

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the ignition system components and the wiring in order to check for an engine starting or will not stay running concern.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

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

- *CH-48027* Digital Pressure Gauge
- *J 26792* HEI Spark Tester

For equivalent regional tools, refer to Special Tools.

Circuit/System Verification

Note: This diagnostic assumes the following:

- The battery is completely charged. Refer to Battery Inspection/Test.
- There is adequate fuel in the fuel tank.

1. Engine cranking for 15 s, observe the DTC information with a scan tool. Verify DTCs P0116, P0118, P0119, P0191, P0192, P0193, P0231, P0232, P023F, P025A, P0335, P0336, P0351 –P0356, P0601, P0602, P0603, P0604, P0606, P06A6, P062B, P062F, P069E, P0627, P0628, P0629, P0641, P064A, P1255, P1631, P2534, P2635, or U0109 are not set.
   ⇒ If any DTCs are set, refer to Diagnostic Trouble Code (DTC) List - Vehicle for diagnosis.
2. Ignition ON, observe the Security Indicator on the instrument cluster. The security indicator should illuminate momentarily and then go out.
   ⇒ 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
3. Engine cranking, observe the Engine Speed parameter with a scan tool. The reading should show engine speed greater than 175 RPM.
   ⇒ If the cranking speed is slow, refer to Engine Cranks Slowly.
   ⇒ If the cranking speed is 0 RPM, refer to DTC P0335 or P0336 for crankshaft position sensor diagnosis.

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4. Disconnect the B75B mass airflow (MAF) sensor and attempt to start the engine. The ECM will ignore MAF sensor input, default to calculated airflow, and the engine should start and run if the MAF sensor is faulted.
   ⇒ If the engine starts and runs, and the MAF sensor circuits and connections test OK, replace the B75B MAF sensor. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
5. Ignition ON, observe the BARO parameter with a scan tool. Determine your altitude and compare the BARO reading to the Altitude Versus Barometric Pressure table. The reading should be within the range specified.
   ⇒ If the reading is not within the specified range in the table, refer to DTC P2227-P2230 for further diagnosis.
6. Install the *J 26792* HEI spark tester between the boot of a spark plug wire and ground.
   Note:
   - Perform this test on at least one cylinder of each cylinder bank.
   - An erratic or weak spark is considered a no spark condition.
7. Engine cranking, verify the spark tester sparks.
   ⇒ If the spark tester does not spark for any cylinder tested, refer to Electronic Ignition System Diagnosis.
8. Ignition OFF, install a *CH-48027* digital pressure gauge—Refer to Fuel Pressure Gauge Installation and Removal.
9. Ignition ON, engine OFF, command the Fuel Pump Enable ON with a scan tool. Verify the fuel pressure is between 345-690 kPa (50-100 psi) while the fuel pump is running.
   ⇒ If the fuel pressure is not the specified value, refer to Fuel System Diagnosis.
10. Verify that the following conditions do not exist:
    - Collapsed air intake duct to throttle body
    - Restricted air filter element
    - A skewed engine coolant temperature (ECT) sensor—Refer to DTC P0116.
    - 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 you find any of the above conditions, repair as necessary.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Mass Airflow Sensor with Intake Air Temperature Sensor Replacement

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Engine Cranks But Does Not Run (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 following conditions:

- The engine control module (ECM) uses the camshaft position sensors to determine engine speed and position when there is a crankshaft position sensor condition.
- 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. With a crankshaft position sensor condition in the signal circuit, the engine will go into a limp home mode after a hard restart. The ECM then calculates engine speed from one of the camshaft position sensors.
- Verify that the liquid propane gas (LPG) fuel tank manual shut-off valve is turned to ON.
- Verify there is adequate LPG in the LPG tank. LPG tank pressure will vary according to the temperature and composition of the LPG fuel, not according to the amount of LPG in the tank. With the ignition ON, observe the scan tool Alternative Fuel Tank Pressure parameter. At 10°C fuel temperature and a 50% Propane and 50% Butane mixture, tank pressure should be approximately 400 kPa (4.0 Bar). At 10°C fuel temperature with 100% propane, tank pressure should be approximately 650 kPa (6.5 Bar).
- The fuel pump control module controls and monitors the operation of the in-tank fuel pump based on information received from the LPG tank pressure sensor. The fuel pump will be ON if fuel tank pressure is less than 490 kPa (71 psi) and OFF when fuel tank pressure is greater than 510 kPa (74 psi). If the fuel pump control module detects a fault, a DTC sets in the fuel pump control module. The fuel pump control module will then send a serial data message to the engine control module (ECM) requesting the illumination of the malfunction indicator lamp (MIL).
- Insufficient fuel can cause a no start condition. Thoroughly inspect the LPG fuel delivery system for sufficient fuel to the fuel injectors. Inspect the fuel supply components for partial blockage or restrictions. Fuel rail differential pressure should be 110 kPa. If the pressure is too low, insufficient fuel will be delivered. If the pressure is too high, the injectors will not open--Refer to Differential Fuel Rail Pressure Adjustment for additional information.
- Fuel injectors with partially blocked and restricted nozzles, or a malfunctioning solenoid, can cause a no start condition. Refer to Fuel Injector Solenoid Coil Test.
- There may be fuel flow at the fuel injectors and the indicated fuel pressure may be correct, yet there may not be enough fuel to start the engine. If the fuel injectors and the injector circuit are OK, and fuel flow is detected, the fuel injector ON time may be inadequate. If the engine control module (ECM) receives incorrect inputs from the various information sensors, the fuel delivered by the fuel injectors may be inadequate to start the engine. Check all the engine data parameters with a scan tool and compare the values indicated with the expected values or the values from a known good vehicle.

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- Inspect the engine for good secure electrical grounds.
- A vehicle that starts and runs after being brought to the repair shop for a no start condition, may have an ignition system that is susceptible to moisture. Spray water on the ignition system components and the wiring in order to check for an engine starting or will not stay running concern.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

- Electronic Ignition System Description
- Fuel System Description
- Immobilizer Description and Operation
- LPG System Description and Operation

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- OTC-3490 LPG Fuel Pressure Gauge
- EN-50958 LPG Fuel Pressure Gauge Adapter

For equivalent regional tools, refer to Special Tools.

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Circuit/System Verification

Note: This diagnostic assumes the following:

- The battery is completely charged.
- There is adequate LPG in the LPG tank.

1. Engine cranking for 15 s, observe the DTC information with a scan tool. Verify DTCs P0116, P0117 or P0118, P0119, P0192 or P0193, P0231 or P0232, P025A, P0335, P0336, P0351–P0356, P0601, P0602, P0603, P0604, P0606, P06A6, P062F, P069E, P0627, P0628, P0629, P0641, P064A, P1255, P1631, P2534, P2635, or U0109 are not set.
   ⇒ If any DTCs are set, refer to Diagnostic Trouble Code (DTC) List - Vehicle for diagnosis.
2. Ignition ON, observe the Security Indicator on the instrument cluster. The security indicator should illuminate 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
3. Engine cranking, observe the Engine Speed parameter with a scan tool. The reading should show engine speed greater than 175 RPM.
   ⇒ If the cranking speed is slow, refer to Engine Cranks Slowly.

⇒ If the cranking speed is 0 RPM, refer to DTC P0335 or P0336 for crankshaft position sensor diagnosis.

4. Disconnect the B75B mass airflow sensor and attempt to start the engine. The engine control module (ECM) will ignore the B75B mass airflow sensor input, default to calculated airflow, and the engine should start and run if the B75B mass airflow sensor is faulted.
   ⇒ If the engine starts and runs, and the B75B mass airflow sensor circuits and connections test OK, replace the B75B mass airflow sensor. Refer to Mass Airflow Sensor with Intake Air Temperature Sensor Replacement.
5. Ignition ON, observe the BARO parameter with a scan tool. Determine your altitude and compare the BARO reading to the Altitude Versus Barometric Pressure table. The reading should be within the range specified.
   ⇒ If the reading is not within the specified range in the table, refer to DTC P2227-P2230 for further diagnosis.
6. Install the *J 26792* HEI spark tester between the boot of a spark plug wire and ground.

   Note:
   - Perform this test on at least one cylinder of each cylinder bank.
   - An erratic or weak spark is considered a no spark condition.
7. Engine cranking, verify the spark tester sparks.
   ⇒ If the spark tester does not spark for any cylinder tested, refer to Electronic Ignition System Diagnosis.
8. Ignition ON, verify the Fuel Pump Enable Command parameter turns ON and OFF when commanding the Fuel Pump Enable ON and OFF with a scan tool.
   ⇒ If the Fuel Pump Enable Command does not change, refer to Fuel Pump Electrical Circuit Diagnosis
9. Verify correct operation of the liquid propane gas (LPG) fuel injectors. Refer to Fuel Injector Solenoid Coil Test.
10. Verify correct operation of the liquid propane gas (LPG) shutoff solenoid valves and relays. You should hear fuel shutoff relay 1 click when commanding the Fuel Pump Enable ON and OFF with a scan tool, and you should hear fuel shutoff relay 2 click when commanding the Fuel Shutoff Solenoid Valves ON and OFF with a scan tool. Refer to Fuel Shutoff Solenoid Valve Diagnosis.
11. Verify correct operation of the liquid propane gas (LPG) fuel system. Refer to Fuel System Diagnosis.
12. Verify that the following conditions do not exist:
    - Collapsed air intake duct to throttle body
    - Restricted air filter element
    - A skewed engine coolant temperature (ECT) sensor—Refer to DTC P0116.
    - Spark plugs gas or coolant fouled—Refer to Spark Plug Inspection and Coolant in Combustion Chamber.
    - Exhaust system restricted—Refer to Restricted Exhaust.
    - Engine mechanical condition, for example, worn timing chain and gears or low compression—Refer to Symptoms - Engine Mechanical.

      ⇒ If you find any of the above conditions, repair as necessary.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Mass Airflow Sensor with Intake Air Temperature Sensor Replacement

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Fuel Pump Electrical Circuit Diagnosis (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 Pump Supply Voltage	P0231	P0231	P0232	—
Low Reference	—	—	—	—

Circuit/System Description

The Chassis Control Module receives fuel pressure information from the Fuel Tank Pressure Sensor and controls the operation of the Fuel Pump located within the fuel tank. The Chassis Control Module sends a 25 kHz PWM signal to the Fuel Pump. The pump speed is changed by varying the duty cycle of this signal. The Fuel Pump will be on if the fuel tank pressure is less than 490 kPa (71 psi) and off if the fuel tank pressure is greater than 510 kPa (74 psi). When the Fuel Pump is on the duty cycle will vary from 50% to 100% based on the fuel flow requirements.

Reference Information

Schematic Reference

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Description and Operation

LPG 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

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1. Ignition ON.
2. Verify the Fuel Pump Enable Command parameter turns on & off when commanding the Fuel Pump Enable ON and OFF with a scan tool.

⇒ **If the Fuel Pump Enable Command does not change**

Refer to Circuit/System Testing.

⇓ **If the Fuel Pump Enable Command changes**

3. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the Fuel Pump. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 3 Ω between the ground circuit terminal G and ground.

⇒ **If 3 Ω or greater**

2.1. Ignition OFF.

2.2. Test for less than 2 Ω in the ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, repair the open/high resistance in the ground connection.

⇒ **If less than 3 Ω**

3. Ignition ON, connect a test lamp between the control circuit terminal A and the ground circuit terminal G.
4. Verify the test lamp turns ON and OFF when commanding the Fuel Pump Enable ON and OFF with a scan tool.

⇒ **If the test lamp is always OFF**

4.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K38 Chassis Control Module.

4.2. Test for infinite resistance between the control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

4.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K38 Chassis Control Module.

⇒ **If the test lamp is always ON**

4.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K38 Chassis Control Module, ignition ON.

4.2. Test for less than 1 V between the control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K38 Chassis Control Module.

⇓ **If the test lamp turns ON and OFF**

5. Replace the Fuel Pump.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Pump Replacement
- Control Module References for K38 Chassis Control Module programming, replacement, and setup.

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Fuel Pump Electrical Circuit Diagnosis (LFW, LFX)

Diagnostic Instructions

- Perform the 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.

Diagnostic Fault Information

Circuit	Short to Ground	Open or High Resistance	Short to Voltage	Signal Performance
Fuel Pump High Signal	P0231	P023F	P0232	P023F, P2635
Fuel Pump Low Signal	—	P023F	—	P023F, P2635

Circuit/System Description

The Engine Control Module (ECM) supplies voltage to the Fuel Pump Driver Control Module when the Engine Control Module detects that the ignition is on. The voltage from the Engine Control Module to the Fuel Pump Driver Control Module remains active for two seconds, 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 pressure.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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1. Ignition ON.
2. Command the Fuel Pump Enable ON and OFF with a scan tool.
3. Verify the fuel pump turns ON and OFF with each command.

⇒ **If the fuel pump does not turn ON and OFF**

Refer to Circuit/System Testing.

⇓ **If the fuel pump turns ON and OFF**

4. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the G12 Fuel Pump. It may take up to 2 minutes for all vehicle systems to power down.
2. Connect a test lamp between the control circuit terminal 1 and ground, ignition ON.
3. Command the Fuel Pump Enable ON and OFF with a scan tool.
4. Verify the test lamp turns ON and OFF with each command.

⇒ **If the test lamp is always ON**

4.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K111 Fuel Pump Driver Control Module.

4.2. Test for less than 1 V between the fuel pump control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, test or replace the K111 Fuel Pump Driver Control Module.

⇒ **If the test lamp is always OFF**

4.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K111 Fuel Pump Driver Control Module.

4.2. Test for infinite resistance between the control circuit and ground

⇒ If less than infinite, repair the short to ground on the circuit.

⇓ If infinite resistance

4.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K111 Fuel Pump Driver Control Module.

⇓ **If the test lamp turns ON and OFF.**

5. Ignition OFF, connect a test lamp between the control circuit terminal 1 and the low reference circuit terminal 2, ignition ON.
6. Command the Fuel Pump Enable ON and OFF with a scan tool.
7. Verify the test lamp turns ON and OFF with each command.

⇒ **If the test lamp is always OFF**

7.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K111 Fuel Pump Driver Control Module.

7.2. Test for less than 1 V between the fuel pump low reference circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇓ If less than 1 V

7.3. Test for infinite resistance between the low reference circuit and ground

⇒ If less than infinite, repair the short to ground on the circuit.

⇓ If infinite resistance

7.4. 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 K111 Fuel Pump Driver Control Module.

⇓ **If the test lamp turns ON and OFF.**

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8. Test or replace the G12 Fuel Pump.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Primary Fuel Tank Module Replacement for G12 Fuel Pump replacement.
- Control Module References for K111 Fuel Pump Driver Control Module programming, replacement, and setup.

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Fuel System Diagnosis (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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

Fuel system service line pressure to the vaporizer is provided by the pressure of the LPG in the LPG fuel tank, which will vary with fuel temperature and fuel composition. When the LPG tank pressure is below approximately 480 kPa (i.e. when the fuel temperature is below 15°C to 0°C, depending on fuel composition) the Chassis Control Module commands the LPG pump on at either 50% or 100% duty cycle, based on fuel flow requirements, to provide additional service line pressure to the vaporizer. When the tank pressure rises above approximately 510 kPa the Chassis Control Module switches the pump OFF. The vaporizer reduces the service line pressure to maintain a fuel rail to intake manifold differential pressure of 110 kPa.

Diagnostic Aids

Fuel system pressure is supplied to the vaporizer by the pressure in the LPG tank. The LPG fuel pump will only operate if the LPG tank pressure is less than approximately 480 kPa

Reference Information

Description and Operation

LPG System Description and Operation

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- EN-50958 LPG Fuel Pressure Gauge Adapter
- OTC-3490 LPG Fuel Pressure Gauge

For equivalent regional tools, refer to Special Tools.

Circuit/System Verification

Note:

- Repair all fuel system related DTCs before performing this diagnostic.
- Verify the manual shut-off valve is open.
- Inspect the fuel system for damage or external leaks before proceeding. Refer to LPG Leak Testing.
- Verify that adequate LPG is in the fuel tank before proceeding.

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- At 10°C fuel temperature and a 50% propane and 50% butane mix, the Alternative Fuel Tank Pressure will be approximately 400 kPa (4.0 Bar). At 10°C fuel temperature with 100% propane the Alternative Fuel Tank Pressure will be approximately 650 kPa (6.5 Bar).

1. Ignition ON, engine OFF.
2. Verify the Alternative Fuel Tank Pressure parameter is at least 400 kPa at 10°C fuel temperature.

⇒ **If the Alternative Fuel Tank Pressure parameter is not at least 400 kPa**

Refer to Circuit/System Testing.

⇓ **If the Alternative Fuel Tank Pressure parameter is at least 400 kPa**

3. Engine idling at normal operating temperature.
4. Verify the Differential Fuel Rail Pressure is 110 kPa. .

⇒ **If the Differential Fuel Rail Pressure is not 110 kPa**

Refer to Differential Fuel Rail Pressure Adjustment

⇓ **If the Differential Fuel Rail Pressure is 110 kPa**

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.

5. Road test the vehicle under varying driving conditions. Observe the Differential Fuel Rail Pressure with a scan tool. Verify the Differential Fuel Rail Pressure is 110 kPa during all driving conditions.

⇒ **If the Differential Fuel Rail Pressure is not 110 kPa during all driving conditions.**

Refer to Circuit/System Testing.

⇓ **If the Differential Fuel Rail Pressure is 110 kPa during all driving conditions.**

6. All OK.

Circuit/System Testing

1. Ignition OFF, all accessories OFF, install EN-50958 LPG Fuel Pressure Gauge Adapter and OTC-3490 LPG Fuel Pressure Gauge. Refer to Fuel Pressure Gauge Installation and Removal.

Note: The Alternative Fuel Tank Pressure will vary with the fuel temperature and fuel composition. At 10°C fuel temperature and a 50% propane and 50% butane mix, the Alternative Fuel Tank Pressure should be approximately 400 kPa (4.0 Bar). At 10°C fuel temperature with 100% propane the Alternative Fuel Tank Pressure will be approximately 650 kPa (6.5 Bar).

2. Crank the engine for at least 5 seconds or until the engine starts, then turn the ignition OFF.
3. Verify that fuel pressure is at least 400 kPa at 10°C fuel temperature.

⇒ **If fuel pressure is less than 400 kPa**

Refer to Fuel Shutoff Solenoid Valve Diagnosis.

⇓ **If fuel pressure is 400 kPa or greater**

4. Ignition ON, command the Fuel Pump ON with a scan tool.
5. Verify the fuel pump is operating.

⇒ **If the fuel pump does not operate**

Refer to Fuel Pump Electrical Circuit Diagnosis.

⇓ **If the fuel pump operates**

6. Engine at idle, command the Fuel Pump ON with a scan tool and observe the fuel pressure gauge while the fuel pump is operating.
7. Verify the fuel pressure is between 250–500 kPa (2.5–5.0 Bar) above line pressure.

⇒ **If the fuel pressure is not within the specified range**

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Test or replace the LPG Fuel Pump.

⇓ **If the fuel pressure is within the specified range**

Test, inspect, and repair the items listed below.

- Restricted fuel feed hose and fuel feed pipe from the LPG tank to the vaporizer
- Fuel vapor hose from the vaporizer to the LPG fuel filter
- Fuel vapor hose from the LPG fuel filter to the fuel rail
- LPG fuel filter
- LPG vaporizer
- Fuel rail and injectors

8. If the fuel system tests normal, refer to Symptoms - Engine Controls and Fuel Injector Solenoid Coil Test.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Differential Fuel Rail Pressure Adjustment
- Fuel Injector and Fuel Rail Replacement
- Fuel Pump Replacement
- LPG Fuel Feed Front Pipe Replacement
- LPG Fuel Feed Hose Replacement
- LPG Fuel Filter Replacement
- LPG Rear Pipe Replacement
- LPG Vaporizer Diaphragm Replacement
- LPG Vaporizer Heater Replacement
- LPG Vaporizer Replacement

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Fuel System Diagnosis (LFW, LFX)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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.

An electric turbine style fuel pump attaches to the Fuel Tank Fuel Pump Module inside the fuel tank. The Fuel Pump supplies fuel through the fuel feed pipe to the High Pressure Fuel Pump. The High Pressure Fuel Pump supplies fuel to a variable-pressure fuel rail. Fuel enters the combustion chamber through precision multi-hole Fuel Injectors. The High Pressure Fuel Pump, fuel rail pressure, fuel injection timing, and injection duration are controlled by the Engine Control Module (ECM).

Diagnostic Aids

Observe the Misfire Counters or perform the Fuel Injector Balance Test to help identify a leaking fuel injector.

Reference Information

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- *CH 48027* Digital Pressure Gauge
- *J 37287* Fuel Line Shut-off Adapter

For equivalent regional tools, refer to Special 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 relay may need to be commanded ON a few times in order to obtain the highest possible fuel pressure.

1. Ignition OFF.
2. Install the *CH-48027* Digital Fuel Pressure Gauge. Refer to Fuel Pressure Gauge Installation and Removal.
3. Ignition ON, command the Fuel Pump Enable ON several times with a scan tool.

   Note: DO NOT perform the Fuel System Diagnosis if the engine coolant temperature is above 60°C (150°F). High fuel pressure readings may result due to hot soak fuel boiling. With the engine OFF, the fuel pressure may increase beyond the pressure relief regulator valve's setting point of 690 kPa (100 psi) ± 5 percent.
4. Verify the fuel pressure 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)**

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.

5. Verify that the fuel pressure decreases to 500–599 kPa (72–87 psi) after the fuel pump is turned off.

⇒ **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)**

6. Verify that the fuel pressure does not decrease greater than 34 kPa (5 psi) in 1 minute.

⇒ **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)**

7. Relieve the fuel pressure to 69 kPa (10 psi), refer to Fuel Pressure Relief.
8. Verify that the fuel pressure does not decrease greater than 14 kPa (2 psi) in 5 minutes.

⇒ **If the fuel pressure decreases greater than 14 kPa (2 psi)**

Replace the G12 Fuel Pump.

⇓ **If the fuel pressure does not decrease greater than 14 kPa (2 psi)**

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.

9. Operate the vehicle within the conditions of the customer's concern while monitoring the fuel pressure with the *CH-48027* Digital Fuel Pressure Gauge.
10. Verify the fuel pressure does not drop off during acceleration, cruise or hard cornering.

⇒ **If the fuel pressure drops off**

Refer to Circuit/System Testing — Fuel Pressure Drops OFF.

⇓ **If the fuel pressure does not drop off**

11. 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

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1. Verify none of the conditions listed below exist:
    - Restricted fuel feed pipe
    - Restricted or plugged strainer
    - Poor connections at the fuel pump harness connector and the ground circuits.

⇒ **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 Relay ON with a scan tool and bleed the air from the fuel pressure gauge.
5. Close the valve on the *EN-37287* Fuel Line Shut-Off Adapters.
6. Verify that the fuel pressure does not decrease greater than 34 kPa (5 psi) in 1 minute.

⇒ **If the fuel pressure drops**

Locate and replace the leaking Q17 Fuel Injector.

⇓ **If the fuel pressure does not drop**

7. Test or replace the G12 Fuel Pump.

Fuel Pressure Drops OFF

1. Verify none of the conditions listed below exist:
    - Restricted fuel feed pipe
    - Restricted or plugged strainer
    - Poor connections at the Fuel Pump harness connector and the ground circuit.

⇒ **If a condition exist**

Repair as necessary.

⇓ **If a condition does not exist**

2. Test or replace the G12 Fuel Pump.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel Feed Pipe Replacement
- Fuel Injection Fuel Rail Assembly Replacement - Bank 1
- Fuel Injection Fuel Rail Assembly Replacement - Bank 2
- Fuel Line Replacement - Chassis
- Primary Fuel Tank Module Replacement

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Fuel Injector Solenoid Coil Test (LFW, LFX)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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 Fuel 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

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.
2. Test for 1.9–2.3 Ω at 20°C (68°F) between terminal A and terminal B at the Q17 Fuel Injector.
   ⇒ **If not within the specified range**
   Replace the Q17 Fuel Injector.

⇓ **If within the specified range**

3. Verify infinite resistance between each terminal at the Q17 Fuel Injector and the 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.

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Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel Injection Fuel Rail Assembly Replacement - Bank 1
- Fuel Injection Fuel Rail Assembly Replacement - Bank 2

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Fuel Injector Solenoid Coil Test (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

Circuit/System Description

The engine control module (ECM) supplies a separate high voltage supply circuit and a high voltage control circuit for each fuel injector. The injector high voltage supply circuit and the high voltage control circuit are both controlled by the ECM. The ECM energizes each fuel injector by grounding the control circuit. The ECM controls each fuel injector with 65 V. This is controlled by a boost capacitor in the ECM. During the 65 V boost phase, the capacitor is discharged through an injector, allowing for initial injector opening. The injector is then held open with 12 V. A fuel injector coil winding resistance that is too high or too low will affect the engine driveability. The fuel injector coil windings are affected by temperature. The resistance of the fuel injector coil windings will increase as the temperature of the fuel injector increases.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

LPG System Description and Operation

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. Test for 1.43–1.58 Ω at 20°C (68°F) between the high voltage supply circuit terminal B and the high voltage control circuit terminal A at the Q17 fuel injector.

⇒ **If not within the specified range**

Replace the Q17 fuel injector.

⇓ **If within the specified range**

2. Measure the resistance between each terminal at the Q17 fuel injector and the Q17 fuel injector housing/case. The DMM should display OL Ω.

⇒ **If not within the specified range**

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Replace the Q17 fuel injector.

⇓ **If within the specified range**

3. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Fuel Injector and Fuel Rail Replacement

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Fuel Injector Balance Test (LFW, LFX)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

Circuit/System Description

The fuel injector balance test is performed while the engine is running at idle. The scan tool pressurizes the fuel rail to a predetermined pressure before each injector is pulsed for a precise amount of time allowing a measured amount of the fuel to be injected. This causes a drop in the system fuel pressure that is recorded and used to compare each injector.

Diagnostic Aids

- Monitoring the Current Misfire Counters may help to isolate the fuel injector that is causing the condition.
- Operating the vehicle over a wide temperature range may help isolate the fuel injector that is causing the condition.

Circuit/System Verification

Note:

- DO NOT perform this test if the engine coolant temperature (ECT) is above 60°C (140°F). Irregular fuel pressure readings may result due to hot soak fuel boiling.
- Verify that adequate fuel is in the fuel tank before proceeding with this diagnostic.

1. Ignition ON.
2. Command the Fuel Pump Enable ON with a scan tool.
3. Verify the fuel pressure is between 345–690 kPa (50–100 psi) with the fuel pump running.

⇒ **If not within the specified range**

Refer to Fuel System Diagnosis

⇓ **If within the specified range**

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.

4. Verify the fuel pressure does not decrease greater than 34 kPa (5 psi) within 1 minute.

⇒ **If the fuel pressure decreases more than the specified value**

Refer to Fuel System Diagnosis.

⇓ **If the fuel pressure does not decreases more than the specified value**

5. Perform the Circuit/System Testing — Fuel Injector Balance Test.

Circuit System Testing

Fuel Injector Balance Test

Note: The engine speed must be between 600–1000 RPM to perform this test.

1. Engine idling.
2. Select the Fuel Injector Balance function within the Output Controls menu of a scan tool.
3. Select and test a Q17 Fuel Injector. Repeat for each Q17 Fuel Injector.
4. Obtain and record a pressure drop value for each Q17 Fuel Injector.

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5. Add all of the individual pressure drop values except for the Fuel Injector suspected of being faulty. This is the total pressure drop.
6. Divide the total pressure drop by the number of Fuel Injectors that were added together. This is the average pressure drop.
7. Multiply the average pressure drop by 0.20. This is the acceptable variance from the average pressure drop, 20%.
8. 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**

9. Perform Fuel Injector Circuit DiagnosisFuel Injector Circuit Diagnosis.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Injection Fuel Rail Assembly Replacement - Bank 1
- Fuel Injection Fuel Rail Assembly Replacement - Bank 2

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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
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

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parameters. An Injector Control Circuit Status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

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**

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**

2.1. Disconnect the harness connector of the Q17 Fuel Injector.

2.2. Test for infinite resistance between the Q17 Fuel Injector control + circuit and ground.

⇓ If infinite resistance

2.3. 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**

4.1. Disconnect the harness connector of the Q17 Fuel Injector, ignition ON.

4.2. 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.

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⇒ 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**

6.1. Disconnect the harness connector of the Q17 Fuel Injector.
6.2. 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
6.3. 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 Injection Fuel Rail Assembly Replacement - Bank 1
- Fuel Injection Fuel Rail Assembly Replacement - Bank 2
- Control Module References for K20 Engine Control Module replacement, programming, and setup

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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

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

For equivalent regional tools, refer to Special 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

1. Test the fuel composition using *CH 44175–A* Alcohol Tester Kitand 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.

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4. Verify the non-blended gasoline fuel sample does not measure greater than 15% or an E85 blended gasoline fuel sample measures greater than 91% ethanol.

⇒ **If greater than the specified value**

4.1. Add fresh regular gasoline to the vehicle's fuel tank.

4.2. Remove a new sample of fuel from the tank.

4.3. Test the fuel composition using *CH 44175–A* Alcohol Tester Kitand Instruction Manual.

4.4. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.

4.5. Verify the non-blended gasoline fuel sample does not measure greater than 15% or an E85 blended gasoline fuel sample measures greater than 91% ethanol.

⇒ 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

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.

1. Using a 100 ml (3.38 oz) specified cylinder with 1 ml (0.034 oz) graduation marks, fill the cylinder with fuel to the 90 ml (3.04 oz) mark.
2. Add 10 ml (0.34 oz) of water in order to bring the total fluid volume to 100 ml (3.38 oz) and install a stopper.
3. Shake the cylinder vigorously for 10–15 seconds.
4. Carefully loosen the stopper in order to release the pressure.
5. Re-install the stopper and shake the cylinder vigorously again for 10–15 seconds.
6. Put the cylinder on a level surface for approximately 5 minutes in order to allow adequate liquid separation. If alcohol is present in the fuel, the volume of the lower layer, which would now contain both alcohol and water, will be more than 10 ml (0.34 oz). For example, if the volume of the lower layer is increased to 15 ml (0.51 oz), this indicates at least 5% 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**

7.1. Add fresh regular gasoline to the vehicle's fuel tank.

7.2. Remove a new sample of fuel from the tank.

7.3. Test the fuel composition of the new sample.

7.4. 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.

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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.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel System Cleaning
- Fuel Tank Draining

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Fuel Heater Diagnosis (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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
LPG Vaporizer Relay 1 Coil Control	P2687	P2687	—	—
LPG Vaporizer Relay 2 Relay Coil Control	P121D	P121D, P2687	—	—
LPG Vaporizer Relay 3 Relay Coil Control	P121E	P121E	—	—
LPG Vaporizer Relay 1 Ignition Voltage	—	P2687	—	—
LPG Vaporizer Relay 2 Ignition Voltage	—	P121D	—	—
LPG Vaporizer Relay 3 Ignition Voltage	—	P121E	—	—

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Circuit/System Description

The LPG vaporizer has three heater elements. The fuel injector control module controls the operation of the heater elements via three relays. The fuel injector control module uses the outside air temperature, the engine coolant temperature, and the transmission temperature to estimate the temperature of the LPG in the fuel tank. The fuel injector control module will activate its heater relay outputs to control the operation of the heater elements. The number of heater elements and the length of time that the heater elements are commanded on will vary depending on the estimated LPG temperature, the engine coolant temperature, the mass air flow, the engine run status, and the engine run time. If any of the GMLAN signals used to control the operation of the LPG vaporizer are not received, then all heater relays will be turned off.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

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LPG 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 the Battery Current increases as each LPG Vaporizer Heater is commanded ON with a scan tool.

⇒ **If the Battery Current does not increase**

Refer to Circuit/System Testing

⇓ **If the Battery Current increases**

2. All OK

Circuit/System Testing

1. Test for 0 Ω in the LPG vaporizer ground circuit end to end.

⇒ **If greater than 0 Ω**

Repair the open/high resistance in the circuit.

⇓ **If 0 Ω**

2. Connect a test lamp between the appropriate ignition circuit terminal and ground.
3. With a scan tool command the appropriate LPG Vaporizer Heater ON and OFF. Verify the test lamp turns ON and OFF with each command.

⇒ **If the test lamp illuminates**

Replace the LPG vaporizer heater.

⇓ **If the test lamp does not illuminate**

4. Ignition OFF, disconnect the appropriate LPG vaporizer relay.
5. Connect a test lamp between the control circuit terminal and ground.
6. With a scan tool command the appropriate LPG Vaporizer Heater ON and OFF. Verify the test lamp turns ON and OFF with each command.

⇒ **If the test lamp is always ON**

6.1. Ignition OFF, disconnect the harness connector at the K103 fuel injector control module. Ignition ON.

6.2. Test for less than 1 V between the appropriate LPG vaporizer relay control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K103 fuel injector control module.

⇒ **If the test lamp is always OFF**

6.1. Ignition OFF.

6.2. Test for less than 2 Ω in the appropriate LPG vaporizer relay control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ If less than 2 Ω.

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6.3. Disconnect the harness connector at the K103 fuel injector control module.

6.4. Test for infinite resistance between the appropriate LPG vaporizer relay control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the K103 fuel injector control module.

⇓ **If the test lamp turns ON and OFF**

7. Connect a test lamp between the appropriate control circuit terminal and the relay ground circuit terminal. Ignition ON.
8. With a scan tool command the appropriate LPG Vaporizer Heater ON and OFF. Verify the test lamp turns ON and OFF with each command.

⇒ **If the test lamp does not turn ON and OFF**

8.1. Ignition OFF.

8.2. Test for less than 2 Ω in the appropriate LPG vaporizer relay ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇓ **If the test lamp turns ON and OFF**

9. Test or replace the appropriate LPG vaporizer relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the appropriate LPG vaporizer relay.
2. Test for 70–110 Ω between terminals 85 and 86.

⇒ **If less than 70 Ω or greater than 110 Ω**

Replace the relay.

⇓ **If between 70–110 Ω**

3. Test for infinite resistance between the terminals listed below:
   - 30 and 86
   - 30 and 87
   - 30 and 85
   - 85 and 87

⇒ **If less than infinite resistance**

Replace the relay.

⇓ **If infinite resistance**

4. Install a 3 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 5 Ω between terminals 30 and 87.

⇒ **If 10 Ω or greater**

Replace the relay.

⇓ **If less than 5 Ω**

6. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

Fuel Injector Control Module Replacement

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Fuel Shutoff Solenoid Valve Diagnosis (LWR)

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using 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
Relay 1 Switch B+	[1]	[1]	—	—
Fuel Shutoff Solenoid 1 Control	[1]	[1]	—	—
Relay 1 Coil Control	P0628, P069E	[1]	P0629, P069E	—
Relay 1 Coil Ground	—	P062B, P0513	P062B, P0513	—
Fuel Shutoff Solenoid 1 Ground	—	[1]	[1]	—
Relay 2 Switch B+	P0005	P0005	—	—
Relay 2 Solenoid Control	[1]	[1]	[2]	—
Relay 2 Coil Control	P0005	P0005	P0005	—
Fuel Shutoff Solenoid 2 Ground	—	[1]	[1]	—

[1] Engine cranks, no start.
[2] Fuel shutoff solenoids always ON.

Circuit/System Description

Fuel shutoff valve 1 is located on the fuel tank outlet and closes off the liquid side of the fuel system when not energized. Fuel shutoff valve 2 is located on the fuel vaporizer and closes off the vapor side of the fuel system when not energized. The fuel injector control module controls the operation of the fuel shutoff solenoids, based on the status of the engine run and engine cranking GMLAN signals from the engine control module. When the fuel injector control module is in standby mode the fuel shutoff output will be switched off. When the engine is cranking or running then the shutoff solenoids will be energized.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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Component Connector End Views

Description and Operation

LPG 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 that fuel shutoff valve relay 1 clicks when commanding the Fuel Pump Enable ON and OFF with a scan tool.

⇒ **If the fuel shutoff valve relay 1 does not click**

Refer to Circuit/System Testing.

⇓ **If the fuel shutoff valve relay 1 clicks**

3. Verify that fuel shutoff valve relay 2 clicks when commanding the Fuel Shutoff Solenoid Valves ON and OFF with a scan tool.

⇒ **If the fuel shutoff valve relay 2 does not click**

Refer to Circuit/System Testing.

⇓ **If the fuel shutoff valve relay 2 clicks**

4. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the fuel shutoff valve relay 1. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 2 Ω between the ground circuit terminal 86 and ground.

⇒ **If 2 Ω or greater**

2.1. Ignition OFF.

2.2. Test for less than 2 Ω in the ground circuit end to end.

⇒ If 1 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 a test lamp illuminates between the B+ circuit terminal 87 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

4.1. Ignition OFF.

4.2. Test for less than 2 Ω in the B+ circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

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⇒ **If the test lamp does not illuminate and the circuit fuse is open**

4.1. Ignition OFF.

4.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

4.3. Test for infinite resistance between the control circuit terminal 30 and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the fuel shutoff valve relay 1.

⇓ **If the test lamp illuminates**

5. Connect a test lamp between the control circuit terminal 85 and the ground circuit terminal 86.
6. Verify the test lamp turns ON and OFF when commanding the Fuel Pump Enable ON and OFF with a scan tool.

⇒ **If the test lamp is always OFF**

6.1. Ignition OFF, disconnect the X-1 harness connector at the engine control module.

6.2. Test for infinite resistance between the control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

6.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the engine control module.

⇒ **If the test lamp is always ON**

6.1. Ignition OFF, disconnect the X-1 harness connector at the engine control module, ignition ON.

6.2. Test for less than 1 V between the control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the engine control module.

⇓ **If the test lamp turns ON and OFF**

7. Verify that a test lamp does not illuminate between the control circuit terminal 30 and ground.

⇒ **If the test lamp illuminates**

Repair the short to voltage on the control circuit

⇓ **If the test lamp does not illuminate**

8. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the fuel shutoff valve 1. It may take up to 2 minutes for all vehicle systems to power down.
9. Test for less than 2 Ω between the fuel shutoff valve 1 ground circuit terminal 2 and ground.

⇒ **If 2 Ω or greater**

9.1. Ignition OFF.

9.2. 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**

10. Connect the harness connector at the fuel shutoff valve 1.
11. Ignition ON, connect a 15 A fused jumper wire between the B+ circuit terminal 87 and the control circuit terminal 30.

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12. Command the Fuel Shutoff Solenoid Valves ON with a scan tool and verify the fuel shutoff valves are activated.

⇒ **If the fuel shutoff valves do not activate**

12.1. Ignition OFF, disconnect the harness connector at the fuel shutoff valve 1.

12.2. 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 fuel shutoff valve 1.

⇓ **If the fuel shutoff valves activate**

13. Test or replace the fuel shutoff valve relay 1.

14. Ignition OFF, disconnect the fuel shutoff valve relay 2, ignition ON.

15. Verify a test lamp illuminates between the B+ circuit terminal 85 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

15.1. Ignition OFF.

15.2. 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**

15.1. Ignition OFF.

15.2. 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,

15.3. Test for greater than 1.8 kΩ between the control circuit terminal 86 and ground.

⇒ If less than 1.8 kΩ, repair the short to ground on the circuit.

⇒ If greater than 1.8 kΩ, test or replace the fuel shutoff valve relay 2.

⇓ **If the test lamp illuminates**

16. Command the Fuel Pump Enable ON with a scan tool and verify a test lamp illuminates between the B+ circuit terminal 30 and ground.

⇒ **If the test lamp does not illuminate**

16.1. Ignition OFF.

16.2. 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 the test lamp illuminates**

17. Connect a test lamp between the B+ circuit terminal 85 and the control circuit terminal 86.

18. Verify the test lamp turns ON and OFF when commanding the Fuel Shutoff Solenoid Valves ON and OFF with a scan tool.

⇒ **If the test lamp is always OFF**

18.1. Ignition OFF, disconnect the harness connector at the fuel injector control module, ignition ON.

18.2. 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

18.3. Ignition OFF.

18.4. 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 fuel injector control module.

⇒ **If the test lamp is always ON**

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18.1. Ignition OFF, disconnect the harness connector at the fuel injector control module control module.

18.2. 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 fuel injector control module.

⇓ **If the test lamp turns ON and OFF**

19. Verify a test lamp does not illuminate between the control circuit terminal 87A and ground.

⇒ **If the test lamp illuminates**

Repair the short to voltage on the circuit.

⇓ **If the test lamp does not illuminate**

20. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the fuel shutoff valve 2. It may take up to 2 minutes for all vehicle systems to power down.
21. Test for less than 2 Ω between the fuel shutoff valve 2 ground circuit terminal 2 and ground.

⇒ **If 2 Ω or greater**

21.1. Ignition OFF.

21.2. 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**

22. Connect the harness connector at the fuel shutoff valve 2.
23. Command the Fuel Shutoff Solenoid Valves OFF with a scan tool and verify that the engine will not start.

⇒ **If the engine starts**

Test or replace the fuel shutoff valve relay 2.

Component Testing

Relay Test

1. Ignition OFF, disconnect the appropriate fuel shutoff valve relay.
2. Test for 70–110 Ω between terminals 85 and 86.

⇒ **If less than 70 or greater than 110**

Replace the relay.

⇓ **If between 70–110 Ω**

3. Test for infinite resistance between the terminals listed below:
   - 30 and 86
   - 30 and 87
   - 30 and 85
   - 85 and 87

⇒ **If less than infinite resistance**

Replace the relay.

⇓ **If infinite resistance**

4. Test for less than 0.5 Ω between terminals 30 and 87A.

⇒ **If 0.5 Ω or greater**

Replace the relay.

⇓ **If less than 0.5 Ω**

5. Install a 15 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.

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6. Test for less than 2 Ω between terminals 30 and 87.

⇒ **If 2 Ω or greater**

Replace the relay.

⇓ **If less than 2 Ω**

7. All OK

Shutoff Valve 1 Static Test

1. Ignition OFF, disconnect the harness connector at the fuel shutoff valve 1.
2. Test for 12.5–14.5 Ω between the control terminal 1 and the ground terminal 2.

⇒ **If not between 12.5–14.5 Ω**

Replace the fuel shutoff valve 1.

⇓ **If between 12.5–14.5 Ω**

3. Test for infinite resistance between each terminal and the fuel shutoff valve 1 housing/case.

⇒ **If less than infinite resistance**

Replace the fuel shutoff valve 1.

⇓ **If infinite resistance**

4. All OK

Shutoff Valve 2 Static Test

1. Ignition OFF, disconnect the harness connector at the fuel shutoff valve 2.
2. Test for 6.5–8.5 Ω between the control terminal 1 and the ground terminal 2.

⇒ **If not between 6.5–8.5 Ω**

Replace the fuel shutoff valve 2.

⇓ **If between 6.5–8.5 Ω**

3. Test for infinite resistance between each terminal and the fuel shutoff valve 2 housing/case.

⇒ **If less than infinite resistance**

Replace the fuel shutoff valve 2.

⇓ **If infinite resistance**

4. All OK

Shutoff Valve Dynamic Test

1. Ignition OFF, disconnect the harness connector at the appropriate fuel shutoff valve.
2. Install a 15 A fused jumper wire between the control terminal 1 and 12 V. Install a jumper wire between the ground terminal 2 and ground.
3. Verify the fuel shutoff valve turns on & off/clicks, etc.

⇒ **If the fuel shutoff valve does not turn on & off/clicks, etc.**

Replace the fuel shutoff valve.

⇓ **If the fuel shutoff valve does turn on & off/clicks, etc.**

4. All OK

Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- LPG Shutoff Valve Replacement
- Control Module References for fuel injector control module replacement, programming, and setup.

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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 (IC) 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 and also to the fuel injectors. 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

Connector End View Reference

Component Connector End Views

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References

Special Tools

EL 26792 HEI Spark Tester

For equivalent regional tools, refer to Special 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.

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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 A and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF.

2.2. Test for less than 2 Ω in the ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, repair the open/high resistance in the ground connection.

⇓ **If less than 5 Ω**

3. Test for less than 5 Ω between the low reference circuit terminal B and ground.

⇒ **If 5 Ω or greater**

3.1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

3.2. Test for less than 2 Ω in the low reference circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If less than 5 Ω**

4. Ignition ON.
5. Verify a test lamp illuminates between the ignition circuit terminal D and ground.

⇒ **If the test lamp does not illuminate**

5.1. Ignition OFF.

5.2. Test for less than 2 Ω in the ignition circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

⇓ **If the test lamp 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* HEI Spark Tester to the appropriate T8 Ignition Coil.
2. Engine Running.
3. Verify the spark output of the T8 Ignition Coil.

⇒ **If no output or the output is weak**

Replace the T8 Ignition Coil

⇓ **If the output is good**

4. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

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- Ignition Coil Replacement - Bank 1
- Ignition Coil Replacement - Bank 2
- Control Module References for engine control module replacement, programming, and setup.

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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.

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Crankshaft Position System 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 following components:

- Crankshaft position sensors activity: If there is a crankshaft position sensor condition, refer to the applicable DTC set.
- Camshaft position sensor signal activity: If there is a camshaft position sensor signal condition, refer to the applicable DTC set.
- Engine coolant temperature (ECT): If the engine coolant temperature is not warm enough, idle the engine until the engine coolant temperature reaches the correct temperature.

1. Verify no DTCs are set.

⇒ **If any DTCs other than P0300–P0308, or P0315 are set**

Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

⇓ **If DTC P0300–P0308, P0315, or no DTCs are set**

Note: The Crankshaft Position Variation Learn may have to be repeated up to 5 times before the procedure is successful.

2. Engine Running at normal operating temperature, perform the scan tool Crankshaft Position Variation Learn procedure and follow the on screen instructions.
3. Verify the scan tool displays Test Passed Successfully when completed.

⇒ **If Test Passed Successfully is not displayed**

Verify that none of the following conditions 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

3.1. Repair or replace as necessary.

3.2. Engine Running at normal operating temperature, perform the scan tool Crankshaft Position Variation Learn procedure and follow the on screen instructions.

⇒ If no conditions exist, replace the K20 Engine Control Module.

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⇓ **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

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Engine Control Module Replacement

Pre-Removal Procedure

Note: If the engine control module (ECM) is replaced with a NEW ECM, the NEW ECM must be updated with the remaining service data retrieved from the OLD ECM.

1. Use a scan tool and retrieve the remaining service data.
2. Record the remaining service data.
3. If the ECM is replaced, the following procedures must be performed:

   Note: The ECM must be reset prior to the removal from the vehicle. Failing to reset the ECM will result in the following:
   Inability to test the ECM for warranty purposes.

   Inability to use the ECM in other vehicles.

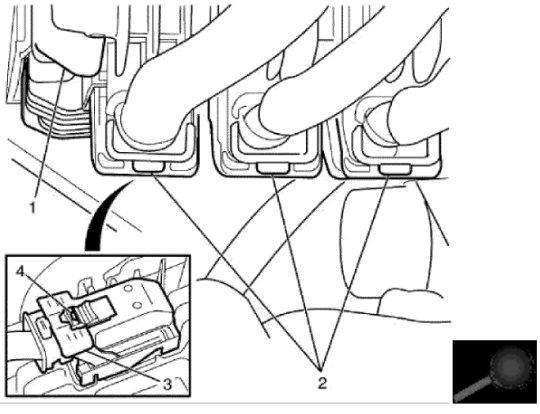
   3.1. Perform the ECM reset procedure. Refer to K20 Engine Control Module: Programming and Setup.

   3.2. Perform the theft deterrent programming. Refer to Control Module References.

Removal Procedure

1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

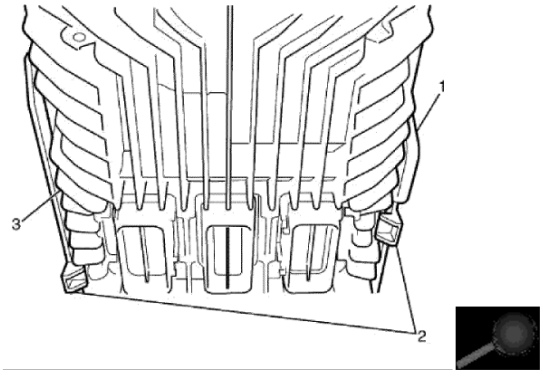


Note: Do not damage the engine wiring harness electrical connectors (2).

3. Unlock all the engine wiring harness electrical connector retainers (4) on the engine wiring harness electrical connectors (2).
4. Unlock all the engine wiring harness electrical connectors (2) by lifting the engine wiring harness electrical connector levers (3).
5. Disconnect the engine wiring harness electrical connectors (2) from the ECM (1).

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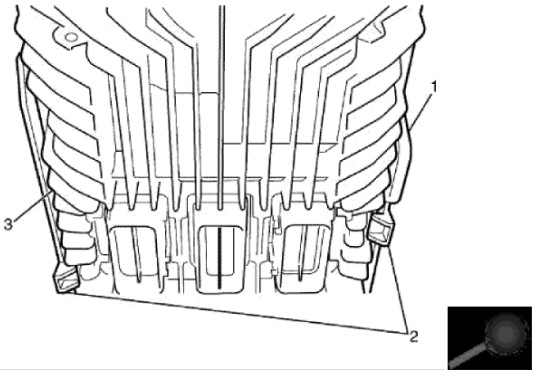
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Note: Do not damage the ECM bracket retainers (2).

6. Apply suitable pressure to the ECM bracket retainers (2) and remove the ECM (3) from the ECM bracket (1).

Installation Procedure

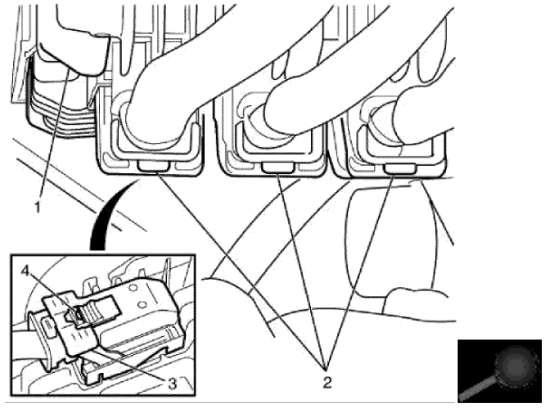


Note:

- Do not damage the ECM bracket retainers (2).
- Listen for an audible click to confirm correct installation of the ECM bracket retainers (2).

1. Install the ECM (3) to the ECM bracket (1).

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Note: Do not damage the engine wiring harness electrical connectors (2).

2. Connect the engine wiring harness electrical connectors (2) to the ECM (1).
3. Lock all the engine wiring harness electrical connectors (2) to the ECM (1) by lowering the engine wiring harness electrical connector levers (3).

   Note: Listen for an audible click to confirm correct installation of engine wiring harness electrical connector retainers (4).
4. Lock all the engine wiring harness electrical connector retainers (4) on the engine wiring harness electrical connectors (2).
5. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

   Note: Update the service data of the NEW ECM with the recorded data if necessary.
6. Program the ECM. Refer to K20 Engine Control Module: Programming and Setup.
7. If an ECM programming error is encountered such as "Starting Disabled, Remove Key" on the driver information centre, with a diagnostic test code (DTC) P1631, perform the "10-Minute relearn procedure" found in programming theft deterrent control module programming and setup. Refer to Control Module References.
8. Turn OFF the ignition for at least 5 seconds after the ECM programming is complete.
9. Use the scan tool to clear all DTCs.

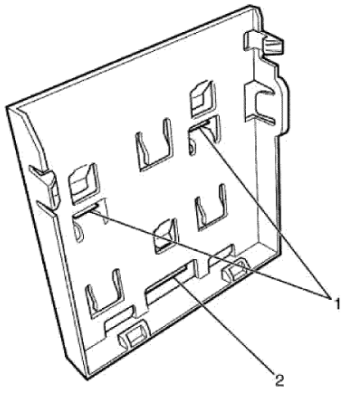
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Engine Control Module Bracket Replacement

Removal Procedure

1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the engine control module. Refer to Engine Control Module Replacement.



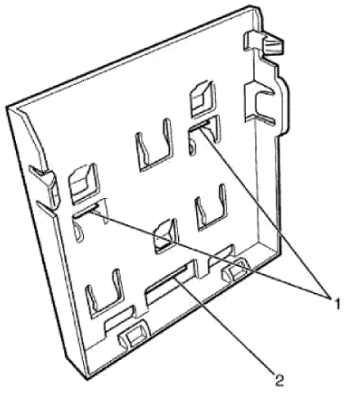
4. Insert a screwdriver into the opening above the bracket retainers (1) and slightly compress it enough while you pull it away from the under hood electrical center retainer bracket. DO NOT LIFT the bracket in order to compress the retainers.
5. Once the bracket retainers (1) have been disengaged, lift the engine control module bracket to disengage the engine control module bracket retainers (2).
6. Remove the engine control module bracket from the vehicle.

Installation Procedure

1. Install the engine control module bracket to the under hood electrical center retainer bracket.

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2. Install the engine control module bracket retainer (2) to the under hood electrical center retainer bracket first.
3. Align the engine control module bracket retainers (1) with the under hood electrical center retainer bracket and apply suitable force to the engine control module bracket to engage the engine control module bracket retainers (1) to the under hood electrical center retainer bracket.
4. Install the engine control module. Refer to Engine Control Module Replacement.
5. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.

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Q38 Throttle Body: Throttle/Idle Learn

Description

The engine control module (ECM) learns the airflow through the throttle body to ensure the correct idle. The learned airflow values are stored within the ECM. These values are learned to adjust for production variation and will continuously learn during the life of the vehicle to compensate for reduced airflow due to throttle body coking. Anytime the throttle body airflow rate changes, for example due to cleaning or replacing, the values must be relearned.

An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to unlearn the coking. To accelerate the process, the scan tool has the ability to reset all learned values back to zero. A new ECM will also have values set to zero.

The idle may be unstable or a DTC may set if the learned values do not match the actual airflow.

Conditions for Running the Throttle Learn Procedure

Scan tool Idle Learn or Idle Learn Reset Procedure

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201–P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300–P0308, P0351–P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P1516, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, or P2176 are not set.
- Ignition ON, engine OFF.
- The vehicle speed sensor (VSS) is 0 km/h (0 mph).

Service Bay/On Road Learn Procedure

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201–P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300–P0308, P0351–P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P1516, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, or P2176 are not set.
- The engine speed is between 450–4,000 RPM.
- The manifold absolute pressure (MAP) is greater than 5 kPa.
- The mass air flow (MAF) is greater than 2 g/s.
- The ignition voltage is greater than 10 volts.

Throttle Learn

Scan Tool Idle Learn or Idle Learn Reset Procedure – Performed after the throttle body is cleaned or replaced

1. Ignition ON, engine OFF, perform the Idle Learn or Idle Learn Reset in Configuration/Reset or Module Setup.
2. Engine idling, observe the scan tool Throttle Body Idle Airflow Compensation parameter. The Throttle Body Idle Airflow Compensation value should equal 0 % and the engine should be idling at a normal idle speed.
3. Clear the DTCs and return to the diagnostic that referred you here.

Service Bay/On Road Idle Learn Procedure – Performed after the ECM is programmed or replaced

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Note: Do NOT perform this procedure if DTCs are set. Refer to Diagnostic Trouble Code (DTC) List - Vehicle.

1. Engine idling for 3 min.
2. Observe the scan tool Desired Idle Speed and the actual Engine Speed parameters.
3. The ECM will start to learn the new idle cells and the Desired Idle Speed should start to decrease.
4. Ignition OFF for 60 s.
5. Start and idle the engine for 3 min.
6. After the 3 min run time the engine should be idling normal.

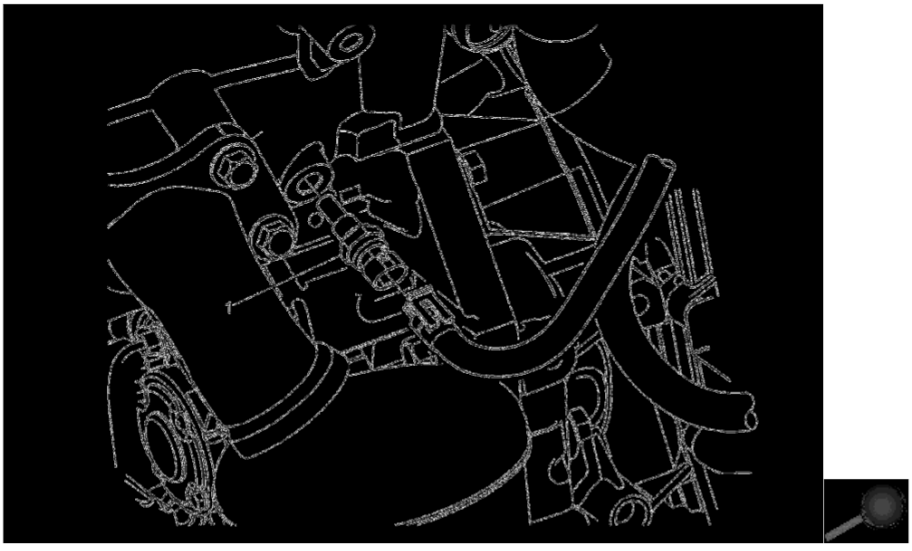
   Note: During the drive cycle the check engine light may come on with idle speed DTCs. If idle speed codes are set, clear codes so the ECM can continue to learn.

   ⇒ If the engine idle speed has not been learned the vehicle will need to be driven at speeds above 70 km/h (44 mph) with several decelerations and extended idles.
7. After the drive cycle, the engine should be idling normally.

   ⇒ If the engine idle speed has not been learned, turn OFF the ignition for 60 s and repeat step 6.
8. Once the engine speed has returned to normal, clear DTCs and return to the diagnostic that referred you here.

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Engine Coolant Temperature Sensor Replacement (LFW or LFX)



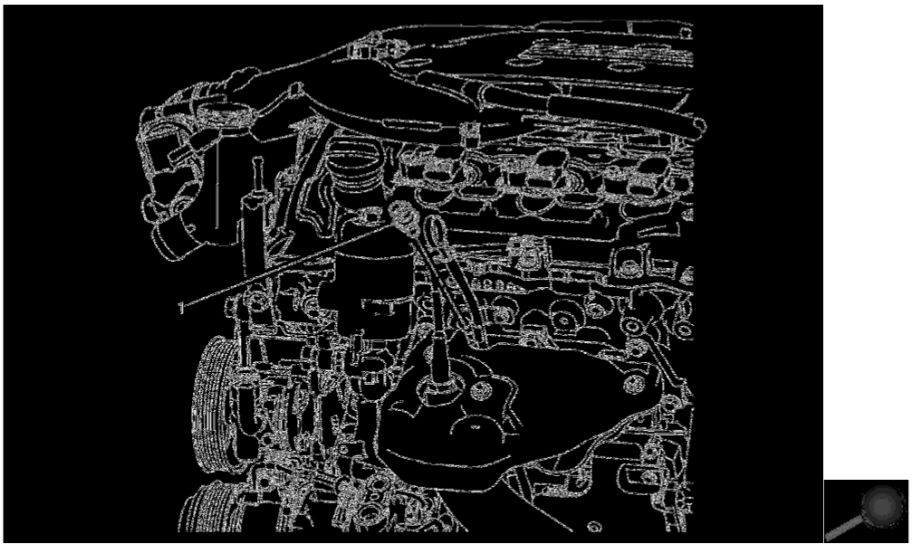
Engine Coolant Temperature Sensor Replacement

Callout	Component Name
Preliminary Procedure Partially drain the cooling system. Refer to Cooling System Draining and Filling.	
1	Engine Coolant Temperature Sensor **Caution:** Refer to Fastener Caution. **Procedure** 1. Reposition the sensor heat shield. 2. Disconnect the ECT sensor harness connector. **Tighten** 20 Y (35 lb in)

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Engine Coolant Temperature Sensor Replacement (LWR)



Engine Coolant Temperature Sensor Replacement

Callout	Component Name
Preliminary Procedure 1. Partially drain the cooling system. Refer to Cooling System Draining and Filling. 2. Disconnect the engine coolant temperature sensor electrical connector.	
1	Engine Coolant Temperature Sensor. **Caution:** Refer to Fastener Caution. **Tighten** 10 N•m (89 lb in)

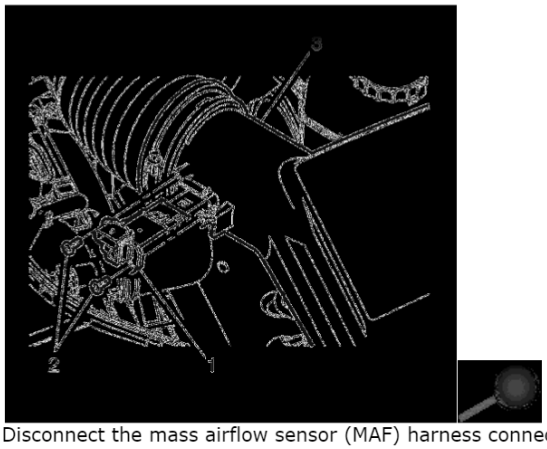
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Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LFW or LFX)

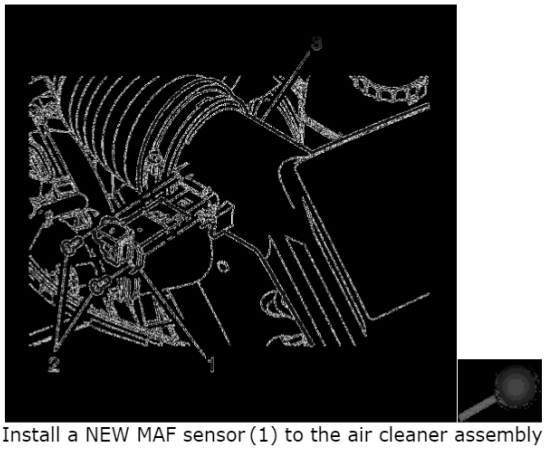
Removal Procedure

1. Ignition off.



2. Disconnect the mass airflow sensor (MAF) harness connector from the MAF sensor (1).
3. Remove the MAF sensor to air cleaner assembly screws (2).
4. Remove the MAF sensor (1) from the air cleaner assembly (3).

Installation Procedure



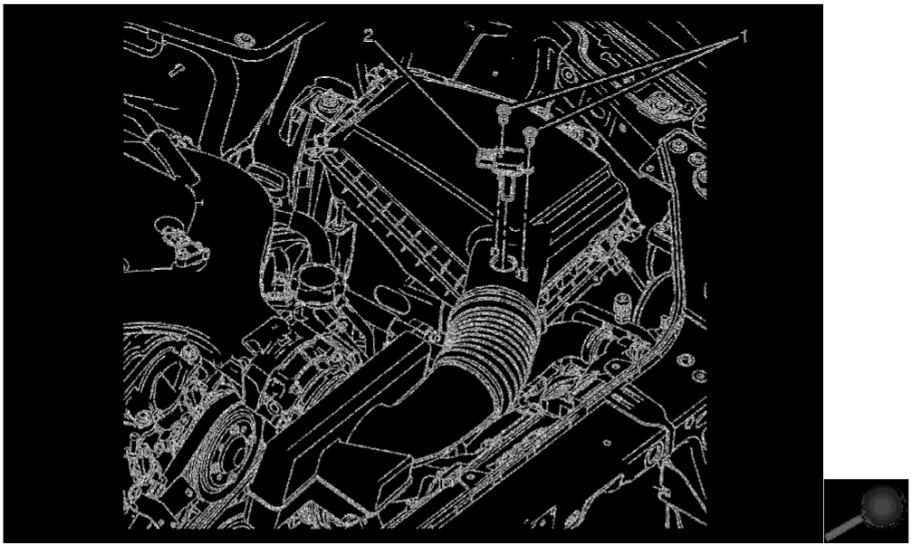
1. Install a NEW MAF sensor (1) to the air cleaner assembly (3).

   Caution: Refer to Fastener Caution.
2. Install the MAF sensor to air cleaner assembly screws (2) and tighten to **1 N·m (9 lb in)**.
3. Connect the MAF sensor harness connector to the NEW MAF sensor (1).

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Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LWR)



Mass Airflow Sensor with Intake Air Temperature Sensor Replacement

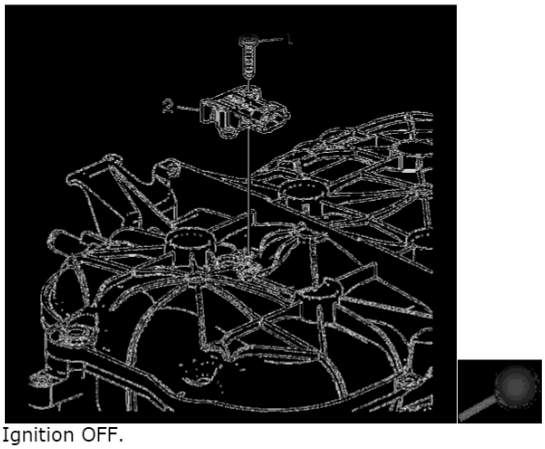
Callout	Component Name
Preliminary Procedure 1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection. 2. Disconnect the mass air flow electrical connector.	
1	Mass Air Flow Sensor Fasteners (Qty: 2). **Caution:** Refer to Fastener Caution. **Tighten** 1 N•m (9 lb in)
2	Mass Air Flow Sensor.

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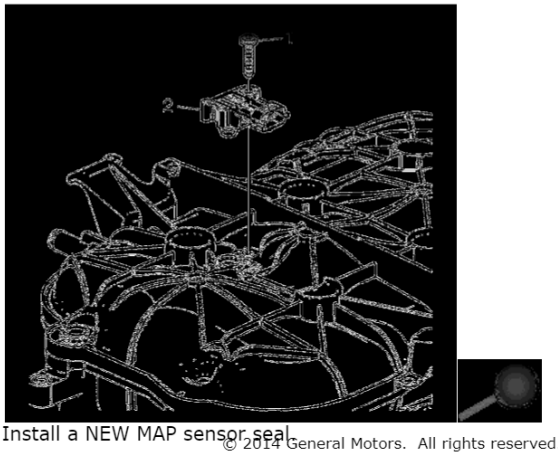
Manifold Absolute Pressure Sensor Replacement (LFW or LFX)

Removal Procedure



1. Ignition OFF.
2. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
3. Disconnect the engine wiring harness from the manifold absolute pressure (MAP) sensor (2).
4. Remove the MAP sensor to intake manifold retaining bolt (1).
5. Remove the MAP sensor (2) from the intake manifold assembly.
6. Discard the MAP sensor seal.

Installation Procedure



1. Install a NEW MAP sensor seal.

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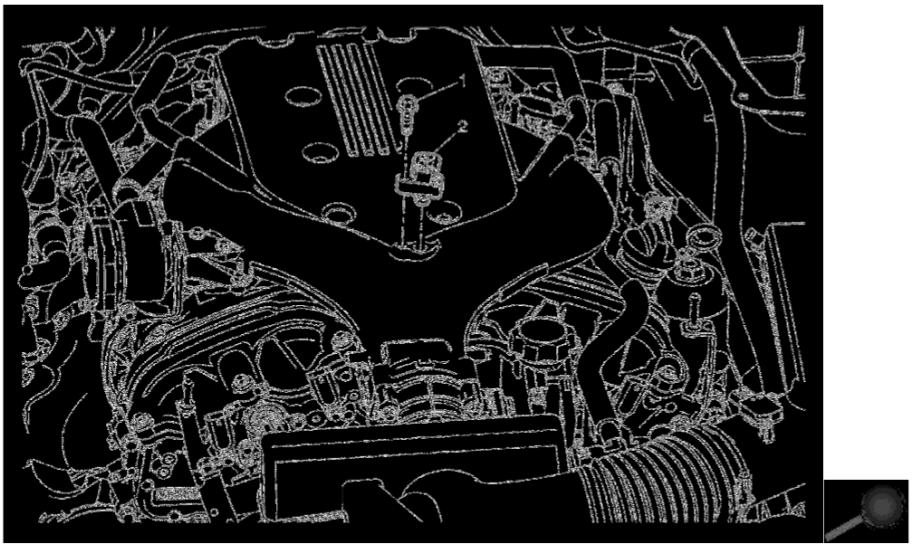
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2. Install the MAP sensor (2) to the intake manifold assembly.

   Caution: Refer to Fastener Caution.
3. Install the MAP sensor to intake manifold retaining bolt (1) and tighten to **4 N•m (35 lb in)**.
4. Connect the engine wiring harness to the manifold absolute pressure (MAP) sensor (2).
5. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.

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Manifold Absolute Pressure Sensor Replacement (LWR)



Manifold Absolute Pressure Sensor Replacement

Callout	Component Name
Preliminary Procedure 1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 2. Disconnect the manifold absolute pressure sensor electrical connector.	
1	Manifold Absolute Pressure Sensor Fastener. **Caution:** Refer to Fastener Caution. **Tighten** 10 N•m (89 lb in)
2	Manifold Absolute Pressure Sensor

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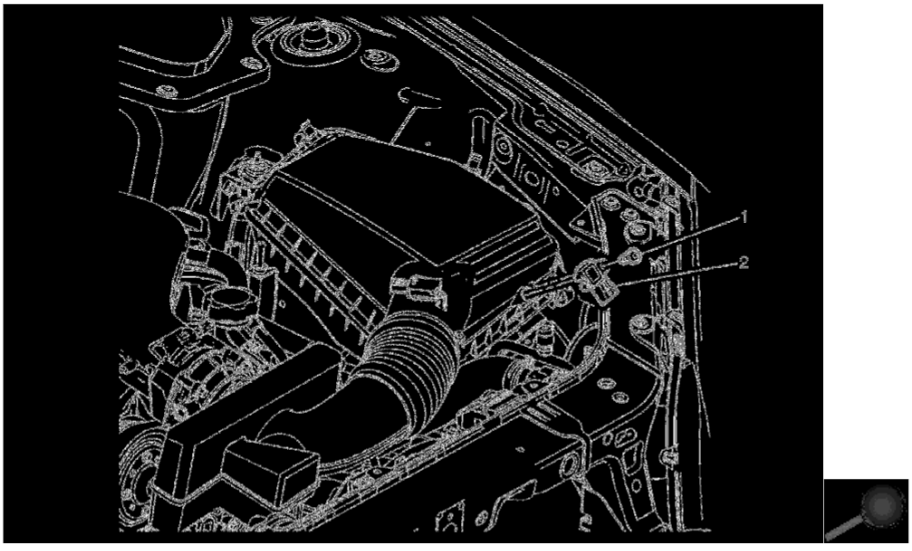
Barometric Pressure Sensor Replacement

The barometric pressure sensor is integrated with the throttle inlet absolute pressure (TIAP) sensor. To replace of the barometric pressure sensor, refer to Throttle Inlet Absolute Pressure Sensor Replacement.

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Throttle Inlet Absolute Pressure Sensor Replacement (LWR)



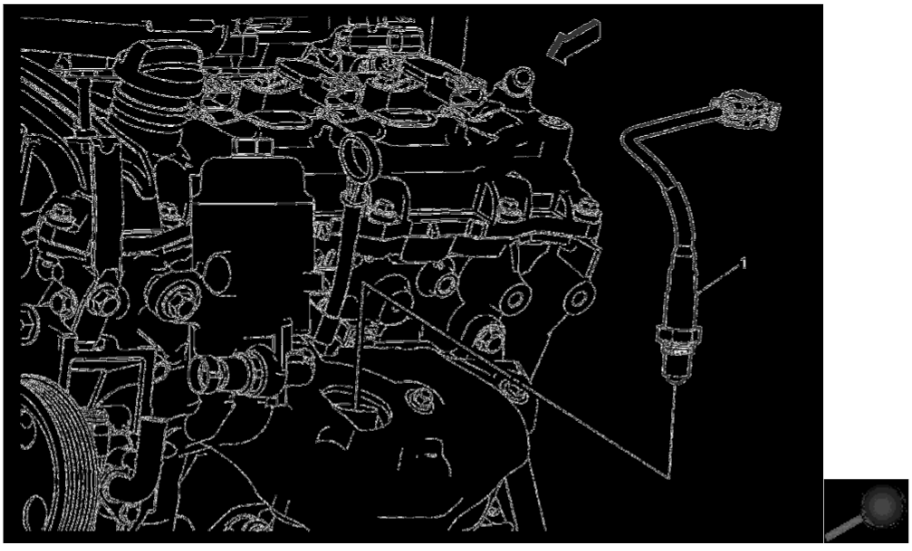
Throttle Inlet Absolute Pressure Sensor Replacement

Callout	Component Name
Preliminary Procedure Disconnect the throttle inlet absolute pressure sensor electrical connector.	
1	Throttle Inlet Absolute Pressure Sensor Fastener **Caution:** Refer to Fastener Caution. **Tighten** 3 N•m (27 lb in)
2	Throttle Inlet Absolute Pressure Sensor

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Heated Oxygen Sensor Replacement - Bank 1 Sensor 1 (LWR)



Heated Oxygen Sensor Replacement - Bank 1 Sensor 1

Callout	Component Name
Preliminary Procedure Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement	
1	Heated Oxygen Sensor **Caution:** Refer to Heated Oxygen and Oxygen Sensor Caution. **Caution:** Refer to Fastener Caution. **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-sieze compound. Refer to Adhesives, Fluids, Lubricants, and Sealers. **Note:** A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads. The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation. **Note:** When re-installing the heated oxygen sensor, ensure that the sensor flylead is routed between the engine assembly and the oil level indicator tube. This will ensure the flylead is isolated from the vehicle body **Tighten** 42 N•m (31 lb ft)

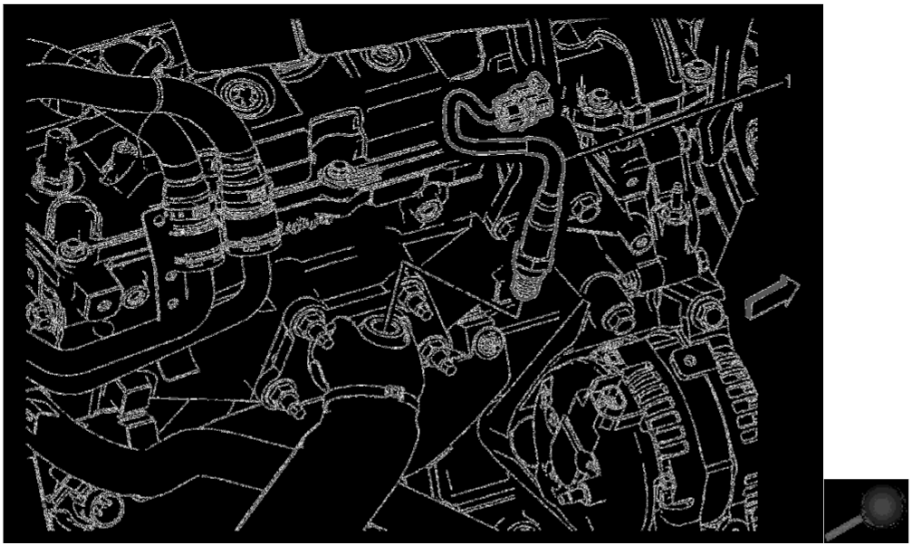
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Callout	Component Name

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Heated Oxygen Sensor Replacement - Bank 1 Sensor 1 (LFW or LFX)



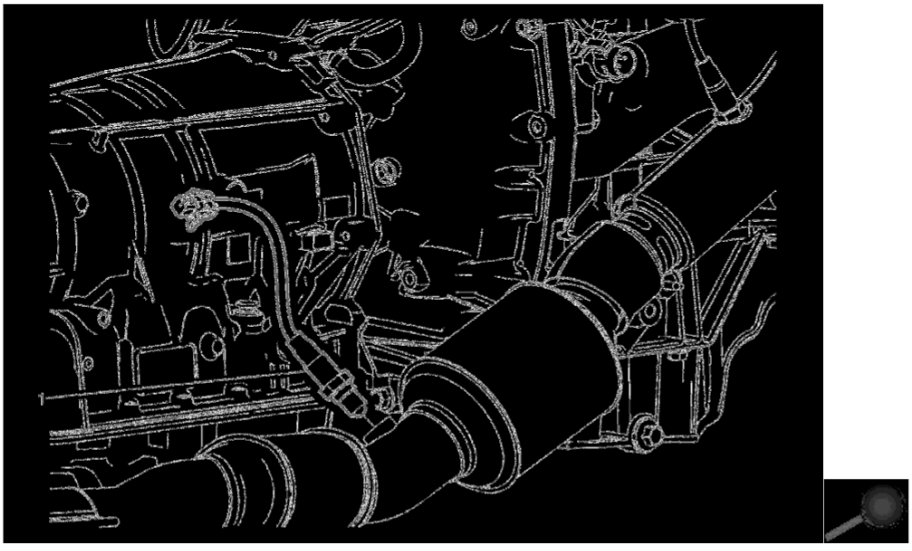
Heated Oxygen Sensor Replacement - Bank 1 Sensor 1

Callout	Component Name
Preliminary Procedure Remove the fuel injector sight shield. Refer to Intake Manifold Sight Shield Replacement.	
1	Heated Oxygen Sensor **Caution:** Refer to Heated Oxygen and Oxygen Sensor Caution. **Caution:** Refer to Fastener Caution. **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. **Note:** A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads. The graphic tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation. **Note:** Upon re-installation, ensure that the heated oxygen sensor flylead is reattached via the harness clip. This will ensure the flylead is isolated from the adjacent fuel lines and vehicle body. **Tighten** 42 N•m (31 lb ft)

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Heated Oxygen Sensor Replacement - Bank 1 Sensor 2 (LFW or LFX)



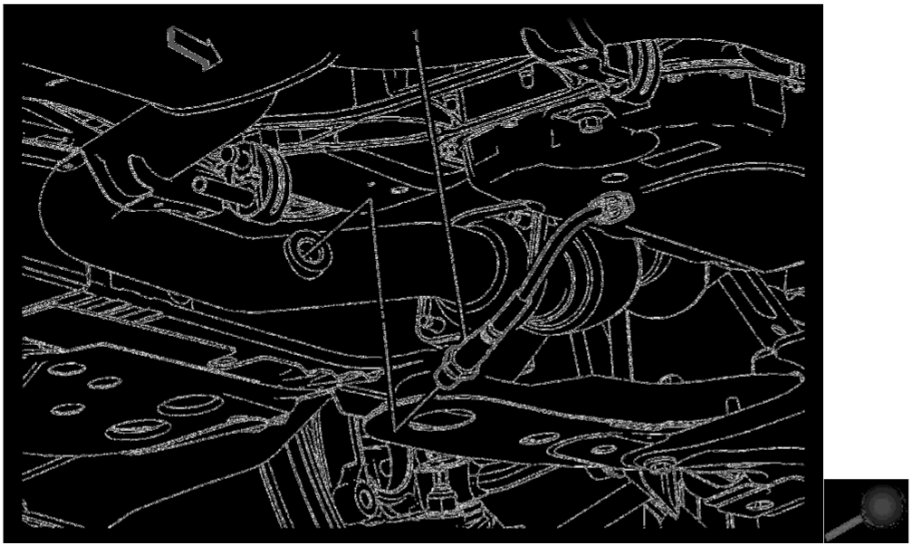
Heated Oxygen Sensor Replacement - Bank 1 Sensor 2

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.	
1	Heated Oxygen Sensor **Caution:** Refer to Heated Oxygen and Oxygen Sensor Caution. **Caution:** Refer to Fastener Caution. **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. **Note:** A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads. The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation. **Tighten** 42 N•m (31 lb in)

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Heated Oxygen Sensor Replacement - Bank 1 Sensor 2 (LWR)



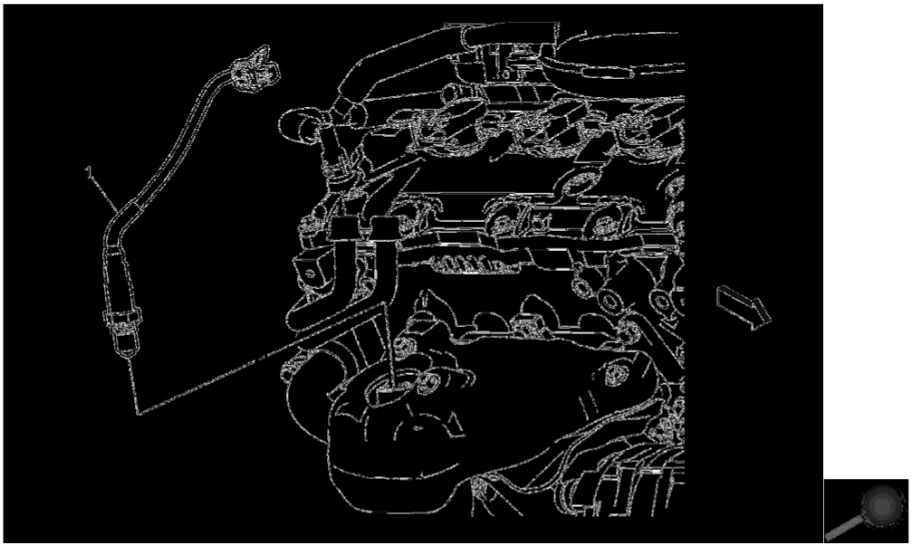
Heated Oxygen Sensor Replacement - Bank 1 Sensor 2

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle	
1	Heated Oxygen Sensor **Caution:** Refer to Heated Oxygen and Oxygen Sensor Caution. **Caution:** Refer to Fastener Caution. **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. Refer to Adhesives, Fluids, Lubricants, and Sealers. **Note:** A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads. The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation. **Tighten** 42 N•m (31 lb in)

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Heated Oxygen Sensor Replacement - Bank 2 Sensor 1 (LWR)



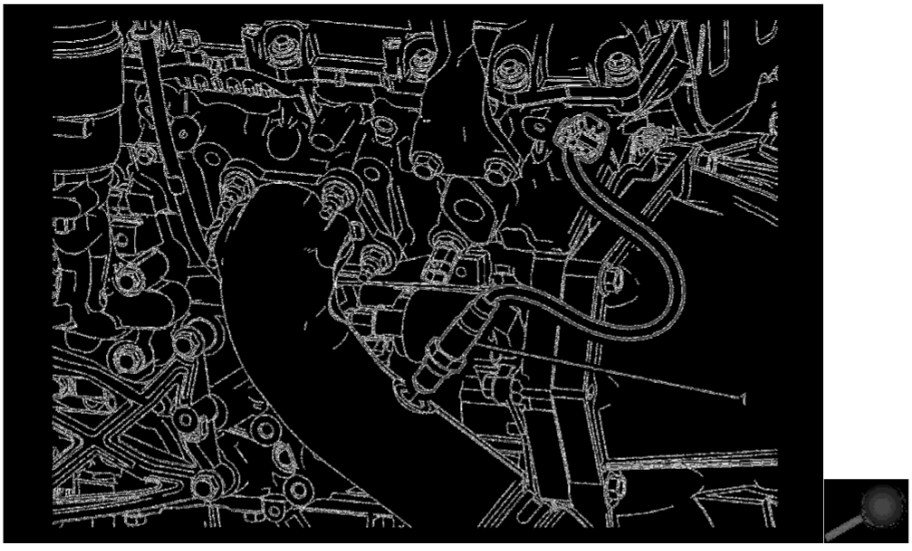
Heated Oxygen Sensor Replacement - Bank 2 Sensor 1

Callout	Component Name
Preliminary Procedure Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement	
1	Heated Oxygen Sensor **Caution:** Refer to Heated Oxygen and Oxygen Sensor Caution. **Caution:** Refer to Fastener Caution. **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. Refer to Adhesives, Fluids, Lubricants, and Sealers. **Note:** A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads. The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation. **Tighten** 42 N•m (31 lb in)

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Heated Oxygen Sensor Replacement - Bank 2 Sensor 1 (LFW or LFX)



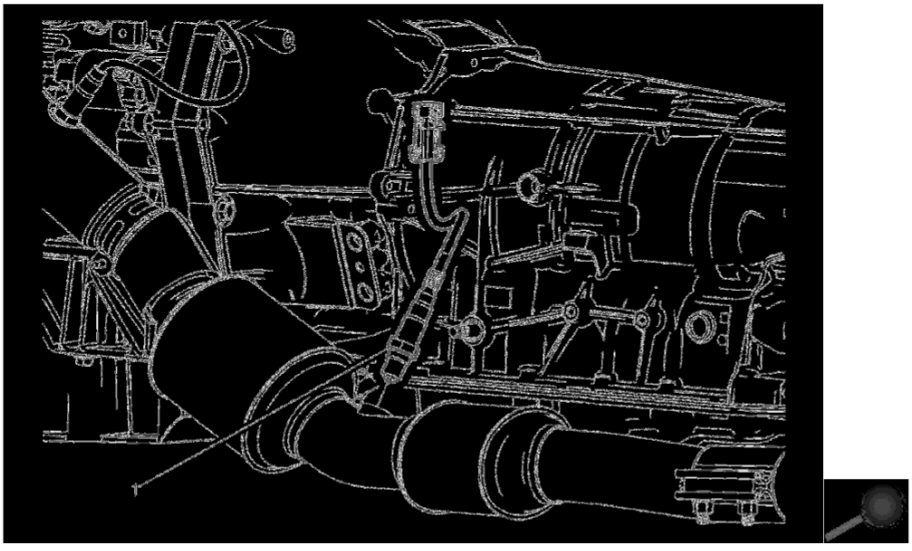
Heated Oxygen Sensor Replacement - Bank 2 Sensor 1

Callout	Component Name
1	Heated Oxygen Sensor **Caution:** Refer to Heated Oxygen and Oxygen Sensor Caution. **Caution:** Refer to Fastener Caution. **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. Refer to Adhesives, Fluids, Lubricants, and Sealers. **Note:** A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphic and glass beads. The graphic tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation. **Note:** Upon re-installation, ensure that the heated oxygen sensor flylead is reattached via the harness clip. This will ensure the flylead is isolated from the adjacent fuel lines and vehicle body. **Tighten** 42 N•m (31 lb ft)

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Heated Oxygen Sensor Replacement - Bank 2 Sensor 2 (LFW or LFX)



Heated Oxygen Sensor Replacement - Bank 2 Sensor 2

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.	
1	Heated Oxygen Sensor **Caution:** Refer to Heated Oxygen and Oxygen Sensor Caution. **Caution:** Refer to Fastener Caution. **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. **Note:** A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads. The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation. **Tighten** 42 N•m (31 lb in)

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Heated Oxygen Sensor Replacement - Bank 2 Sensor 2 (LWR)



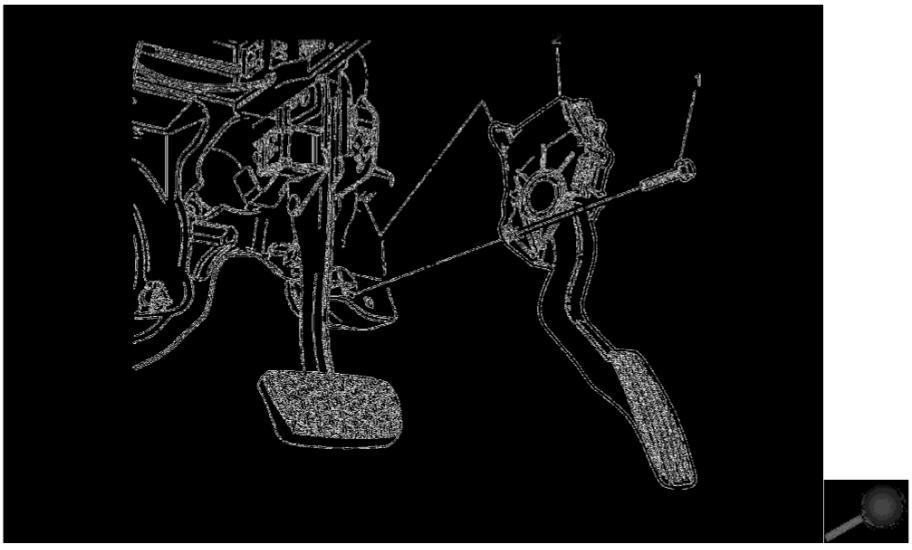
Heated Oxygen Sensor Replacement - Bank 2 Sensor 2

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle	
1	Heated Oxygen Sensor **Caution:** Refer to Heated Oxygen and Oxygen Sensor Caution. **Caution:** Refer to Fastener Caution. **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. Refer to Adhesives, Fluids, Lubricants, and Sealers. **Note:** A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads. The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation. **Tighten** 42 N•m (31 lb in)

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Accelerator Pedal Position Sensor Replacement



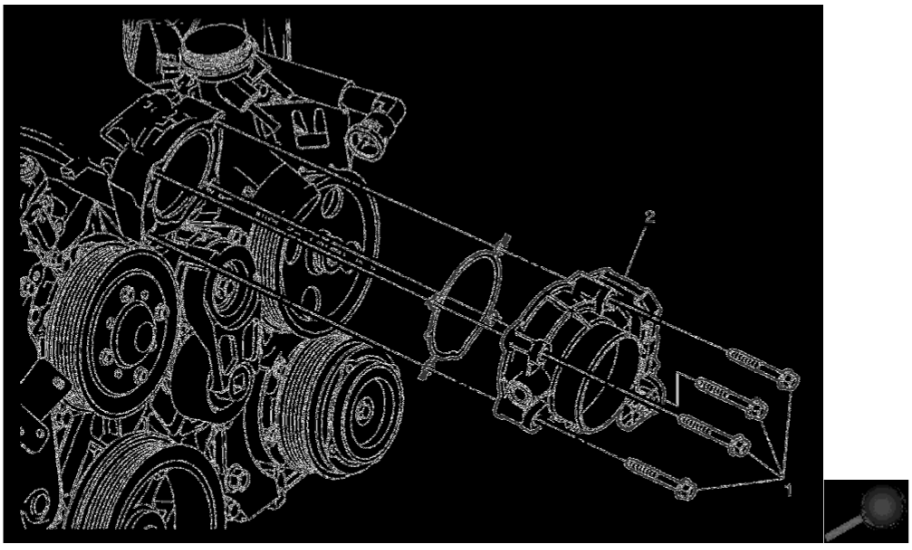
Accelerator Pedal Position Sensor Replacement

Callout	Component Name
Preliminary Procedure Remove the instrument panel lower trim panel insulator right side. Refer to Instrument Panel Lower Trim Panel Insulator Replacement - Right Side.	
1	Accelerator Pedal Position Sensor Bolt **Caution:** Refer to Fastener Caution **Tighten** 9 N•m (80 lb in)
2	Accelerator Pedal Position Sensor **Procedure** Disconnect the electrical connector.

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Throttle Body Assembly Replacement (LWR)



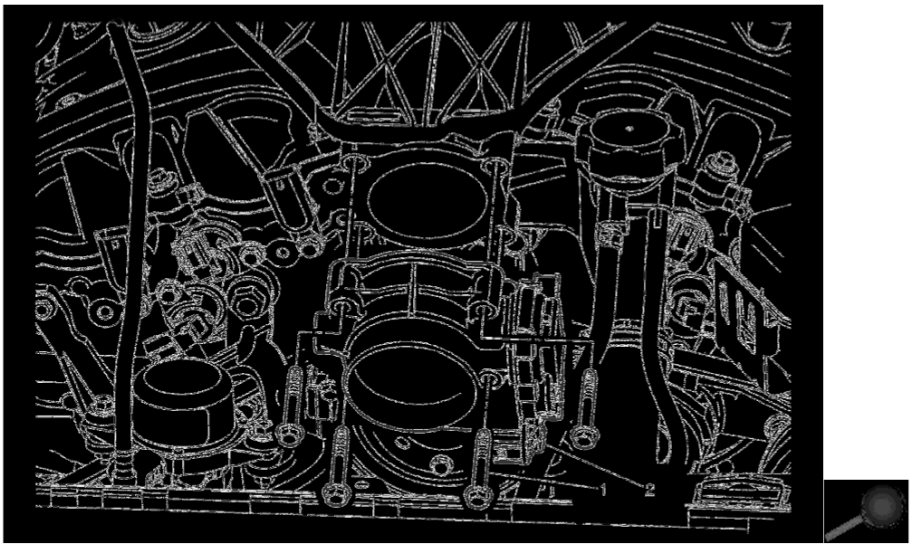
Throttle Body Assembly Replacement

Callout	Component Name
Preliminary Procedures 1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 2. Remove the outlet duct. Refer to Air Cleaner Outlet Duct Replacement.	
1	Throttle Body Assembly Fastener (Qty: 4) **Caution:** Refer to Fastener Caution. **Tighten** 10 N•m (89 lb in)
2	Throttle Body Assembly **Procedure** 1. Install a NEW throttle body seal. 2. Disconnect the electrical connectors. 3. Perform the throttle learn procedure. Refer to Q38 Throttle Body: Throttle/Idle Learn.

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Throttle Body Assembly Replacement (LFW or LFX)



Throttle Body Assembly Replacement

Callout	Component Name
Preliminary Procedures 1. Remove the fuel injector sight shield. Refer to Intake Manifold Sight Shield Replacement. 2. Remove the outlet duct. Refer to Air Cleaner Outlet Duct Replacement.	
1	Throttle Body Assembly Fastener (Qty: 4) **Caution:** Refer to Fastener Caution. **Tighten** 10 N•m (89 lb in)
2	Throttle Body Assembly **Procedure** 1. Install a NEW throttle body seal. 2. Disconnect the electrical connectors. 3. Perform the throttle learn procedure. Refer to Q38 Throttle Body: Throttle/Idle Learn.

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Throttle Body Inspection and Cleaning

Warning: Refer to Safety Glasses Warning.

1. Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement.
2. Fully open the throttle valve in order to Inspect the throttle body bore and the throttle valve plate for any 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.
3. Use a clean shop towel and an approved GM engine cleaner. Clean the throttle body bore and the throttle valve plate.

   If necessary, use a parts cleaning brush in order to remove heavy deposits.
4. Install the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement.
5. Perform the Throttle/Idle Learn procedure. Refer to Q38 Throttle Body: Throttle/Idle Learn.

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Fuel Pressure Relief (High Fuel Pressure)

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.

Note: If a scan tool is not available, WAIT at LEAST 2 hours after the engine has stopped running before disconnecting any of the high pressure fuel line connections.

1. Connect a scan tool to the vehicle and command the fuel pump relay OFF.
2. Start the vehicle and run the engine at idle speed until the engine stops.
3. Turn the ignition OFF.
4. Observe the scan tool and verify that the fuel pressure is equal to 0 kpa (psi).
5. If the fuel pressure is still above 0 kpa (psi), repeat step 2.

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Fuel Pressure Relief (Low Fuel Pressure)

Special Tools

- *EN-338-AU* Fuel Pressure Gauge
- *CH 48027* Digital Pressure Gauge

For equivalent regional tools, refer to Special Tools

Special Tools

Fuel Pressure Gauge Installation Mechanical

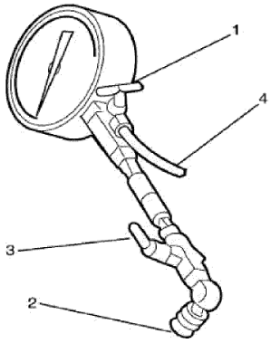
Warning: Refer to Gasoline/Gasoline Vapors Warning.

Warning: Refer to Relieving Fuel Pressure Warning.

Warning: Refer to Safety Glasses Warning.

1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement



4. Turn the fuel gauge assembly valve (3) to the open position.

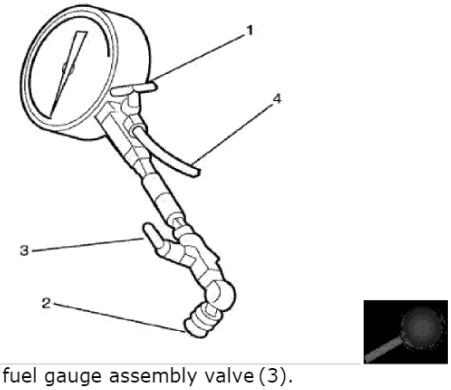
   Note: Wrap a shop towel around the schrader valve (2) when connecting the fuel gauge assembly to the fuel pressure inspection valve on the fuel feed pipe to avoid fuel spilling.

   Note: Screw on the schrader valve quickly to avoid fuel spillage.
5. Connect the schrader valve (2) to the fuel pressure inspection valve on the fuel feed pipe.
6. Place the bleed hose (4) into an approved container.
7. Open the bleed valve (1) to bleed any pressurized fuel.
8. Close the bleed valve (1) when the fuel pressure has dropped to 0 kPa (psi).

Fuel Pressure Gauge Removal Mechanical

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1. Close the fuel gauge assembly valve (3).
2. Place the bleed hose (4) into an approved container.
3. Open the bleed valve (1) to bleed any pressurized fuel.
4. Close the bleed valve (1).

   Note: Wrap a shop towel around the schrader valve when disconnecting the fuel gauge assembly from the fuel pressure inspection valve to avoid fuel spilling.

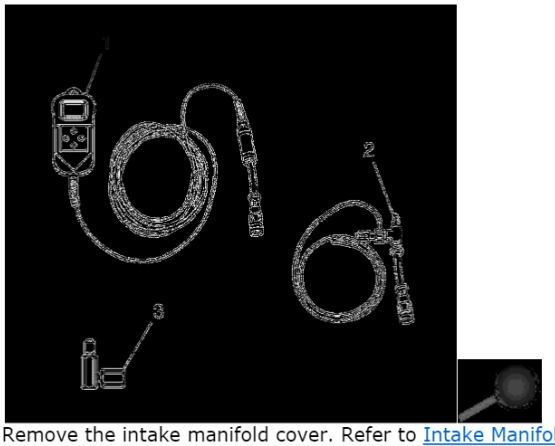
   Note: Unscrew the schrader valve quickly to avoid fuel spillage.
5. Disconnect the schrader valve (2) from the fuel pressure inspection valve on the fuel feed pipe.
6. Remove the fuel gauge assembly from the vehicle.
7. Empty any excess fuel from the fuel gauge and hose assembly.
8. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement
9. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.
10. Inspect for leaks.

Fuel Pressure Gauge Installation Digital

Warning: Refer to Gasoline/Gasoline Vapors Warning.

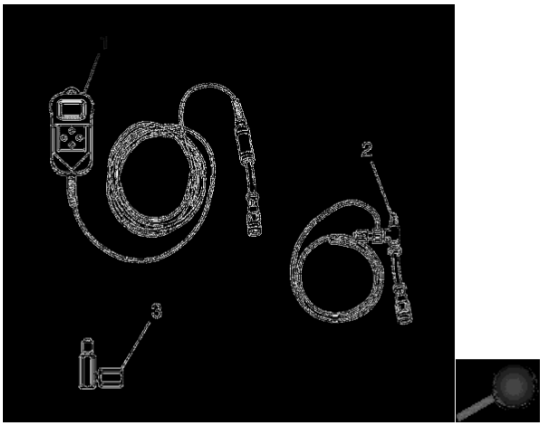
Warning: Remove the fuel tank cap and relieve the fuel system pressure before servicing the fuel system in order to reduce the risk of personal injury. After you relieve the fuel system pressure, a small amount of fuel may be released when servicing the fuel lines, the fuel injection pump, or the connections. 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.

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1. Remove the intake manifold cover. Refer to Intake Manifold Sight Shield Replacement.
2. Connect the *CH 48027* gauge(1) to the *CH 48027* adapter(2).
3. Remove the shop towel from around the fuel rail service port, and place in an approved gasoline container.
4. Perform any tests and/or diagnostics as needed. For the proper usage of the *CH 48027* gauge(1), refer to the manufacture's directions.

Fuel Pressure Gauge Removal Digital



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.

1. Relieve the fuel system pressure, if required. Perform the following steps:
   1.1. Wrap a shop towel around the fuel rail service port.
   1.2. Place the hose on the *CH 48027* adapter(2) into an approved gasoline container.
   1.3. Open the valve on the *CH 48027* adapter(2) in order to bleed any fuel from the fuel rail.
   1.4. Close the valve on the *CH 48027* adapter(2).
   1.5. Remove the hose on the *CH 48027* adapter(2) from the approved gasoline container.

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1.6. Remove the shop towel from around the fuel rail service port, and place in an approved gasoline container.

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

2. Disconnect the *CH 48027* gauge(1) from the *CH 48027* gauge(2).
3. Disconnect the *CH 48027* adapter(2) from the *CH 48027* adapter(3).
4. Disconnect the *CH 48027* adapter(3) from the fuel rail service port.
5. Install the fuel rail service port cap.
6. Install the intake manifold cover. Refer to Intake Manifold Sight Shield Replacement.
7. Tighten the fuel fill cap.

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Fuel Pressure Relief (LPG LWR)

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Note: If at any time the manual valve becomes stuck, no service operations on the system will be possible.

1. Turn the manual service valve off (1).
2. Start the engine and allow to run on LPG until the engine stalls, then crank it several times to ensure the service lines are empty of LPG.
3. The service lines should now be empty of liquid LPG.

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Fuel Pressure Gauge Installation and Removal (Gasoline)

The fuel pressure gauge removal and installation procedure is incorporated in the fuel pressure relief procedure. Refer Fuel Pressure Relief.

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Fuel Pressure Gauge Installation and Removal (LPG LWR)

LPG Fuel Pressure Gauge Installation

Special Tools

- *OTC-3490* LPG Fuel Pressure Gauge
- *EN-50958* LPG Fuel Pressure Gauge Adapter

For equivalent regional tools, refer to Special Tools.

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

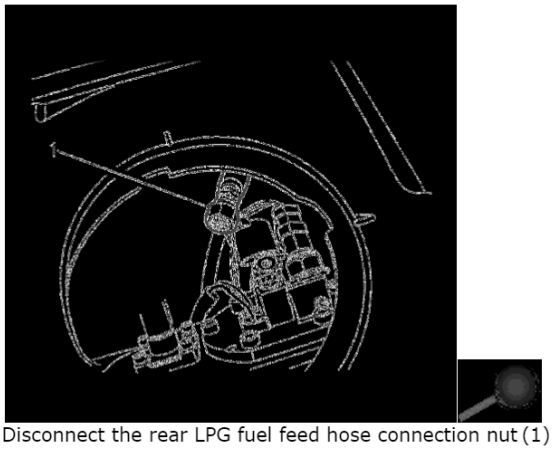
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

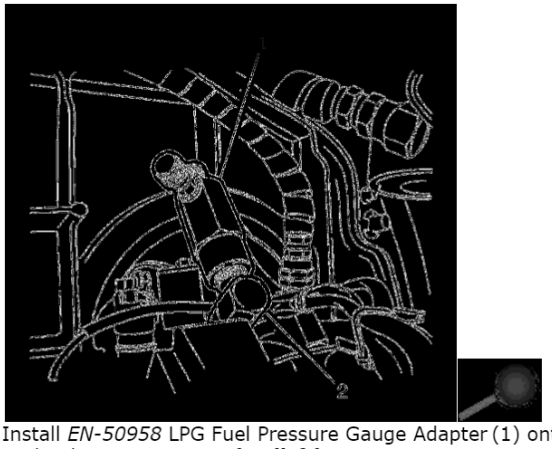
1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle



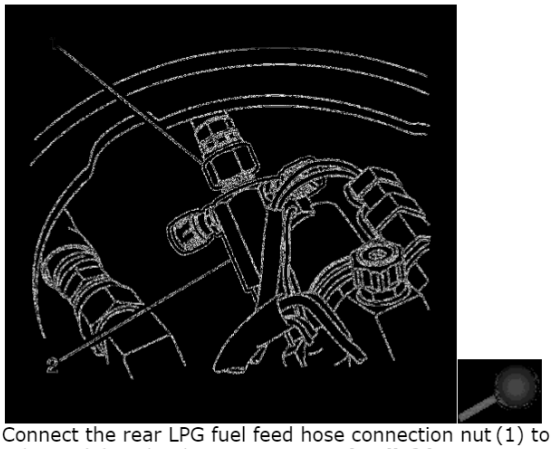
3. Disconnect the rear LPG fuel feed hose connection nut (1) from the fuel pump outlet fitting.

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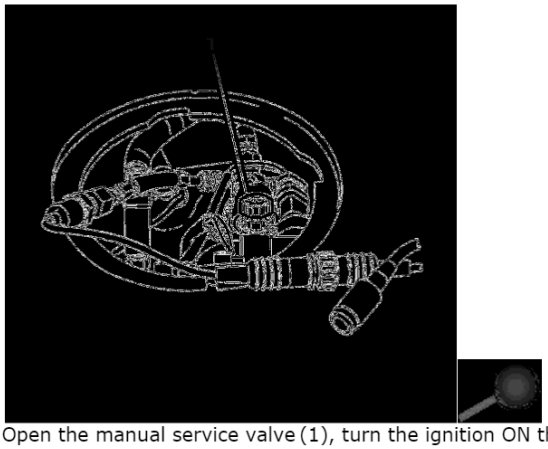


4. Install *EN-50958* LPG Fuel Pressure Gauge Adapter (1) onto the fuel pump outlet fitting (2), and tighten to **28.5 N•m (21 lb ft)**.



5. Connect the rear LPG fuel feed hose connection nut (1) to the LPG fuel pressure gauge adapter (2) and tighten to **28.5 N•m (21 lb ft)**.
6. Install *OTC-3490* LPG Fuel Pressure Gauge to the most accessible connector on the LPG fuel pressure gauge adapter.

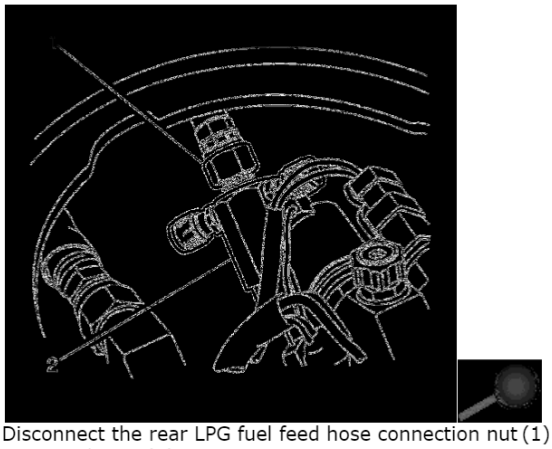
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7. Open the manual service valve (1), turn the ignition ON then OFF. Perform the LPG leak test to all installed components, refer to LPG Leak Testing.

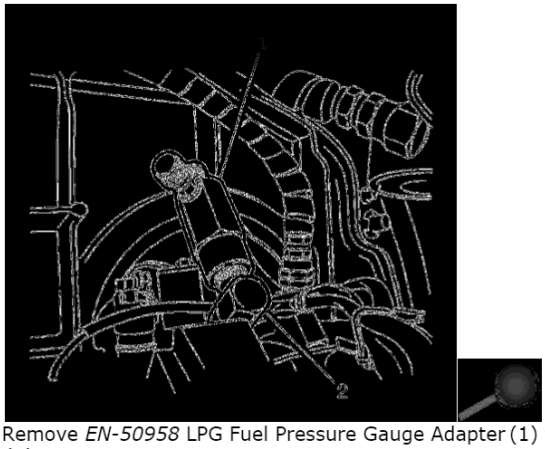
LPG Fuel Pressure Gauge Removal

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Disconnect the *OTC-3490* LPG Fuel Pressure Gauge from the LPG fuel pressure gauge adapter.

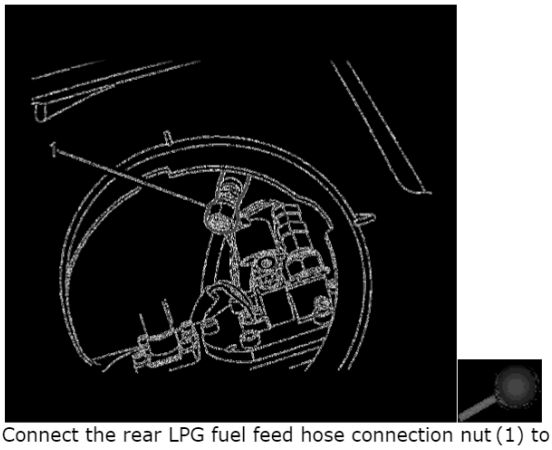


3. Disconnect the rear LPG fuel feed hose connection nut (1) from the LPG fuel pressure gauge adapter (2).

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4. Remove *EN-50958* LPG Fuel Pressure Gauge Adapter (1) from the fuel pump outlet fitting (2).



5. Connect the rear LPG fuel feed hose connection nut (1) to the fuel pump outlet fitting.
6. Open the manual service valve, turn the ignition ON then OFF. Perform the LPG leak test, refer to LPG Leak Testing.

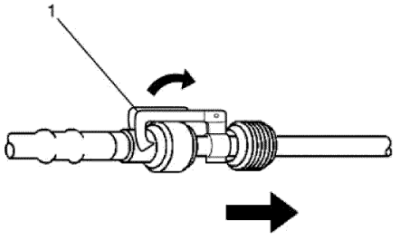
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Metal Collar Quick Connect Fitting Service

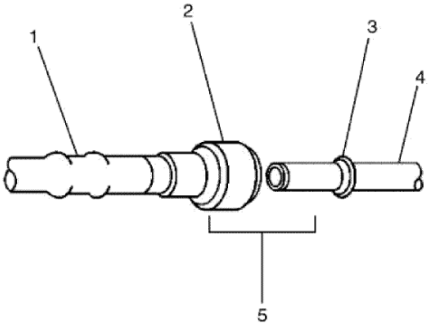
Special Tools

- *7370* Fuel Line Quick Connect Separator
- *7371* Quick Connect Release Tool
- *J 41769* Fuel Line Quick Disconnect Tool
- *J 41623-B* Cooler Quick Connect Tool

Removal Procedure Quick Connect Fitting Type 1



1. Relieve the fuel system pressure. Refer to the Fuel Pressure Relief.
2. Slide the dust cover from the quick-connect fitting if a dust cover is fitted.
3. Clean any grime from the metal collar quick connect fitting.
4. Detach the metal collar quick connect fitting verifier clip (1).



5. Choose the correct special tool and install the special tool onto the male connector pipe (4).
6. Apply suitable pressure and push the special tool into the female connector (2) to release the retaining tabs.

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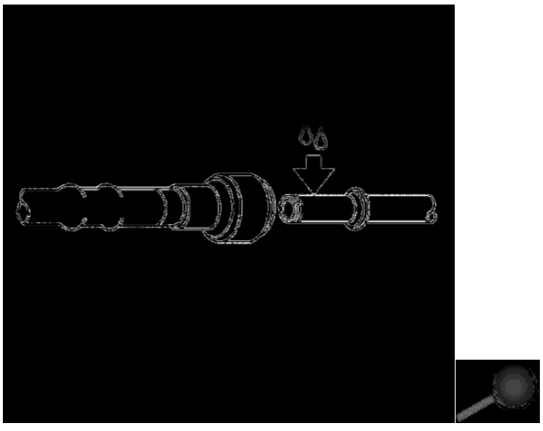
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7. Pull the female connector pipe (1) away from the male connector pipe (4).
8. Remove the special tool from the metal collar quick connect fitting.

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.

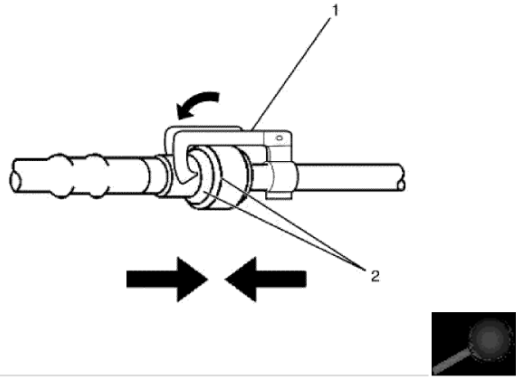
9. Clean the metal collar quick connect fittings using a clean shop towel.
10. Inspect the metal collar quick connect fittings for damage. Replace any damaged metal collar quick connect fittings.

Installation Procedure Quick Connect Fitting Type 1



Warning: Always apply a few drops of clean engine oil to the male pipe ends before connecting the fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. Always replace O-rings.

1. Apply a few drops of clean engine oil to the metal collar quick connect fitting.



Note: Apply suitable pressure to both ends of the metal collar quick connect fitting to make sure that the retaining tabs snap into place.

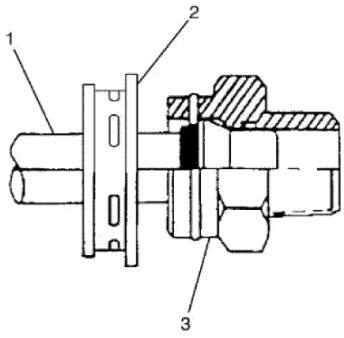
Note: Listen for an audible click to confirm the correct installation of the metal collar quick connect fitting.

2. Connect the metal collar quick connect fittings (2).

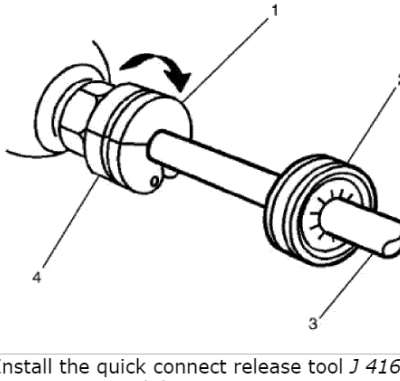
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3. Install the metal collar quick connect fitting verifier clip (1).
4. Slide the dust cover into position if fitted.

Removal Procedure Quick Connect Fitting Type 2



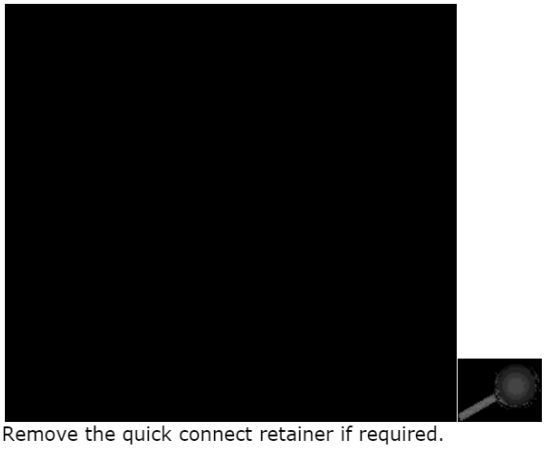
1. Detach the verifier cap (2) by pulling the verifier cap back along the male connector pipe (1).



2. Install the quick connect release tool *J 41623-B* cooler quick connect tool (1) onto the male connector pipe (3).
3. Apply suitable pressure while pushing and turning the quick connect release tool *J 41623-B* cooler quick connect tool into the female connector (4) to release the retaining tabs.
4. Pull the male connector pipe (3) away from the female connector (4).
5. Remove the quick connect release tool *J 41623-B* cooler quick connect tool from the male connector pipe (3).

   Caution: If necessary, remove rust or burrs from the fuel pipes with an emery cloth. Use a radial motion with the fuel pipe end in order to prevent damage to the O-ring sealing surface. Use a clean shop towel in order to wipe off the male tube ends. Inspect all the connections for dirt and burrs. Clean or replace the components and assemblies as required.
6. Clean the metal collar quick connect fittings using a clean shop towel.

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7. Remove the quick connect retainer if required.
8. Inspect the metal collar quick connect fittings for damage. Replace any damaged metal collar quick connect fitting components.

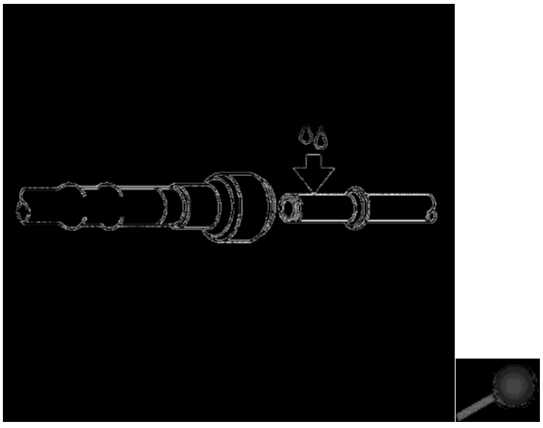
Installation Procedure Quick Connect Fitting Type 2



Note: The new quick connect retainer should align with the three slots of the quick connect fitting.

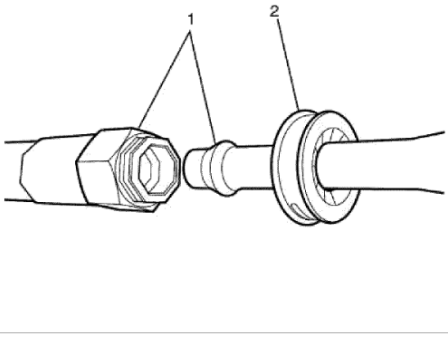
1. If required, install a new quick connect retainer by rotating the new quick connect retainer around the fitting until the new quick connect retainer is seated correctly.

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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. Apply a few drops of clean engine oil to the metal collar quick connect fitting.

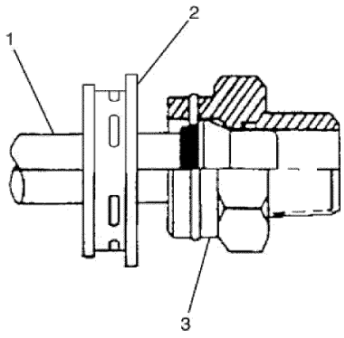


Note: Apply suitable pressure to both ends of the metal collar quick connect fitting to make sure that the retaining tabs snap into place.

Note: Listen for an audible click to confirm the correct installation of the metal collar quick connect fitting.

3. Connect the metal collar quick connect fittings (1).

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Note: To Instal the metal collar quick connect fitting verifier cap (2), slide the metal collar quick connect fitting verifier cap (2) along the pipe.

4. Install the metal collar quick connect fitting verifier cap (2) to the metal collar quick connect fitting (3).

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Plastic Collar Quick Connect Fitting Service

Special Tools

EN-46843 Quick Connect Release Tool

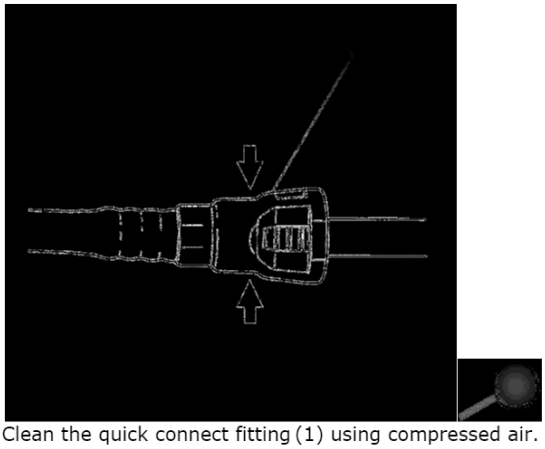
For equivalent regional tools, refer to Special Tools.

Removal Procedure Quick Connect Fitting Type 1

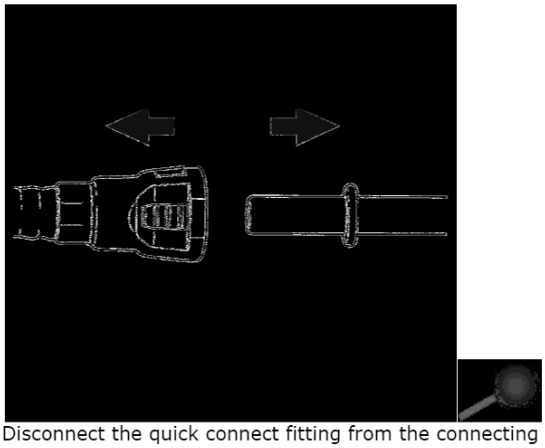
Warning: Refer to Gasoline/Gasoline Vapors Warning.

Warning: Refer to Safety Glasses Warning.

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.



2. Clean the quick connect fitting (1) using compressed air.
3. Install the quick connect release tool *EN-46843* quick connect release tool over the quick connect fitting (1).



4. Disconnect the quick connect fitting from the connecting pipe.
5. Dry the quick connect fitting and the connecting pipe with a clean shop towel.

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6. Inspect the quick connect fitting and the connecting pipe for damage.
7. Replace damaged parts as required.

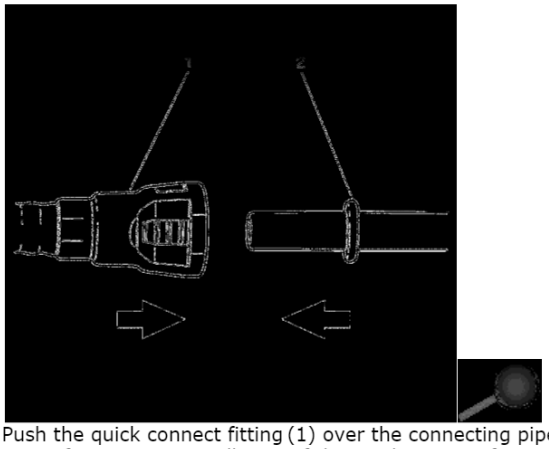
Installation Procedure Quick Connect Fitting Type 1

Warning: In order to reduce the risk of fire and personal injury, before connecting fuel pipe fittings, always apply a few drops of clean engine oil to the male pipe ends.

This will ensure proper reconnection and prevent a possible fuel leak.

During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.

1. Apply a few drops of clean engine oil to the quick connect fitting.



2. Push the quick connect fitting (1) over the connecting pipe (2). Listen for and audible click to confirm correct installation of the quick connect fitting (1).
3. Inspect for leaks using the following procedure:
   3.1. Turn the ignition ON, with the engine OFF for 2 seconds.
   3.2. Turn the ignition OFF, for 10 seconds.
   3.3. Turn the ignition ON, with the engine OFF for 2 seconds.
   3.4. Turn the ignition OFF.
   3.5. Inspect for leaks.

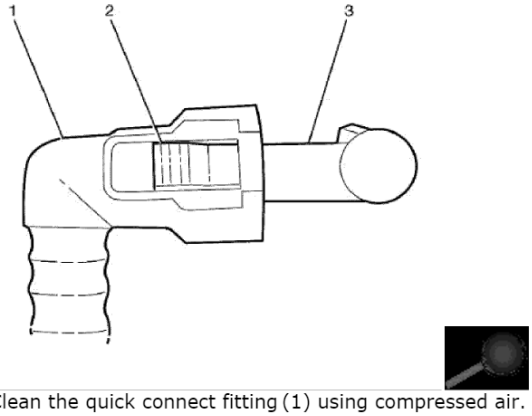
Removal Procedure Quick Connect Fitting Type 2

Warning: Refer to Gasoline/Gasoline Vapors Warning.

Warning: Refer to Safety Glasses Warning.

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.

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2. Clean the quick connect fitting (1) using compressed air.
3. Push the quick connect fitting (1) towards the connecting pipe (3).
4. Grasp the quick connect fitting release tabs (2) and disconnect the quick connect fitting (1) from the connecting pipe (3).
5. Dry the quick connect fitting (1) and the connecting pipe (3) with a clean shop towel.
6. Inspect the quick connect fitting (1) and the connecting pipe (3) for damage.
7. Replace damaged parts as required.

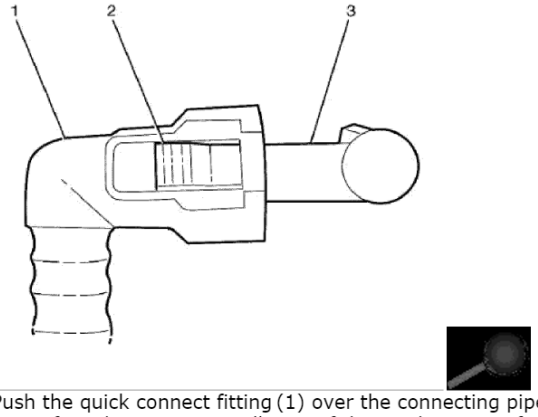
Installation Procedure Quick Connect Fitting Type 2

Warning: In order to reduce the risk of fire and personal injury, before connecting fuel pipe fittings, always apply a few drops of clean engine oil to the male pipe ends.

This will ensure proper reconnection and prevent a possible fuel leak.

During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.

1. Apply a few drops of clean engine oil to the quick connect fitting.



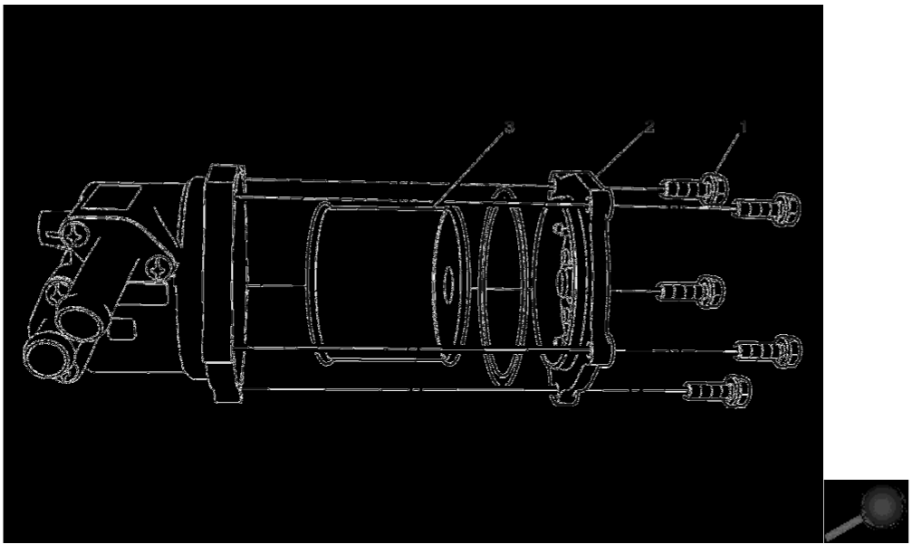
2. Push the quick connect fitting (1) over the connecting pipe (3). Listen for and audible click to confirm the correct installation of the quick connect fitting (1).
3. Inspect for leaks using the following procedure:
   3.1. Turn the ignition ON, with the engine OFF for 2 seconds.
   3.2. Turn the ignition OFF, for 10 seconds.

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3.3. Turn the ignition ON, with the engine OFF for 2 seconds.
3.4. Turn the ignition OFF.
3.5. Inspect for leaks.

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Fuel Filter Replacement (TAR Filter Element LWR)



Fuel Filter Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief. 2. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 3. Remove the LPG fuel filter from the engine. Refer to LPG Fuel Filter Replacement.
1	Fuel Filter Bolts (Qty: 5). **Caution:** Refer to Fastener Caution.

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Callout	Component Name
	Tighten 6.5 N•m (58 lb in)
2	Fuel Filter Cover.
3	Fuel Filter Element. **Procedure** Perform leak test after final assembly. Refer to LPG Leak Testing.

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Fuel Tank Draining

Special Tools

- *J-42960-2* Fuel Flapper Door Holder
- *J-45004* Fuel Tank Drain Hose
- Commercially Available Fuel Pump

For equivalent regional tools, refer to Special Tools.

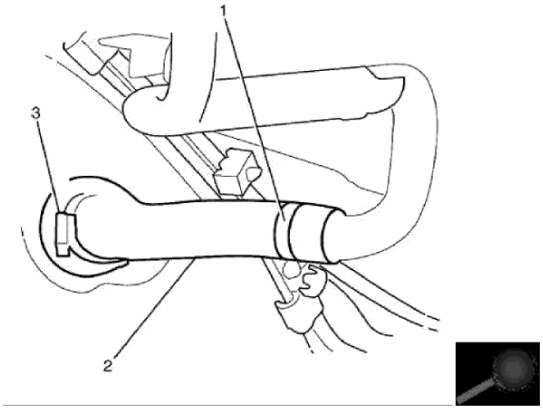
Fuel Tank Draining Method 1

1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

   Danger: To avoid any vehicle damage, serious personal injury or death, always use the jackstands to support the vehicle when lifting the vehicle with a jack.

   Warning: Refer to Safety Glasses Warning.
3. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
4. Remove the right rear wheel. Refer to Tire and Wheel Removal and Installation.

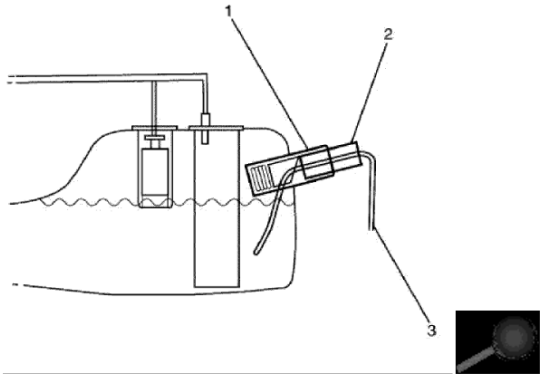


   Warning: Refer to Gasoline/Gasoline Vapors Warning.

   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.
5. Remove the retaining hose clamp (1) from the fuel filler hose (2).
6. Remove the retaining hose clamp (3) from the fuel filler hose (2).
7. Remove the fuel filler hose (2) from the vehicle.

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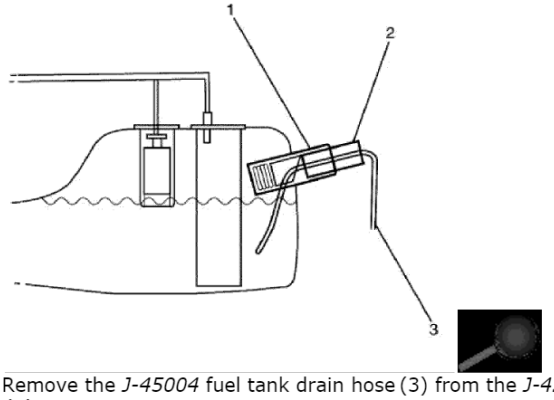


Note: Up to approximately 36 litres (8 gallons) of residual fuel may remain in the secondary side of the fuel tank.

Note: The *J-42960-2* fuel flapper door holder (2) is used to keep the roll over anti spill valve open.

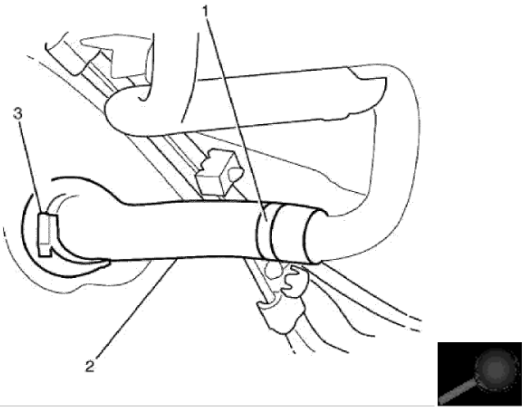
8. Install the *J-42960-2* fuel flapper door holder (2) to the fuel tank fuel filler pipe (1).
9. Insert the *J-45004* fuel tank drain hose (3) through the *J-42960-2* fuel flapper door holder (2) until the*J-45004* fuel tank drain hose (3) reaches the bottom of the tank.
10. Use a commercially available pump to drain the fuel from the fuel tank.

Adding The Drained Fuel to The Fuel Tank for Method 1



1. Remove the *J-45004* fuel tank drain hose (3) from the *J-42960-2* fuel flapper door holder (2) .
2. Remove the *J-42960-2* fuel flapper door holder (2) from the fuel tank fuel filler pipe (1).

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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.

3. Install the fuel filler hose (2) to the vehicle.

Caution: Refer to Fastener Caution.

4. Install the retaining hose clamp (3) to the fuel filler hose (2) and tighten to **4 N•m (35 lb in).**
5. Install the retaining hose clamp (1) to the fuel filler hose (2) and tighten to **4 N•m (35 lb in).**
6. Install the right rear wheel. Refer to Tire and Wheel Removal and Installation.
7. Lower the vehicle to the ground. Refer to Lifting and Jacking the Vehicle.
8. Add the drained fuel to the fuel tank.
9. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

Fuel Tank Draining Method 2

1. Install the fuel pressure gauge to the vehicle. Refer to Fuel Pressure Gauge Installation and Removal.
2. Place the bleed hose of the fuel pressure gauge into a suitable container.

Note: Do not leave the vehicle unattended when performing this procedure.

3. Command the fuel pump ON with a scan tool.

Note: Do not fully open the bleed valve on the fuel pressure gauge. To drain both sides of the fuel tank simultaneously there should be a restriction on the flow rate at the bleed hose.

4. Open the bleed valve on the fuel pressure gauge just enough to cause a restriction to the flow of the fuel rate at the bleed hose.

Note: To avoid damage to the fuel pump do not allow the fuel pump to run dry while the fuel pump is in the ON state.

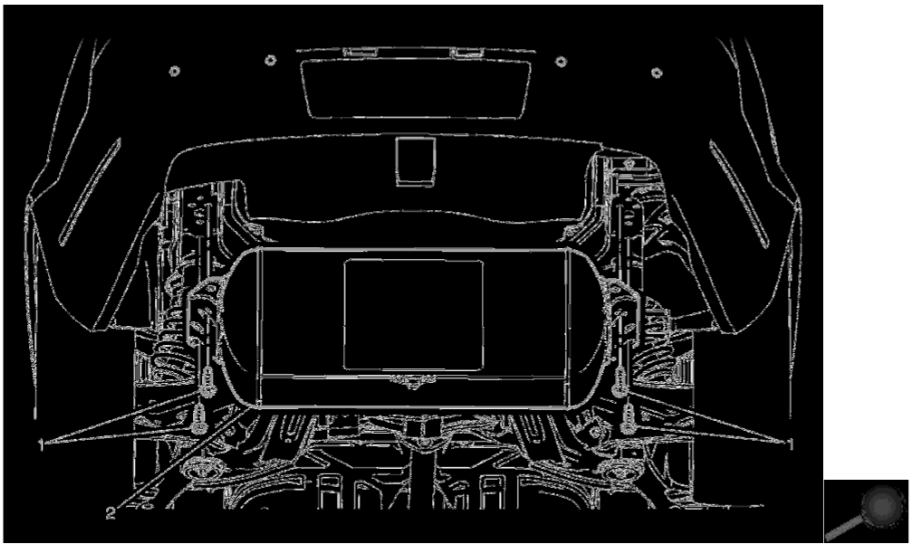
5. Command the fuel pump OFF with the scan tool as soon as it is observed that no more fuel is coming out of the bleed hose.
6. Remove the fuel pressure gauge from the vehicle. Refer to Fuel Pressure Gauge Installation and Removal.

Adding The Drained Fuel to The Fuel Tank for Method 2

1. Lower the vehicle to the ground. Refer to Lifting and Jacking the Vehicle.
2. Add the drained fuel to the fuel tank.

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Fuel Tank Replacement (LWR)



Fuel Tank Replacement

Callout	Component Name

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Preliminary Procedure

1. Empty the LPG tank. Refer to LPG Tank Unloading
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Remove rear bumper fascia retaining screws from fuel tank shield. Refer to Fuel Tank Shield Replacement.
4. Remove the fuel tank shield if required. Refer to Fuel Tank Shield Replacement
5. Disconnect the electrical connectors and harness clips.
6. Remove exhaust muffler right side. Refer to Exhaust Muffler Replacement - Right Side.

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Callout	Component Name
7. Remove exhaust muffler heat shield from fuel tank. Refer to Exhaust Muffler Heat Shield Replacement - Right Side.	
1	Fuel Tank Bolts (Qty: 4). **Caution:** Refer to Fastener Caution. **Note:** Single use item, do not reuse, replace with NEW bolt. **Tighten** 90 N•m (66 lb ft)
2	Fuel Tank **Preliminary Procedure** 1. While still supporting the tank (2) remove the four tank retaining fasteners (1). 2. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.

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Fuel Tank Replacement (LFW or LFX)

Special Tools

- *EN-48536* Frame Support Tool (Engine Lower 65 mm Kit)
- *7371* Quick Connect Release Tool
- *7370* Fuel Line Quick Connect Separator

For equivalent regional tools, refer to Special Tools.

Removal Procedure

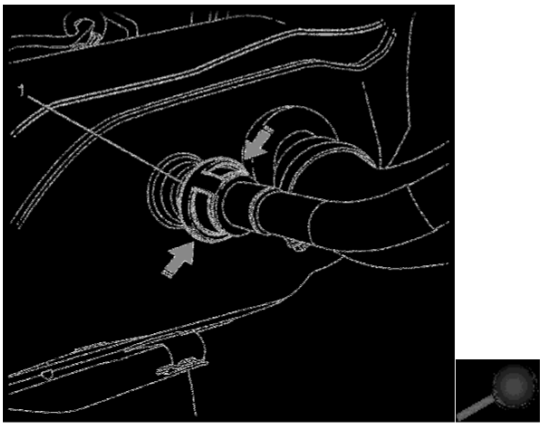
1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

   Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

   Warning: Refer to Safety Glasses Warning.
3. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.

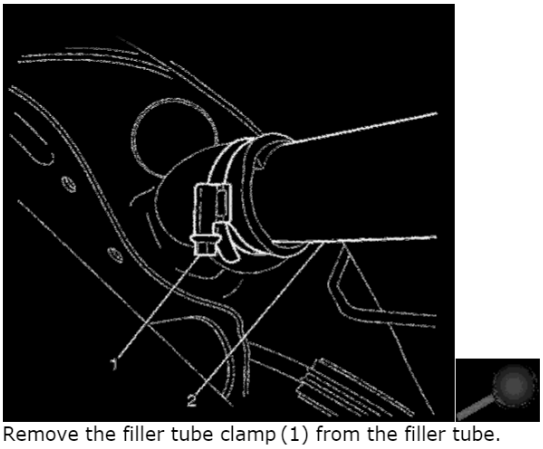
   Warning: Refer to Gasoline/Gasoline Vapors Warning.
4. Relieve the low side fuel pressure. Refer to Fuel Pressure Relief.
5. Drain the fuel tank. Refer to Fuel Tank Draining.
6. Remove the right rear wheel. Refer to Tire and Wheel Removal and Installation.
7. Remove the exhaust crossover pipe. Refer to Exhaust Crossover Pipe Replacement.
8. Remove the propeller shaft. Refer to Propeller Shaft Replacement.
9. Remove the fuel tank heat shield. Refer to Fuel Tank Heat Shield Replacement.
10. Disconnect the fuel feed line pressure sensor connector. Refer to Fuel Pressure Sensor Replacement - Fuel Feed Pipe.



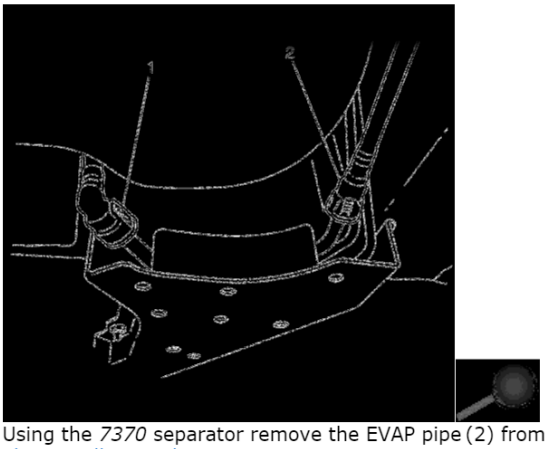
    Note: Squeeze the connector of the evaporative emission (EVAP) hose (1) to release the EVAP hose from the fuel tank.
11. Remove the EVAP hose (1) from the fuel tank.

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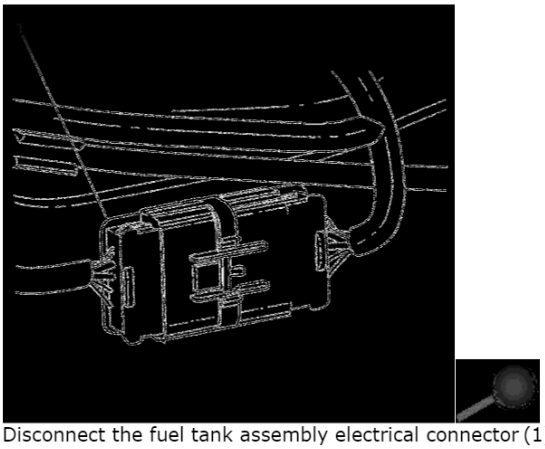


12. Remove the filler tube clamp (1) from the filler tube.
13. Remove the filler tube (2) from the fuel tank assembly.

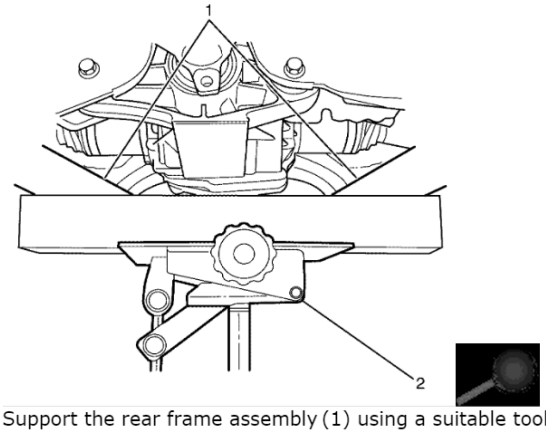


14. Using the *7370* separator remove the EVAP pipe (2) from the chassis EVAP pipe. Refer to Plastic Collar Quick Connect Fitting Service.
15. Using the *7371* tool remove the fuel feed pipe (1) from the chassis fuel feed pipe. Refer to Plastic Collar Quick Connect Fitting Service.

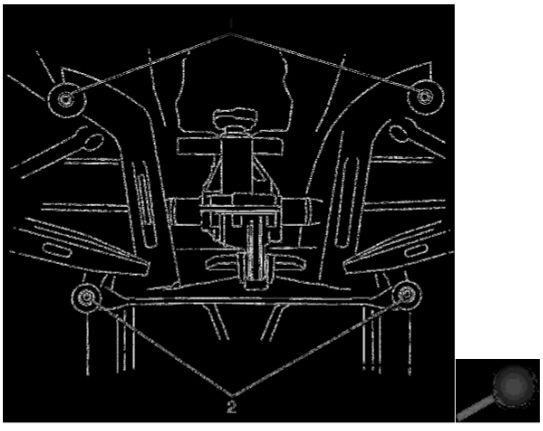
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16. Disconnect the fuel tank assembly electrical connector (1) from the chassis electrical harness.



17. Support the rear frame assembly (1) using a suitable tool (2).

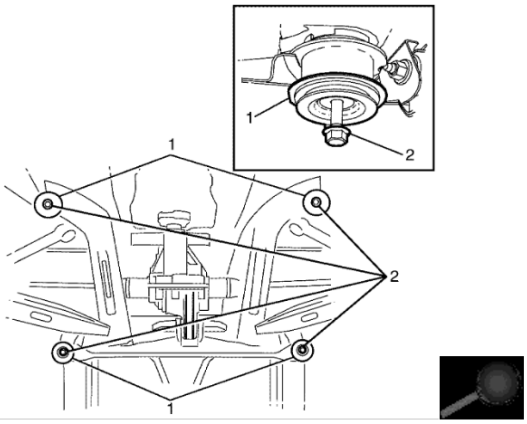


Note: The rear frame to chassis retaining bolts are single use items and must be replaced with NEW bolts.

18. Remove the rear frame to chassis retaining bolts (1) and discard.

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19. Remove the rear frame to chassis retaining bolts (2) and discard.

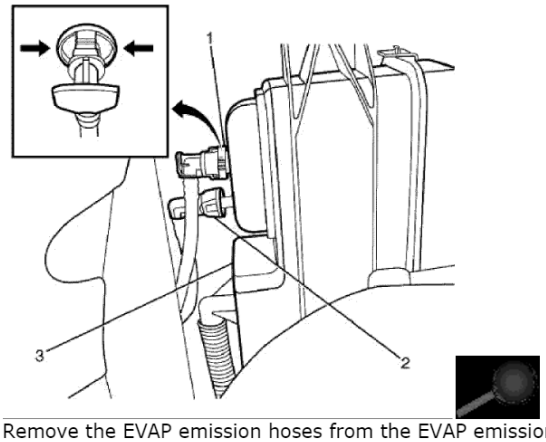


Note: Make sure that the *EN-48536* tool bolts (2) extends 50 mm (2 in) from the rear frame.

20. Install the *EN-48536* tool to the rear frame mounts (1).

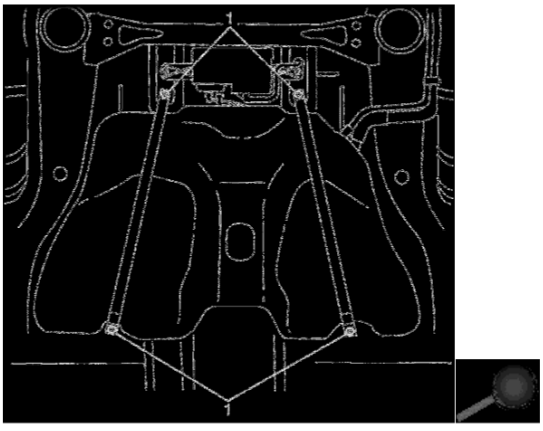
Note: When lowering the rear frame do not to damage the rear brake hoses.

21. Lower the rear frame onto the frame support tool *EN-48536* tool (2).



22. Remove the EVAP emission hoses from the EVAP emission canister (3). Refer to Plastic Collar Quick Connect Fitting Service.

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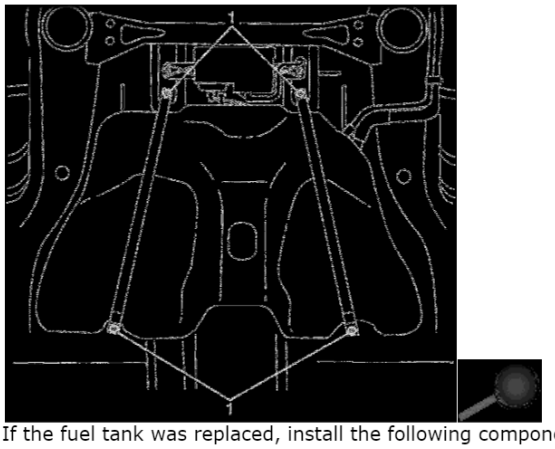


Note: Do not to damage the following components when lowering the fuel tank assembly.
- The fuel tank assembly wiring harness.
- The fuel feed pipe.
- The EVAP pipes.

Note: Support the fuel tank assembly while removing the fuel tank assembly retaining straps to chassis retaining bolts (1)

23. Remove the fuel tank assembly retaining straps to chassis retaining bolts (1).
24. With the aid of an assistant, carefully manoeuvre the fuel tank assembly from the vehicle.
25. If the fuel tank is to be replaced, remove the following components.
    - The primary fuel tank module. Refer to Primary Fuel Tank Module Replacement.
    - The secondary fuel tank module. Refer to Secondary Fuel Tank Module Replacement.
    - The fuel feed pipe pressure sensor. Refer to Fuel Pressure Sensor Replacement - Fuel Feed Pipe.
    - Fuel tank electrical harness.
    - EVAP pipes.

Installation Procedure



1. If the fuel tank was replaced, install the following components.

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- The fuel feed pipe pressure sensor. Refer to Fuel Pressure Sensor Replacement - Fuel Feed Pipe.
- The secondary fuel tank module. Refer to Secondary Fuel Tank Module Replacement.
- The primary fuel tank module. Refer to Primary Fuel Tank Module Replacement.
- The fuel tank assembly electrical harness.
- The fuel tank EVAP pipes.

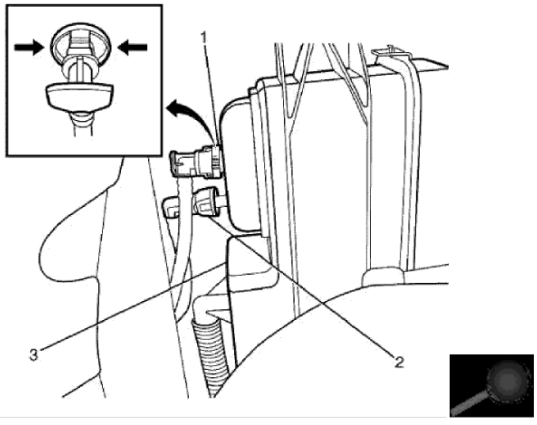
Note:

- Do not to damage the following components when installing the fuel tank assembly:
- The fuel tank assembly wiring harness.
- The fuel tank assembly electrical harness.
- The fuel tank EVAP pipes.
- Support the fuel tank assembly while installing the fuel tank assembly retaining straps to chassis retaining bolts (1).

2. With the aid of an assistant install the fuel tank assembly to the vehicle.
3. Install the fuel tank assembly retaining straps.

Caution: Refer to Fastener Caution.

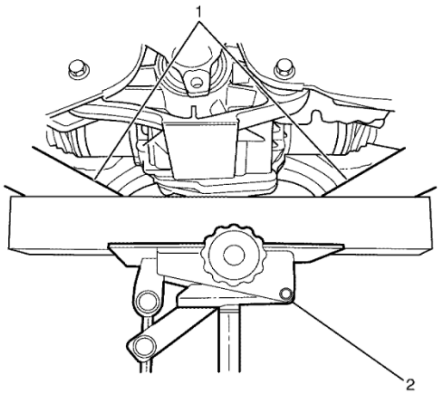
4. Install the fuel tank assembly strap to chassis retaining bolts (1) and tighten to **30 N·m (22 lb ft)**.



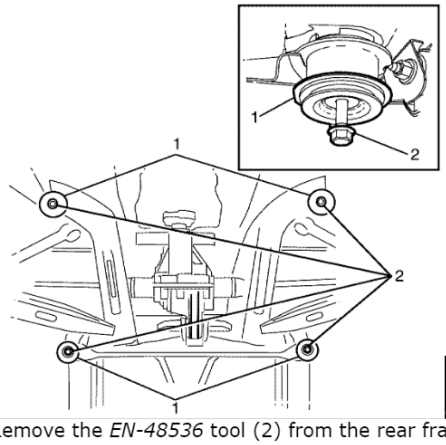
Note: Listen for an audible click to confirm correct installation of the EVAP emission hoses.

5. Connect the EVAP emission hoses to the EVAP emission canister (3). Refer to Plastic Collar Quick Connect Fitting Service.

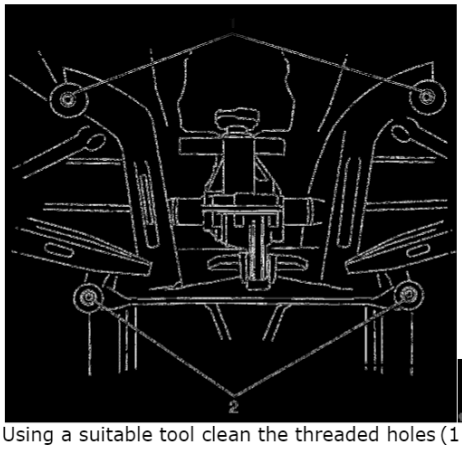
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6. Raise and support the rear frame assembly (1) into its position using a suitable tool (2).



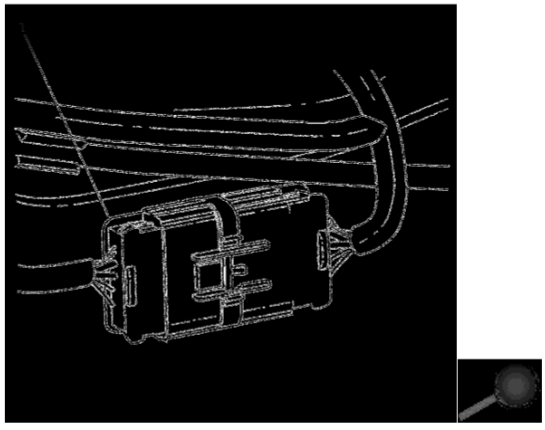
7. Remove the *EN-48536* tool (2) from the rear frame mounts (1).



8. Using a suitable tool clean the threaded holes (1 and 2) in the rear frame.
9. Install NEW rear frame to chassis retaining bolts (2).
   Do not fully tighten at this stage.

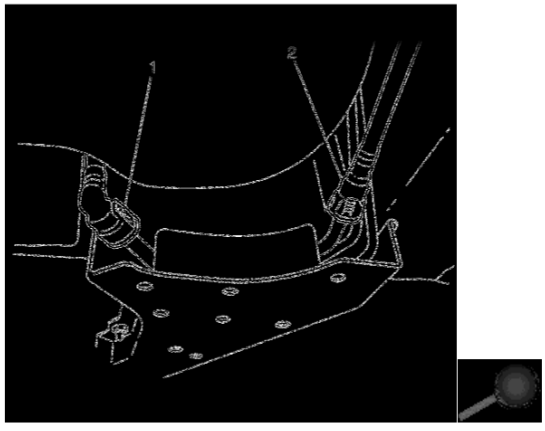
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10. Install NEW rear frame to chassis retaining bolts (1).
    Do not fully tighten at this stage.
11. Tighten the NEW rear frame to chassis retaining bolts (1) and (2).
    11.1. First Pass: Tighten the bolts to **65 N•m (48 lb ft)**.
    11.2. Final Pass: Tighten the bolts a further **125 degrees**.



Note: Listen for an audible click to confirm correct installation of the fuel tank electrical connector.

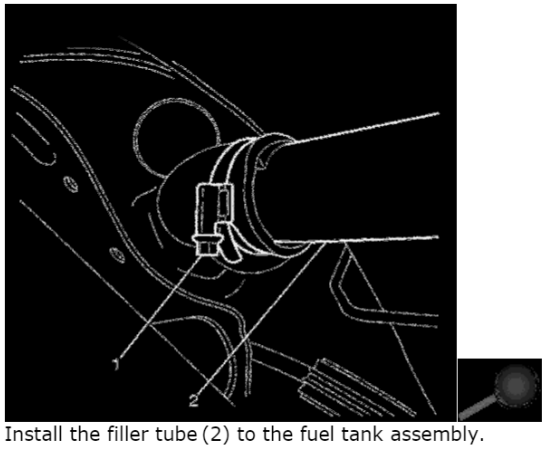
12. Connect the fuel tank assembly electrical connector (1) to the chassis electrical harness.



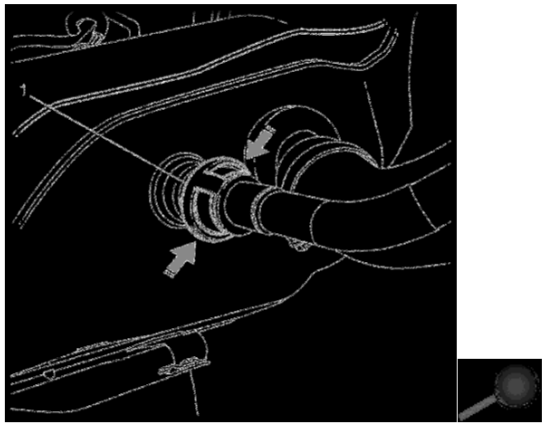
Note: Listen for an audible click to confirm correct installation of the EVAP pipe (2) and the fuel feed pipe (1).

13. Connect the EVAP pipe (2) to the EVAP chassis pipe .
14. Connect the fuel feed pipe (1) to the chassis fuel feed pipe.

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15. Install the filler tube (2) to the fuel tank assembly.
16. Install the filler tube clamp (1) to the fuel tank assembly. Tighten the filler tube hose clamp (1) to **4 N•m (35 lb in)**.

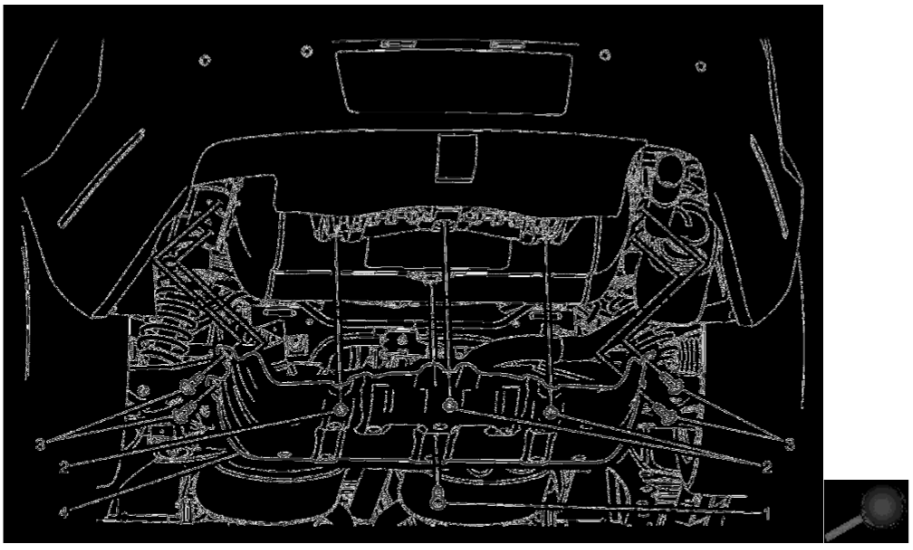


Note: Listen for an audible click to confirm correct installation of the EVAP hose (1).

17. Install the EVAP hose (1) to the fuel tank assembly.
18. Connect the fuel feed line pressure sensor. Refer to Fuel Pressure Sensor Replacement - Fuel Feed Pipe.
19. Install the fuel tank heat shield. Refer to Fuel Tank Heat Shield Replacement.
20. Install the propeller shaft. Refer to Propeller Shaft Replacement.
21. Install the exhaust crossover pipe. Refer to Exhaust Crossover Pipe Replacement.
22. Install the right rear wheel. Refer to Tire and Wheel Removal and Installation.
23. Lower the vehicle.
24. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
25. Inspect for fuel leaks using the following procedure:
    25.1. Turn ON the ignition, with the engine OFF for 2 seconds.
    25.2. Turn OFF the ignition, for 10 seconds.
    25.3. Turn ON the ignition, with the engine OFF.
    25.4. Inspect for leaks.

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Fuel Tank Shield Replacement (LWR)



Fuel Tank Shield Replacement

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle	
1	Fuel Tank Shield Fastener. **Caution:** Refer to Fastener Caution. **Tighten** 4.5 N•m (40 lb in)
2	Fuel Tank Shield Bolts (Qty: 3). **Tighten** 2.5 N•m (22 lb in)
3	Fuel Tank Shield Bolts (Qty: 4). **Tighten** 22 N•m (16 lb lb)
4	Fuel Tank Shield. **Procedure** Disconnect the electrical connectors from the fuel tank shield.

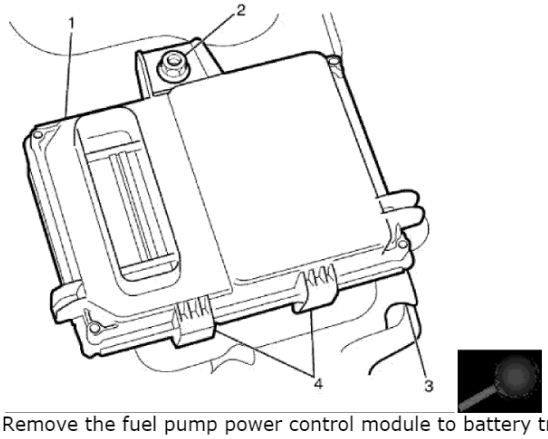
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Fuel Pump Power Control Module Replacement (Sedan, Sportwagon, LWB)

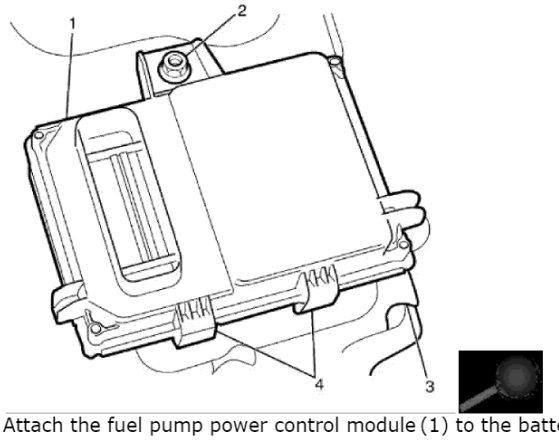
Removal Procedure

1. Remove the left side rear compartment side trim panel access hole cover. Refer to Rear Compartment Side Trim Panel Access Hole Cover Replacement.
2. Remove the battery. Refer to Battery Replacement.
3. Remove the battery tray. Refer to Battery Tray Replacement.



4. Remove the fuel pump power control module to battery tray underside retaining nut (2).
5. Detach the fuel pump power control module retainers (4).
6. Remove the fuel pump power control module (1) from the battery tray (3).

Installation Procedure



1. Attach the fuel pump power control module (1) to the battery tray (3).

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2. Attach the fuel pump power control module retainers (4).

   Caution: Refer to Fastener Caution.
3. Install the fuel pump power control module to battery tray underside retaining nut (2) and tighten to **9 N·m (80 lb in)**.
4. Install the battery tray. Refer to Battery Tray Replacement.
5. Install the battery. Refer to Battery Replacement.
6. Install the left side rear compartment side trim panel access hole cover. Refer to Rear Compartment Side Trim Panel Access Hole Cover Replacement.

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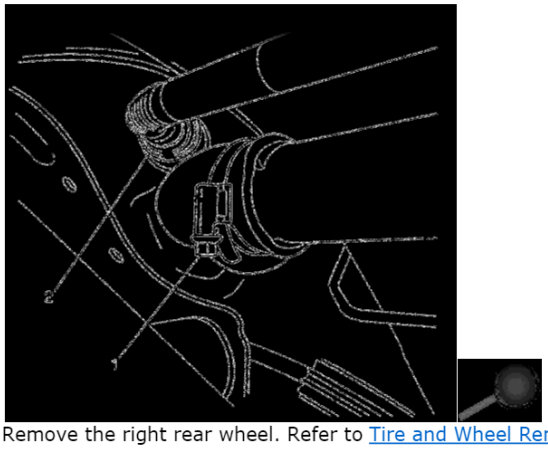
Filler Tube Replacement (LFW or LFX)

Removal Procedure

1. Remove the fuel filler cap.

   Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

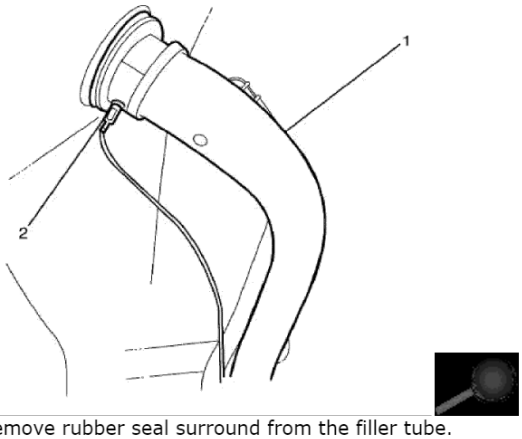
   Warning: Refer to Safety Glasses Warning.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Drain the fuel tank below the level of the fuel filler hose. Refer to Fuel Tank Draining.



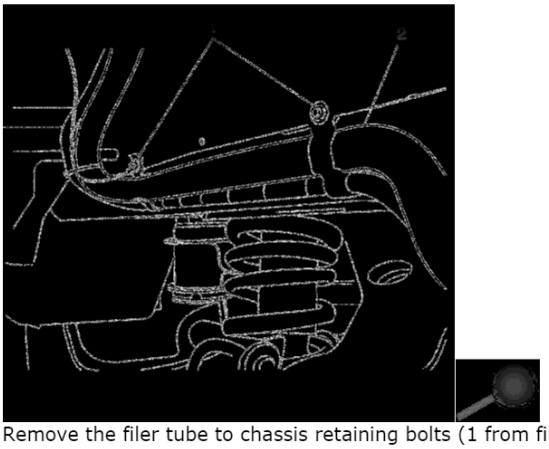
4. Remove the right rear wheel. Refer to Tire and Wheel Removal and Installation.
5. Remove the Wheelhouse Liner Replacement - Rear. Refer to Rear Wheelhouse Liner Replacement.
6. Remove the rear bumper fascia. Refer to Rear Bumper Fascia Replacement.
7. Disconnect the filler tube from the fuel tank (1).
8. Disconnect the evaporative emission (EVAP) line (2), by squeezing both sides of the line and pulling it toward the rear of the vehicle.

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9. Remove rubber seal surround from the filler tube.
10. Remove the earth lead (2) from the filler tube (1).

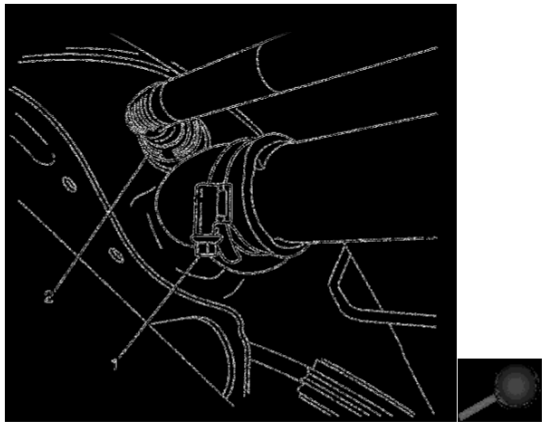


11. Remove the filer tube to chassis retaining bolts (1 from filler tube (2).
12. Remove the fuel filler tube from the vehicle (2).

Installation Procedure

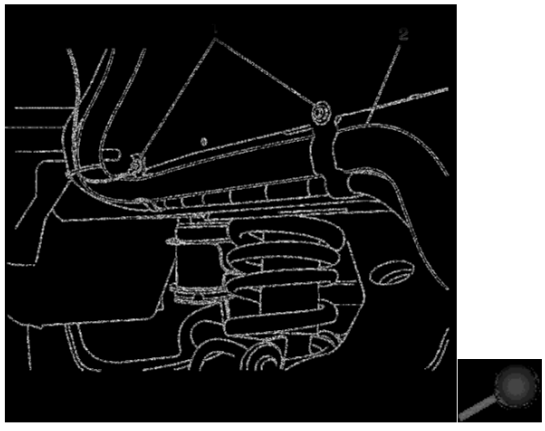
1. Position the fuel filler tube to the vehicle.

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Caution: Refer to Component Fastener Tightening Caution.

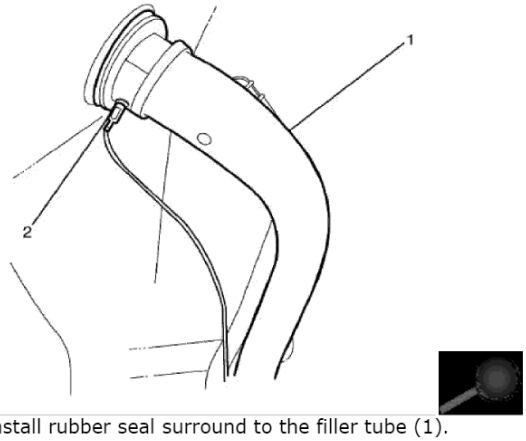
2. Connect the filler hose (1) to the fuel tank.
   Tighten
   Tighten the fuel filler tube hose clamp (3) to 3.5 N•m (31 lb in).
3. Install the evaporative emission (EVAP) line (2), listen for an audible click to confirm fitting.



Caution: Refer to Fastener Caution.

4. Install the fuel filler tube to chassis retaining bolts.
   Tighten
   Tighten the bolts to 9 N•m (80 lb in).

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5. Install rubber seal surround to the filler tube (1).
6. Install the earth lead to the filler tube (2).
7. Install the rear bumper fascia. Refer to Rear Bumper Fascia Replacement.
8. Install the Wheelhouse Liner Replacement - Rear. Refer to Rear Wheelhouse Liner Replacement.
9. Lower the vehicle.
10. Add fuel to the fuel tank.
11. Inspect for fuel leaks.
12. Install the fuel filler cap.

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Filler Tube Replacement (LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

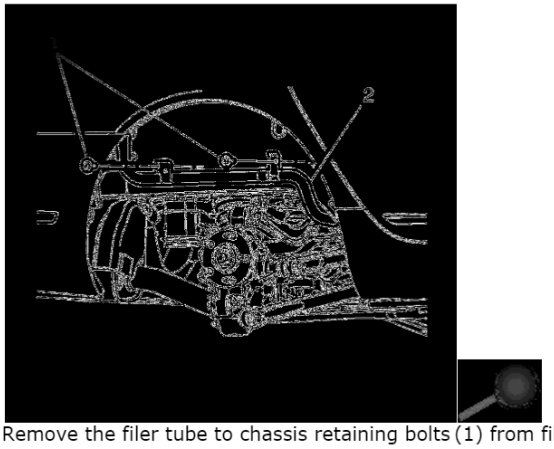
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

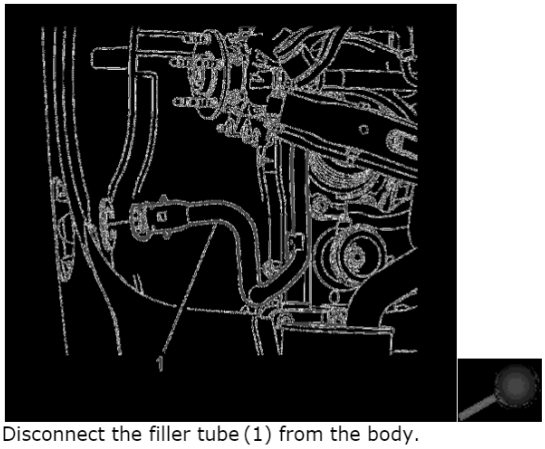
1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Detend the filler valve to release the pressure on the filler valve, filler tube, and filler hose. Refer to LPG Tank Filler Hose Pressure Relief.
3. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
4. Remove the rear wheelhouse liner. Refer to Rear Wheelhouse Liner Replacement.



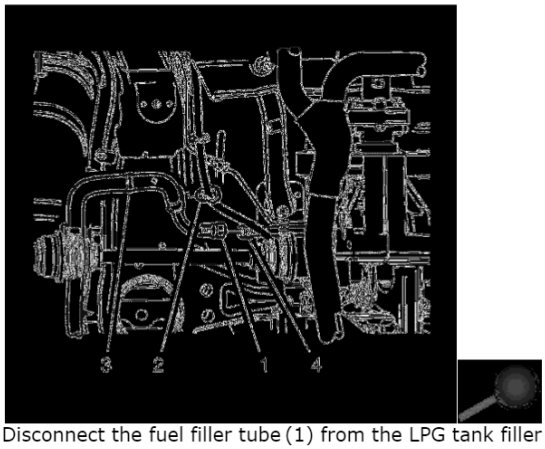
5. Remove the filer tube to chassis retaining bolts (1) from filler tube (2).

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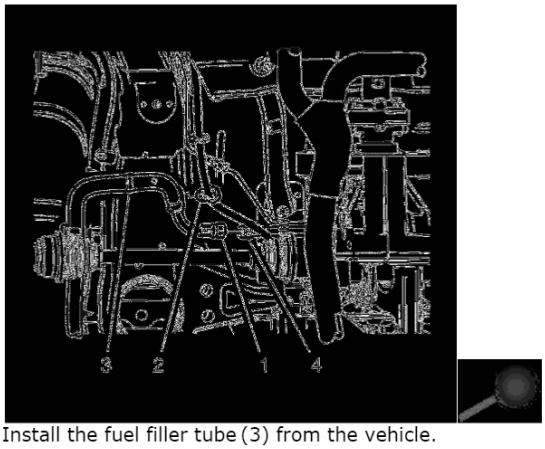
6. Disconnect the filler tube (1) from the body.



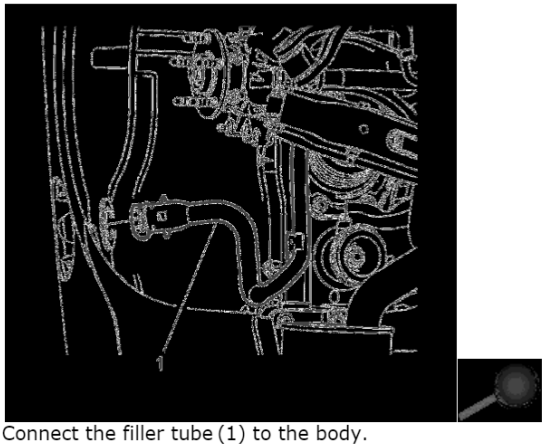
7. Disconnect the fuel filler tube (1) from the LPG tank filler hose (4).
8. Disconnect the LPG wiring harness retainer (2) from the filler tube.
9. Remove the fuel filler tube (3) from the vehicle.

Installation Procedure

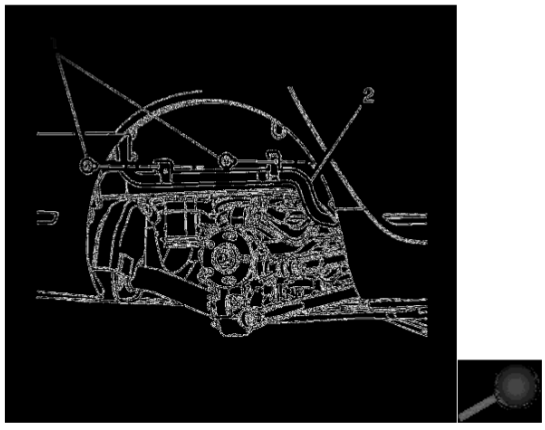
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1. Install the fuel filler tube (3) from the vehicle.
2. Connect filler tube (1) to tank filler hose (4) and tighten to **60.5 N·m (44 lb ft)**.
3. Connect the LPG wiring harness retainer (2) to the filler tube.



4. Connect the filler tube (1) to the body.



Caution: Refer to Fastener Caution.

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5. Install the filer tube to chassis retaining bolts (1) to filler tube (2) and tighten to **9 N•m (80 lb in)**.
6. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.
7. Install the rear wheelhouse liner. Refer to Rear Wheelhouse Liner Replacement.
8. Lower the vehicle.

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Primary Fuel Tank Module Replacement (LFW or LFX)

Special Tools

J 45722 Fuel Tank Sender Wrench

Removal Procedure

1. Ignition OFF.

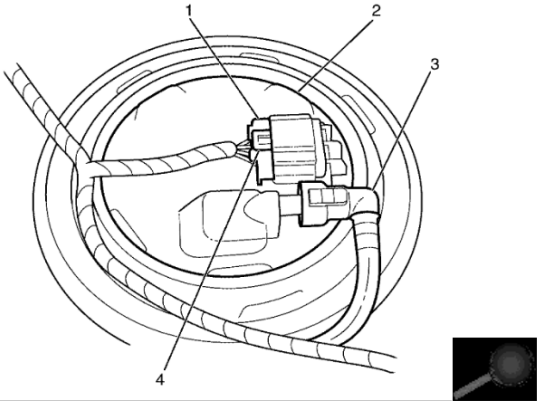
   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

   Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

   Warning: Refer to Safety Glasses Warning.

   Warning: Refer to Gasoline/Gasoline Vapors Warning.

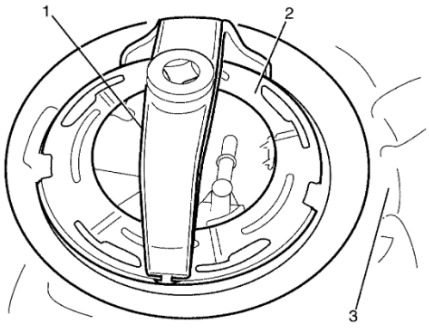
   Warning: Refer to Relieving Fuel Pressure Warning.
3. Relieve the low side fuel pressure. Refer to Fuel Pressure Relief.
4. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
5. Remove the fuel tank assembly. Refer to Fuel Tank Replacement.



   Note: Press the locking tang (4) to release the electrical harness connector (1) from the primary fuel tank module (2).
6. Disconnect the electrical harness connector (1) from the primary fuel tank module (2).
7. Detach the fuel feed pipe (3) from the primary fuel tank module (2). Refer to Plastic Collar Quick Connect Fitting Service.

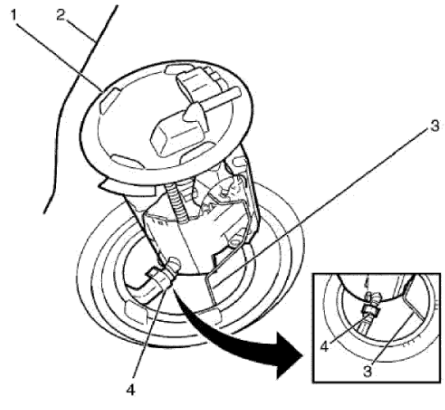
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Note: The cam lock ring (2) is a single use item and must be discarded after removal.

8. Remove the cam lock ring (2) from the fuel tank assembly (3) by rotating the cam lock ring (2) counter-clockwise using the fuel tank sender wrench *J 45722* fuel tank sender wrench (1).
9. Discard the cam lock ring (2).



Note: To release the transfer tube connector (4) from the primary fuel tank module (1), squeeze the releasing buttons on the transfer tube connector (4).

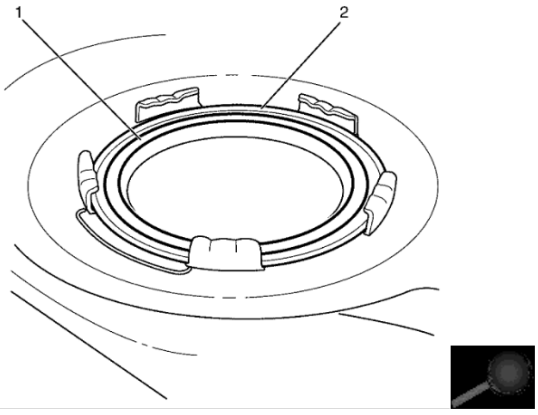
Note: Note the orientation of the primary fuel tank module (1) in relation to the fuel tank assembly (2).

10. Carefully lift the primary fuel tank module (1) from the fuel tank assembly (2), allowing enough clearance to disconnect the transfer tube connector (4) from the primary fuel tank module (1).
11. Disconnect the transfer tube connector (4) from the primary fuel tank module (1).

Note: Care should be taken not to damage the fuel level sensor float rod (3) when removing the primary fuel tank module (1) from the fuel tank assembly (2).

12. Carefully manoeuvre the primary fuel tank module (1) from the fuel tank assembly (2)

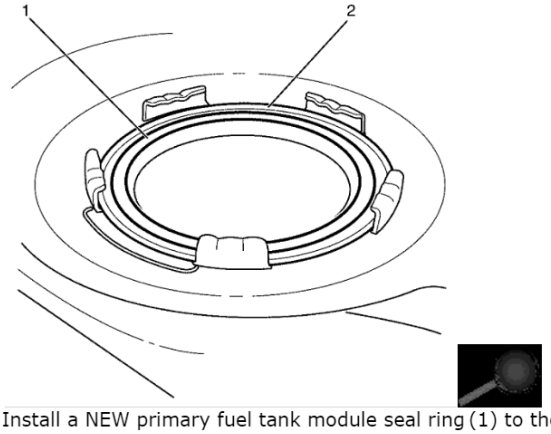
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Note: The primary fuel tank module seal ring (1) is a single use item and must be discarded after removal.

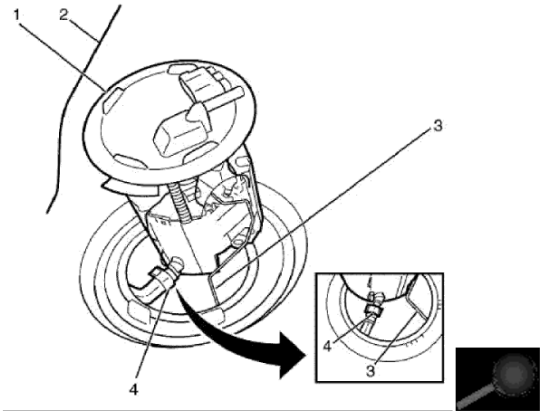
13. Remove the primary fuel tank module seal ring (1) from the fuel tank assembly (2).
14. Discard the primary fuel tank module seal ring (1).

Installation Procedure



1. Install a NEW primary fuel tank module seal ring (1) to the fuel tank assembly (2).

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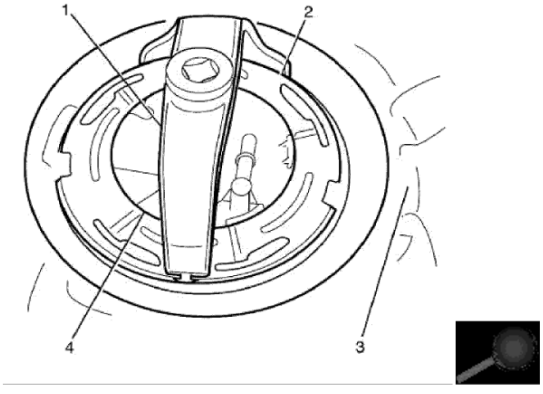


Note: Care should be taken not to damage the fuel level sensor float rod (3) when installing the primary fuel tank module (1) to the fuel tank assembly (2).

2. Carefully lower the primary fuel tank module (1) into the fuel tank assembly (2), enough to connect the transfer tube connector (4) to the primary fuel tank module (1).

Note: Listen for an audible click to confirm the correct installation of the transfer tube connector (4) to the primary fuel tank module (1).

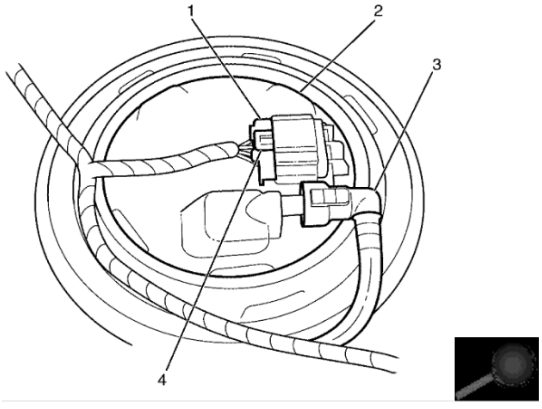
3. Connect the transfer tube connector (4) to the primary fuel tank module (1).
4. Install the primary fuel tank module (1) to the fuel tank assembly (2).



Note: Apply suitable pressure onto the primary fuel tank module (4) to hold the primary fuel tank module (4) in place while installing the NEW cam lock ring (2).

5. Hold the primary fuel tank module (4) in place while installing the NEW cam lock ring (2) to the fuel tank assembly (3) by rotating the cam lock ring (2) clockwise using the fuel tank sender wrench *J 45722* fuel tank sender wrench (1).

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Note: Listen for an audible click to confirm the correct installation of the electrical harness connector (1) to the primary fuel tank module (2).

6. Connect the electrical harness connector (1) to the primary fuel tank module (2).
7. Connect the fuel feed pipe (3) to the primary fuel tank module (2). Refer to Plastic Collar Quick Connect Fitting Service.
8. Install the fuel tank assembly. Refer to Fuel Tank Replacement.
9. Lower the vehicle. Refer to Lifting and Jacking the Vehicle.
10. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

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Secondary Fuel Tank Module Replacement (LFW or LFX)

Special Tools

CH-48482 Fuel Tank Sender Wrench

Removal Procedure

1. Ignition OFF.

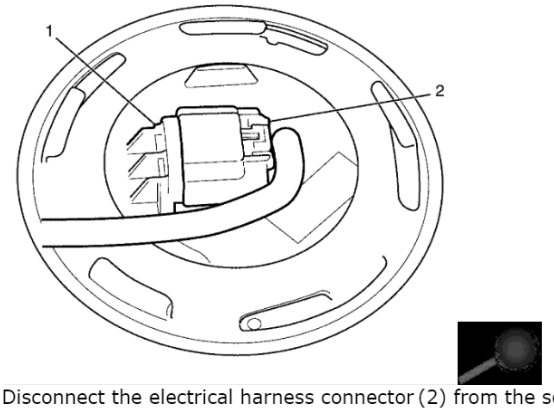
   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

   Warning: Refer to Safety Glasses Warning.

   Warning: Refer to Gasoline/Gasoline Vapors Warning.

   Warning: Refer to Relieving Fuel Pressure Warning.
3. Relieve the low side fuel pressure. Refer to Fuel Pressure Relief.

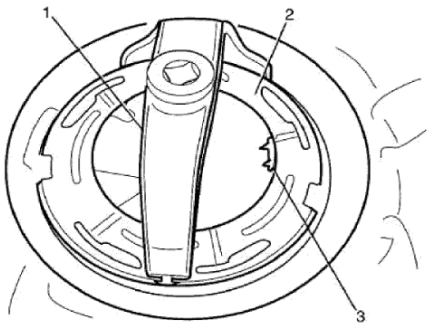
   Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.
4. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
5. Remove the fuel tank assembly. Refer to Fuel Tank Replacement.



6. Disconnect the electrical harness connector (2) from the secondary fuel tank module (1).

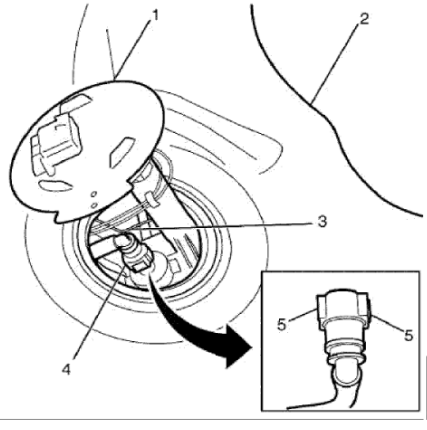
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Note: The cam lock ring is a single use item and must be replaced after it was removed.

7. Remove the cam lock ring (2) from the secondary fuel tank module (3) by rotating the cam lock ring (2) counter-clockwise using the fuel tank sender wrench *CH-48482* fuel tank sender wrench (1).
8. Discard the cam lock ring (2).



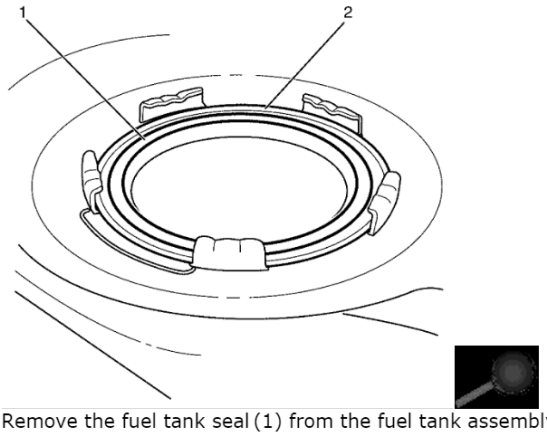
Note: To release the transfer tube (4) from the secondary fuel tank module (1), squeeze the releasing buttons (5) on the transfer tube (4).

Note: Note the orientation of the secondary fuel tank module (1) in relation to the fuel tank assembly (2).

Note: Do not damage the fuel level sensor float rod (3) when removing the secondary fuel tank module (1) from the fuel tank.

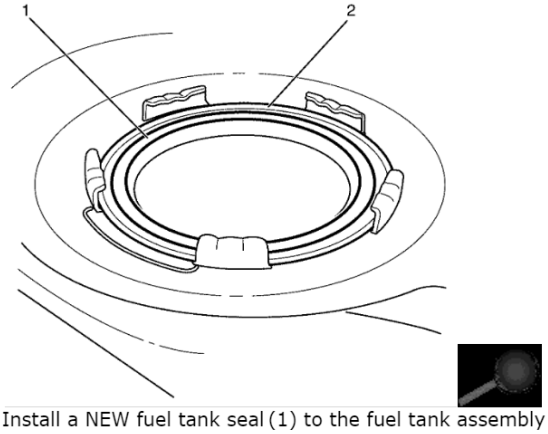
9. Carefully lift the secondary fuel tank module (1) from the fuel tank assembly (2), enough to disconnect the transfer tube (4) from the secondary fuel tank module (1).
10. Disconnect the transfer tube (4) from the secondary fuel tank module (1).
11. Carefully manoeuvre the secondary fuel tank module (1) from the fuel tank assembly (2).

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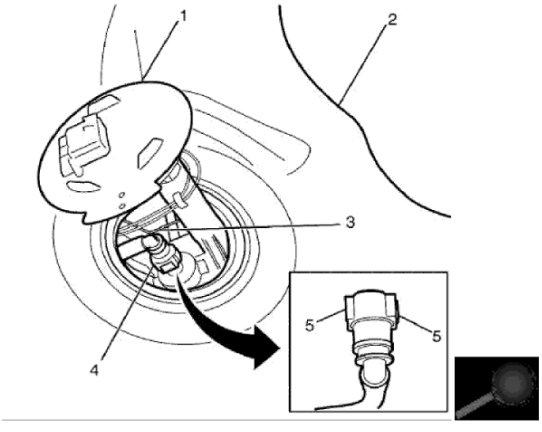


12. Remove the fuel tank seal (1) from the fuel tank assembly (2).
13. Discard the fuel tank seal (1).

Installation Procedure



1. Install a NEW fuel tank seal (1) to the fuel tank assembly (2).



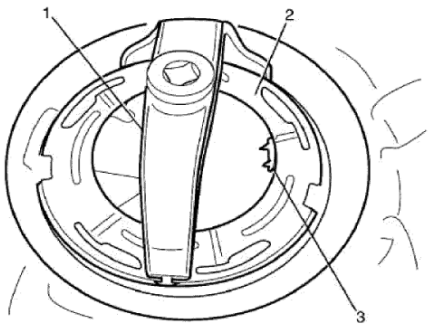
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Note: Do not damage the fuel level sensor float rod (3) when installing the secondary fuel tank module (1).

2. Carefully install the secondary fuel tank module (1) into the fuel tank (2), enough to connect the transfer tube (4) to the secondary fuel tank module (1).

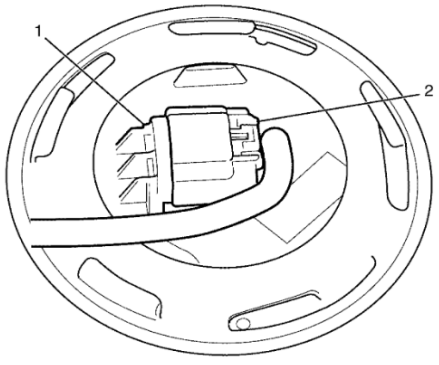
Note: Listen for an audible click to confirm the correct installation of the transfer tube connector (4) to the secondary fuel tank module (1).

3. Connect the transfer tube (4) to the secondary fuel tank module (1).
4. Carefully manoeuvre and install the secondary fuel tank module (1) to the fuel tank assembly (2).



Note: Apply suitable pressure onto the secondary fuel tank module (3) to hold the secondary fuel tank module (3) in position while installing the NEW cam lock ring (2).

5. Install a NEW cam lock ring (2) to the secondary fuel tank module (3) by rotating the cam lock ring (2) clockwise using the fuel tank sender wrench *CH-48482* fuel tank sender wrench (1).



Note: Listen for an audible click to confirm the correct installation of the electrical harness connector (2) to the secondary fuel tank module (1).

6. Connect the electrical harness connector (2) to the secondary fuel tank module (1).
7. Install the fuel tank assembly to the vehicle. Refer to Fuel Tank Replacement.
8. Lower the vehicle. Refer to Lifting and Jacking the Vehicle.
9. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

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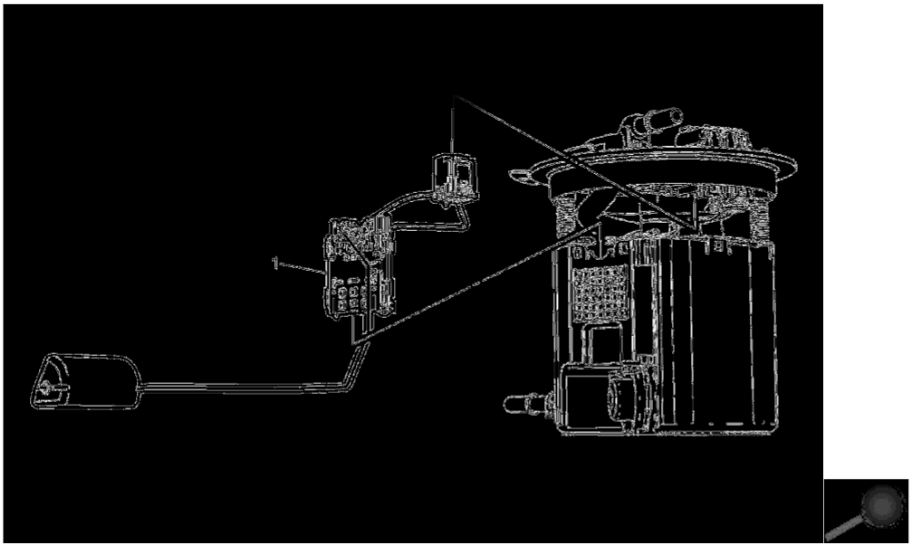
Fuel Level Sensor Replacement

The fuel level sensor is an integral part of the secondary fuel tank module assembly. For replacement refer to Secondary Fuel Tank Module Replacement.

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Fuel Tank Fuel Pump Module Fuel Level Sensor Replacement



Fuel Tank Fuel Pump Module Fuel Level Sensor Replacement

Callout	Component Name
	Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist. **Warning:** Refer to Gasoline/Gasoline Vapors Warning. **Warning:** Refer to Safety Glasses Warning. **Preliminary Procedures** 1. Remove the primary fuel tank fuel pump module. Refer to Primary Fuel Tank Module Replacement. 2. Disconnect the electrical connector.
1	Primary Fuel Level Sensor **Procedure** Release tabs and slide primary fuel level sensor up to remove.

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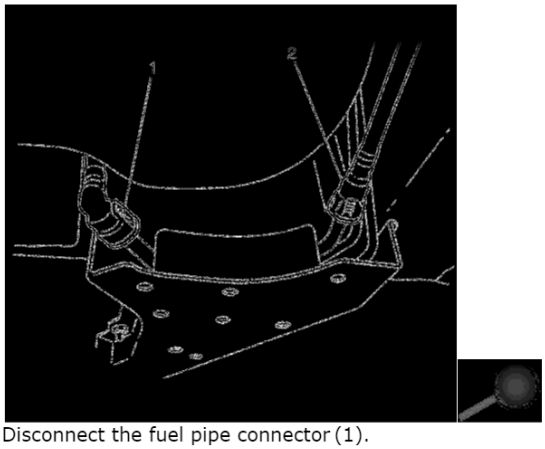
Fuel Line Replacement - Chassis (LFW or LFX)

Removal Procedure

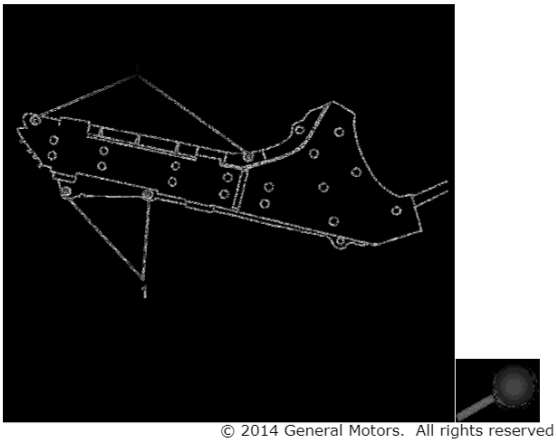
Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

Note: The fuel system pipes can be serviceable individually or as a complete fuel/brake pipe assembly. The following is the procedure for servicing the fuel pipes individually.

1. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Relieve the fuel system pressure. Refer to the Fuel Pressure Relief.
3. Remove the exhaust system. Refer to Exhaust System Replacement.
4. Remove the engine. Refer to Engine Replacement.
5. Remove the appropriate heat shields for access to the fuel/brake pipe assembly.



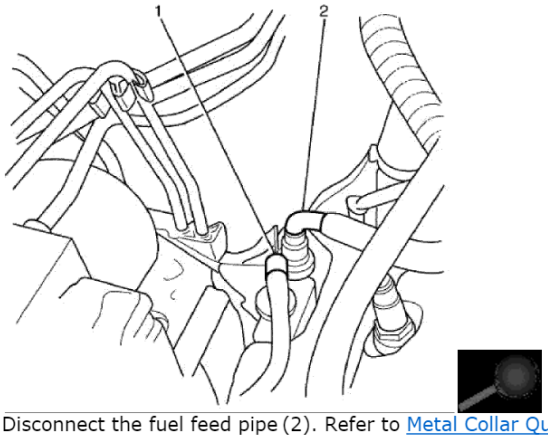
6. Disconnect the fuel pipe connector (1).



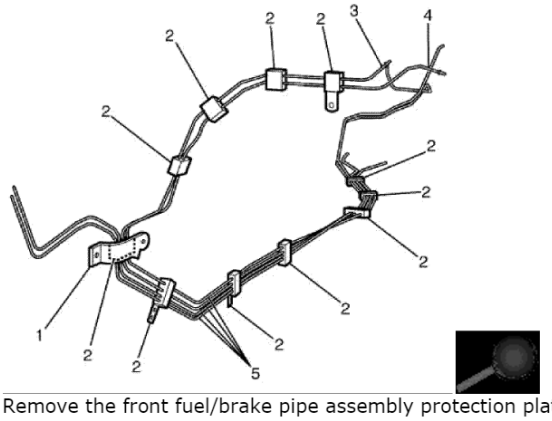
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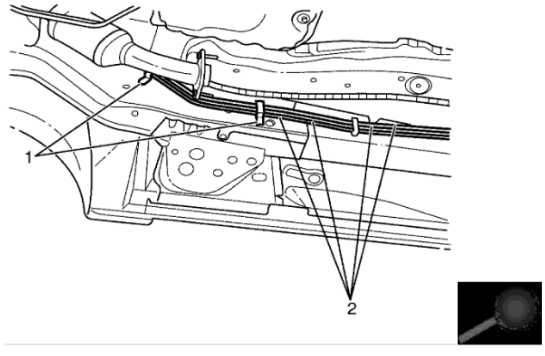
7. Remove the rear fuel/brake pipe assembly stone guard retaining nuts (1).
8. Remove the rear fuel/brake pipe assembly stone guard from the vehicle.



9. Disconnect the fuel feed pipe (2). Refer to Metal Collar Quick Connect Fitting Service.
10. Disconnect the EVAP pipe (1). Refer to Plastic Collar Quick Connect Fitting Service.



11. Remove the front fuel/brake pipe assembly protection plate (1) from the vehicle.



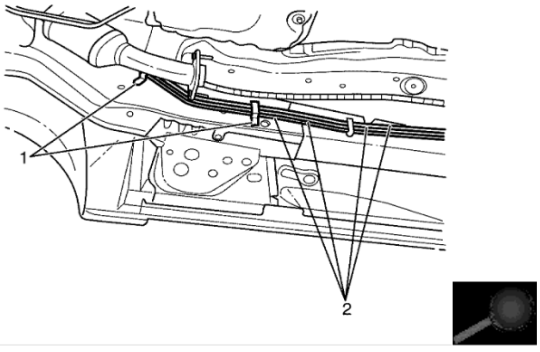
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Note: Mark the positions of the fuel/brake pipe retainers (1) before removing the fuel/brake pipe retainers (1) from the fuel/brake pipes assembly.

12. Remove all the fuel/brake pipe retainers (1) from the fuel/brake pipe assembly (2).
13. Manoeuvre and remove the fuel line from the vehicle.

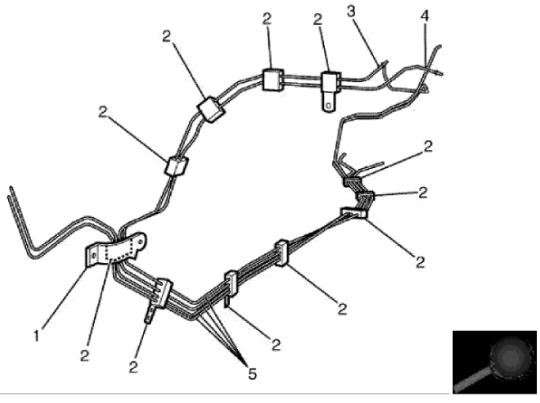
Installation Procedure

1. Manoeuvre and install the fuel line to the vehicle.



Note: Observed the marked the positions of the fuel/brake pipe retainers (1) when installing the fuel/brake pipe retainers (1) to the fuel/brake pipes assembly.

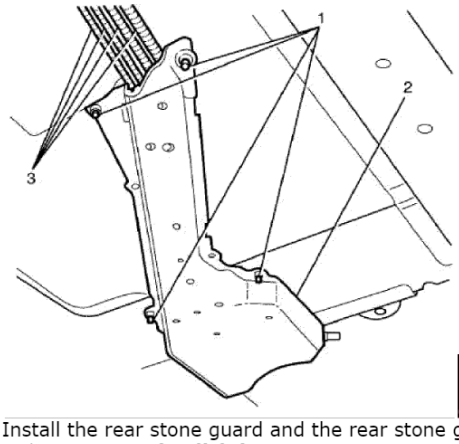
2. Install all the fuel/brake pipe retainers (1) to the fuel/brake pipe assembly (2).



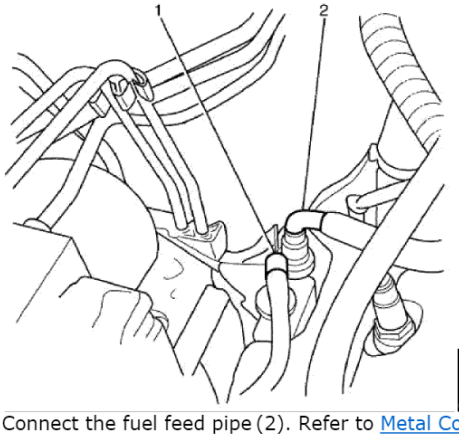
Caution: Refer to Fastener Caution.

3. Install the front fuel/brake pipe assembly protection plate (1) to the vehicle and tighten the bolts to **22 N•m (16 lb in)**.

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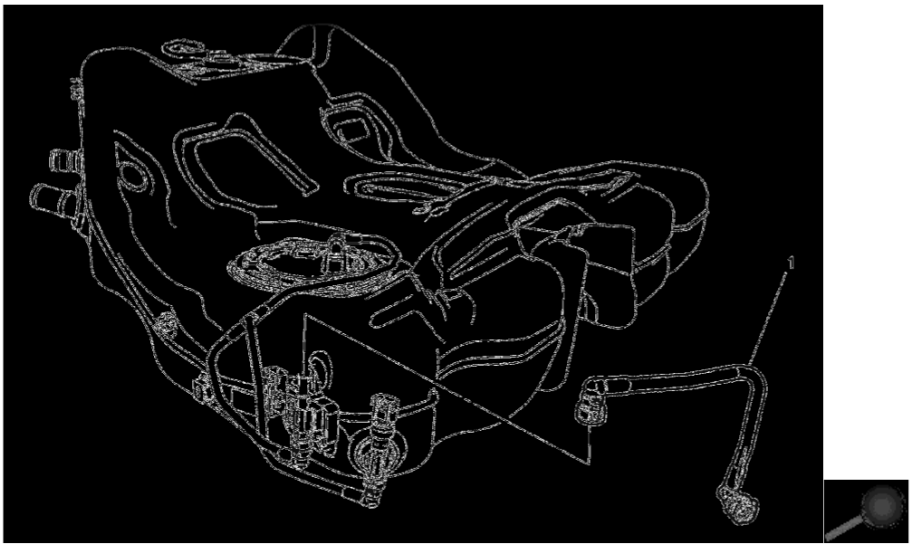
4. Install the rear stone guard and the rear stone guard to chassis retaining nuts (1) and tighten to **4 N•m (35 lb in)**.



5. Connect the fuel feed pipe (2). Refer to Metal Collar Quick Connect Fitting Service.
6. Connect the EVAP pipe (1). Refer to Plastic Collar Quick Connect Fitting Service.
7. Install the removed heat shields.
8. Install the engine. Refer to Engine Replacement.
9. Install the exhaust system. Refer to Exhaust System Replacement.
10. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.

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Fuel Feed Hose Replacement (Flex Sensor to Pipe)



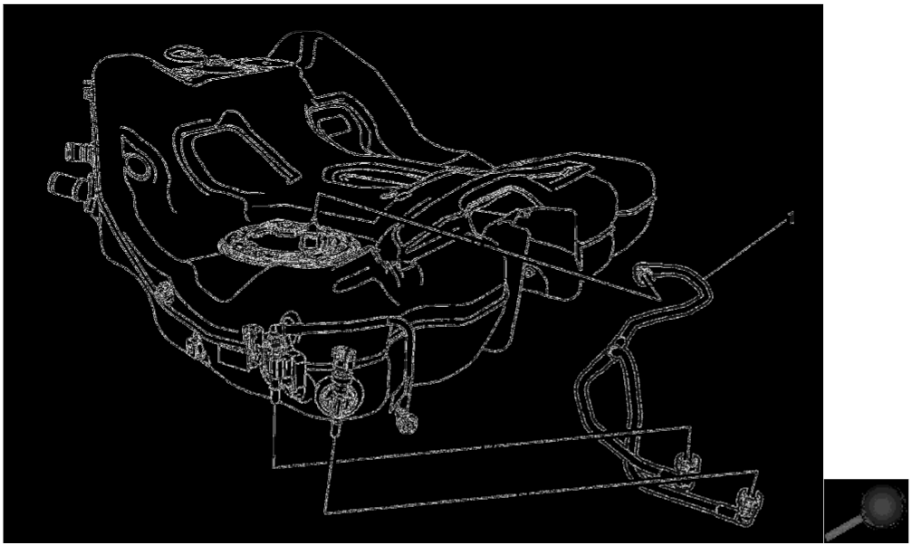
Fuel Feed Hose Replacement

Callout	Component Name
	Warning: Refer to Gasoline/Gasoline Vapors Warning. **Warning:** Refer to Safety Glasses Warning. **Preliminary Procedures** Remove the fuel tank. Refer to Fuel Tank Replacement.
1	Fuel Feed Hose **Procedure** Disconnect the quick connect fitting. Refer to Plastic Collar Quick Connect Fitting Service.

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Fuel Feed Hose Replacement (Flex Sensor to Module to Fuel Pressure Sensor)



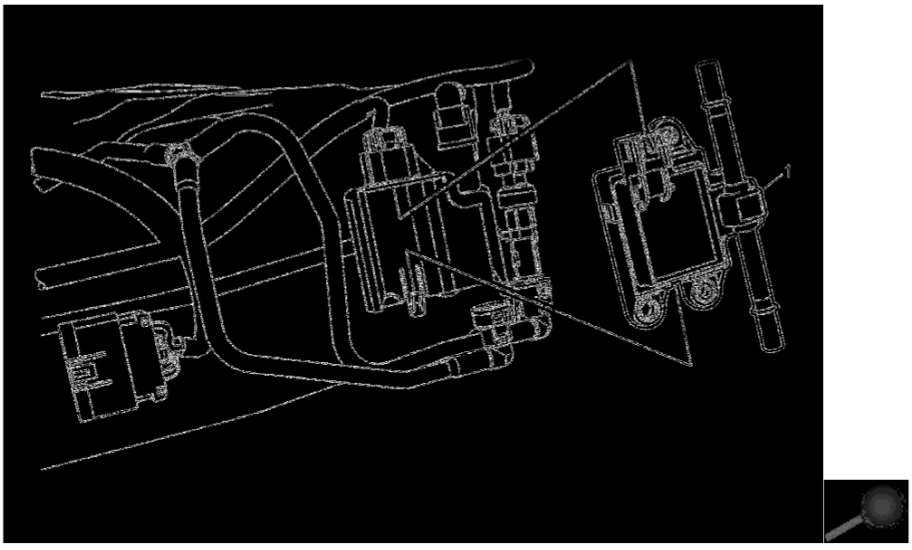
Fuel Feed Hose Replacement

Callout	Component Name
	Warning: Refer to Gasoline/Gasoline Vapors Warning. **Warning:** Refer to Safety Glasses Warning. **Preliminary Procedures** Remove the fuel tank. Refer to Fuel Tank Replacement.
1	Fuel Feed Hose **Procedure** Disconnect the quick connect fittings. Refer to Plastic Collar Quick Connect Fitting Service.

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Flexible Fuel Sensor Replacement



Flexible Fuel Sensor Replacement

Callout	Component Name
Preliminary Procedure 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief. 2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle. 3. Disconnect the fuel line connectors. Refer to Plastic Collar Quick Connect Fitting Service.	
1	Flexible Fuel Sensor **Procedure** 1. Release the plastic retaining tab. 2. Disconnect the electrical connector.

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Fuel Pressure Sensor Replacement - Fuel Feed Pipe

Removal Procedure

1. Ignition OFF.

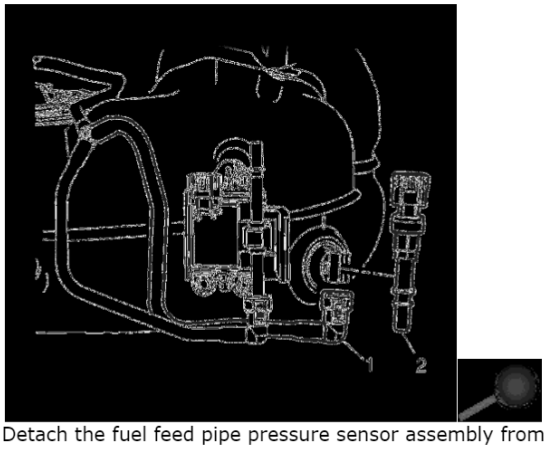
   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

   Warning: Refer to Safety Glasses Warning.

   Warning: Refer to Gasoline/Gasoline Vapors Warning.

   Warning: Refer to Relieving Fuel Pressure Warning.
3. Relieve the low side fuel pressure. Refer to Fuel Pressure Relief.

   Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.
4. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.

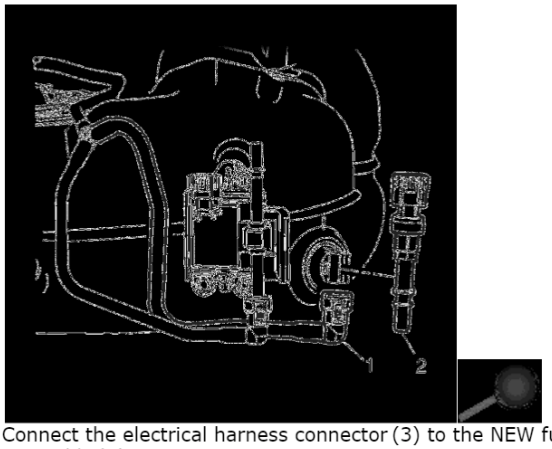


5. Detach the fuel feed pipe pressure sensor assembly from the fuel tank.
6. Disconnect the fuel feed line (1) from the fuel feed pipe pressure sensor assembly (2). Refer to Plastic Collar Quick Connect Fitting Service.
7. Disconnect the electrical harness connector (3) from the fuel feed pipe pressure sensor assembly (2).
8. Remove the fuel feed pipe pressure sensor assembly (2) from the vehicle.

Installation Procedure

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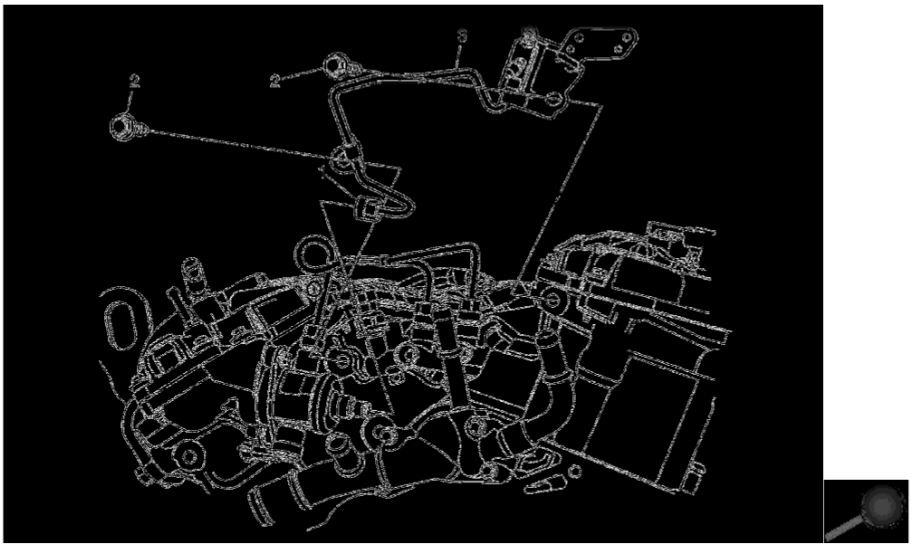
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1. Connect the electrical harness connector (3) to the NEW fuel feed pipe pressure sensor assembly (2).
2. Connect the fuel feed line (1) to the NEW fuel feed pipe pressure sensor assembly (2). Refer to Plastic Collar Quick Connect Fitting Service.
3. Install the NEW fuel feed pipe pressure sensor assembly (2) to the fuel tank.
4. Lower the vehicle. Refer to Lifting and Jacking the Vehicle.
5. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
6. Inspect for fuel leaks using the following procedure:
   6.1. Turn ON the ignition, with the engine OFF for 2 seconds.
   6.2. Turn OFF the ignition, for 10 seconds.
   6.3. Turn ON the ignition, with the engine OFF.
   6.4. Inspect for leaks.

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Fuel Feed Pipe Replacement (At Engine)



Fuel Feed Pipe Replacement

Callout	Component Name
Preliminary Procedures 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief. 2. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 3. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.	
1	Fitting **Caution:** Refer to Fastener Caution. **Tighten** 28 N•m (21 lb ft)
2	Bolt (Qty: 2) **Tighten** 50 N•m (37 lb ft)
3	Fuel Feed Pipe **Procedure** 1. DISCARD the old fuel feed pipe, install a NEW fuel feed pipe. 2. Ensure that the high pressure fuel pipe, and fuel pump fittings are clean and dry prior to assembly. 3. Pressure up the fuel system and check for leaks.

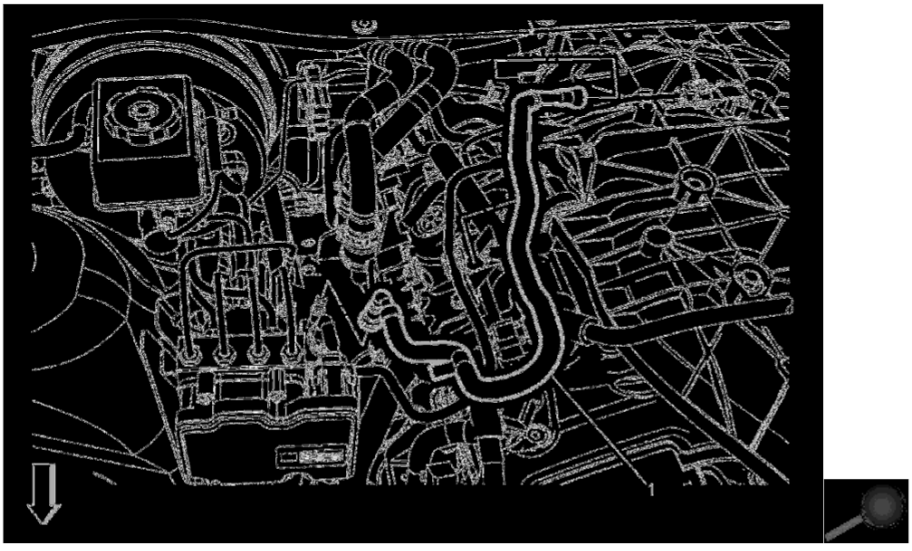
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Callout	Component Name

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Fuel Injection Fuel Feed Hose Replacement (LFW or LFX)



Fuel Injection Fuel Feed Hose Replacement

Callout	Component Name
	Warning: Refer to Gasoline/Gasoline Vapors Warning. **Warning:** Refer to Safety Glasses Warning. **Preliminary Procedures** 1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 2. Relieve the fuel pressure. Refer to Fuel Pressure Relief.
1	Fuel Injection Fuel Feed Hose **Procedure** Disconnect the quick connect fittings. Refer to Metal Collar Quick Connect Fitting Service.

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Fuel System Cleaning

1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

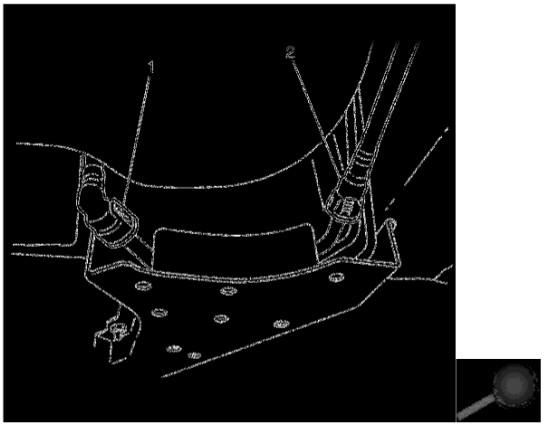
   Warning: Refer to Safety Glasses Warning.

   Warning: Refer to Gasoline/Gasoline Vapors Warning.

   Warning: Refer to Relieving Fuel Pressure Warning.

   Warning: Refer to Safety Glasses and Compressed Air Warning.
3. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
4. Relieve the low fuel pressure. Refer to Fuel Pressure Relief.
5. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement

   Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.
6. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.



   Note: The following procedure covers the disassembly and the inspection of the complete fuel supply system. If the fuel system is contaminated, the fuel system can be cleaned. The extent of the contamination can be determined during the disassembly procedure.
7. Detach the fuel feed line connector (1) and inspect for contamination. Refer to Plastic Collar Quick Connect Fitting Service.
8. Remove the fuel tank if contamination is found. Refer to Fuel Tank Replacement.
9. Remove the fuel tank module assemblies. Refer to the following procedures:
   - Primary Fuel Tank Module Replacement.
   - Secondary Fuel Tank Module Replacement.
10. Place the fuel tank in a suitable work area away from any heat or any source of ignition.
11. Perform the following procedures:
    - Inspect the primary fuel tank module for contamination. Replace the primary fuel tank module if contamination is found.

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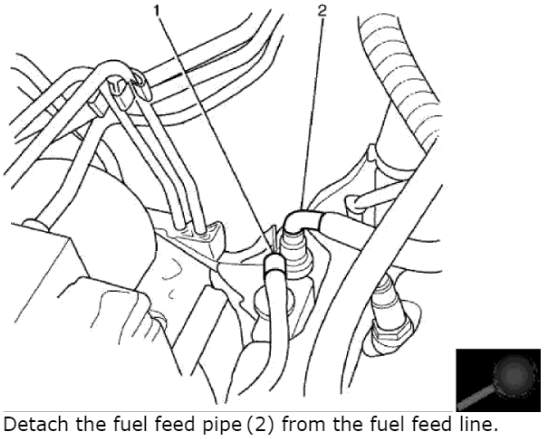
- Do not replace the primary fuel level sensor. Clean the primary level sensor with hot water.
- Inspect the secondary fuel tank module for contamination. Clean the secondary fuel tank module with hot water if contamination is found.
- Inspect the transfer tube for contamination. Clean the transfer tube with compressed air.

Note: The fuel and water mixture is a hazardous material. Observe local, state, and federal laws and regulations when discarding hazardous materials.

12. Flush the fuel tank with hot water.

Note: Make sure that all the water is removed from the fuel tank after the fuel tank has been cleaned from all contamination.

13. Pour the water out of the fuel tank at the fuel tank module openings by rocking the fuel tank several times.

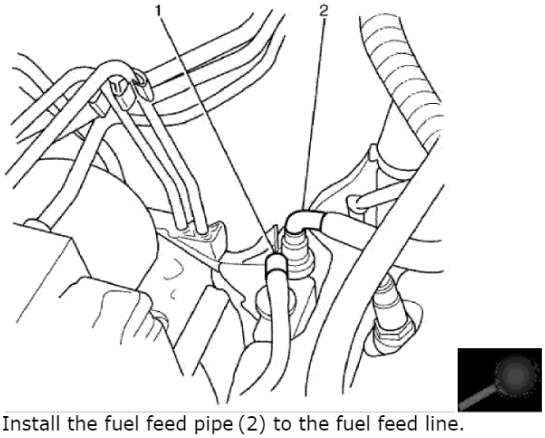


14. Detach the fuel feed pipe (2) from the fuel feed line.
15. Clean the fuel feed lines with compressed air.
16. Remove the fuel rails and fuel injectors. Refer to the following procedures:
    - Fuel Injection Fuel Rail Assembly Replacement - Bank 1
    - Fuel Injection Fuel Rail Assembly Replacement - Bank 2
17. Clean the fuel injectors and fuel rails with compressed air.
18. Inspect the fuel injectors. Replace damaged fuel injectors.

Installation Procedure

1. Install the fuel injectors and fuel rails if it was removed. Refer to the following procedures:
    - Fuel Injection Fuel Rail Assembly Replacement - Bank 1.
    - Fuel Injection Fuel Rail Assembly Replacement - Bank 2.
2. Install a NEW fuel pressure sensor. Refer to Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail.
3. Install the a NEW high pressure fuel pump. Refer to Fuel Pump Replacement.
4. Install a NEW fuel feed intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
5. Install a NEW fuel feed pipe. Refer to Fuel Feed Pipe Replacement.

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6. Install the fuel feed pipe (2) to the fuel feed line.
7. Install the fuel pipe shield. Refer to Fuel Pipe Shield Replacement
8. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
9. Install the primary fuel tank module assembly. Refer to Primary Fuel Tank Module Replacement.
10. Install the secondary fuel tank module assembly. Refer to Secondary Fuel Tank Module Replacement.
11. Install the fuel tank. Refer to Fuel Tank Replacement.
12. Lower the vehicle.
13. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

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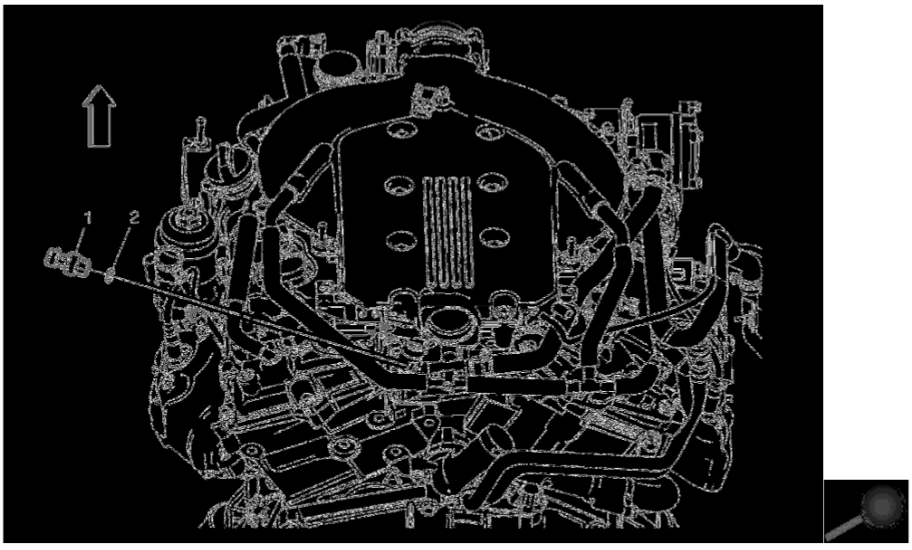
Fuel Injector Cleaning (LFW, LLT or LFX)

The petrol direct fuel injection system fuel injectors are not serviceable. If the fuel injectors has been contaminated with foreign materials, the fuel injectors must be replaced.

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Fuel Pressure Service Valve Replacement (LWR)



Fuel Pressure Service Valve Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief. 2. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 3. Disconnect the electrical connector.
1	Fuel Pressure Service Valve. **Caution:** Refer to Fastener Caution.

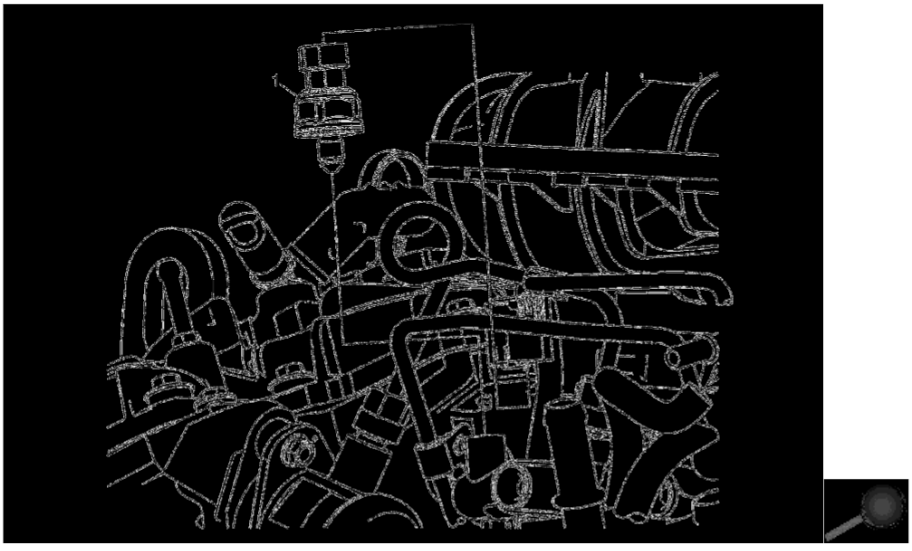
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Callout	Component Name
	Procedure 1. Install NEW o-ring. 2. Conduct a leak test after final assembly. Refer to LPG Leak Testing. **Tighten** 14 N•m (10 lb ft)

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Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail (LFW or LFX)



Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail

Callout	Component Name
Preliminary Procedures 1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 2. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.	
1	Fuel Injection Fuel Rail Fuel Pressure Sensor **Caution:** Refer to Fastener Caution. **Tighten** 33 N•m (24 lb ft)

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Fuel Pressure Sensor Replacement (Fuel Pump Assembly LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

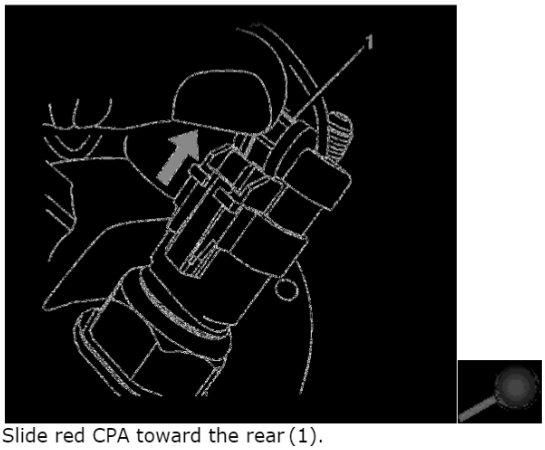
The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Warning: Refer to Safety Glasses Warning.

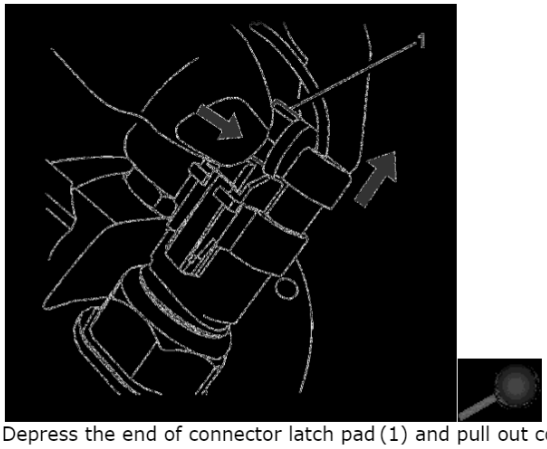
1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Empty the fuel tank. Refer to LPG Tank Unloading.
3. Remove the fuel tank. Refer to Fuel Tank Replacement.



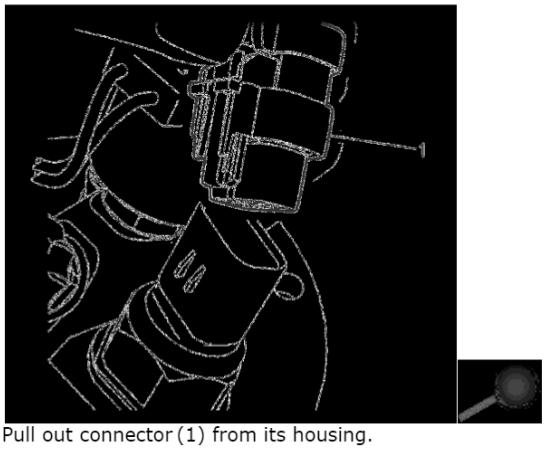
4. Slide red CPA toward the rear (1).

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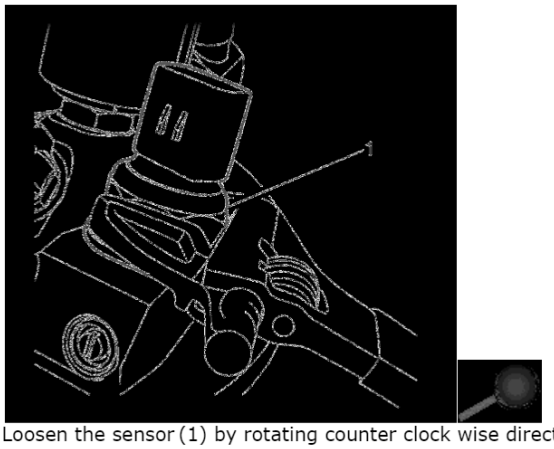
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5. Depress the end of connector latch pad (1) and pull out connector.

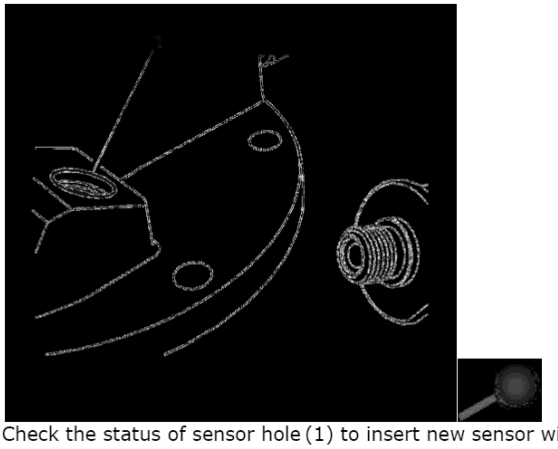


6. Pull out connector (1) from its housing.



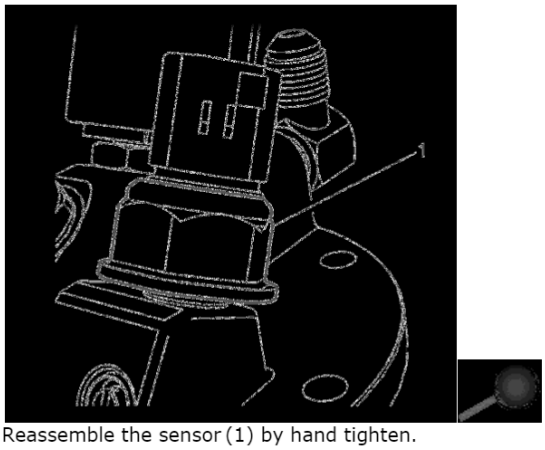
7. Loosen the sensor (1) by rotating counter clock wise direction.

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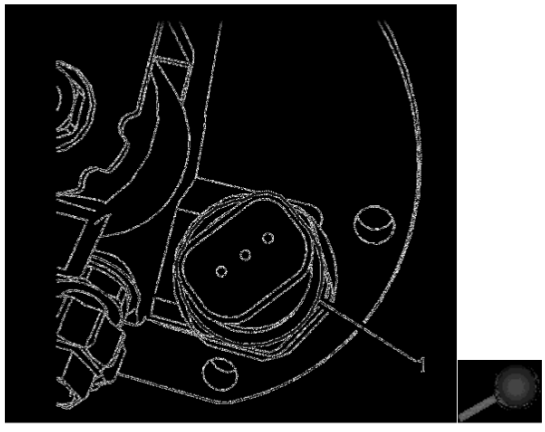


8. Check the status of sensor hole (1) to insert new sensor with o- ring.

Installation Procedure



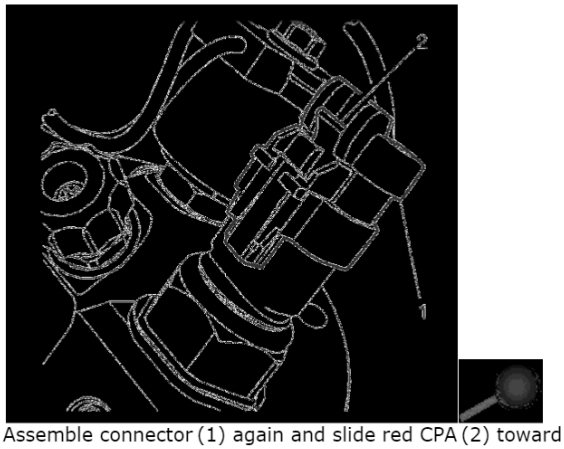
1. Reassemble the sensor (1) by hand tighten.



Caution: Refer to Fastener Caution.

2. Tighten the sensor (1) to **15 N·m (11 lb ft)**.

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3. Assemble connector (1) again and slide red CPA (2) toward plug housing, check the CPA as locked position
4. Replace the fuel tank. Refer to Fuel Tank Replacement.
5. Perform LPG leak test after final assembly. Refer to LPG Leak Testing

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Fuel Injection Fuel Rail Assembly Replacement - Bank 1 (LF1, LFW or LFX)

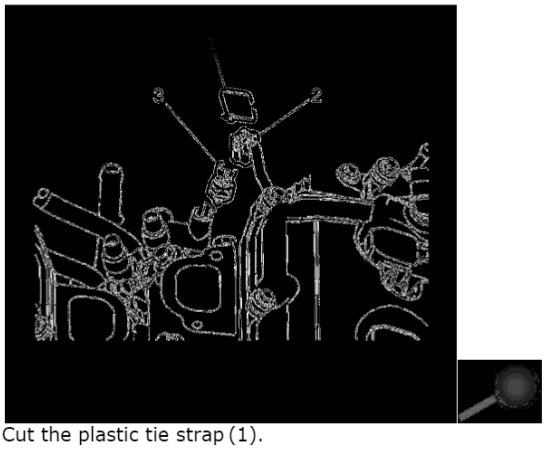
Special Tools

EN-49248 Injector Rail Assembly Remover

For equivalent regional tools, refer to Special Tools.

Removal Procedure

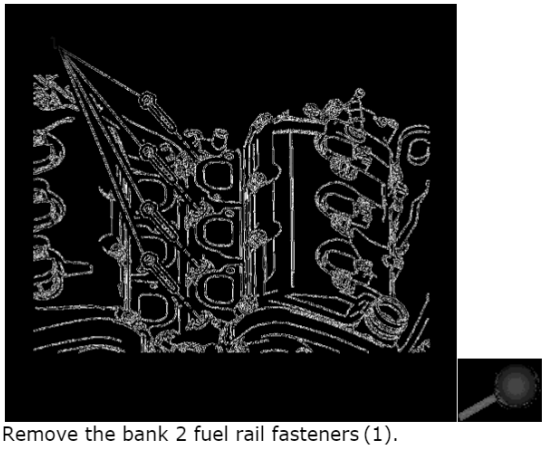
1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
3. Remove the intake manifold. Refer to Intake Manifold Replacement.
4. Remove the fuel feed intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
5. Remove the fuel injection fuel rail noise shield from the fuel rails.



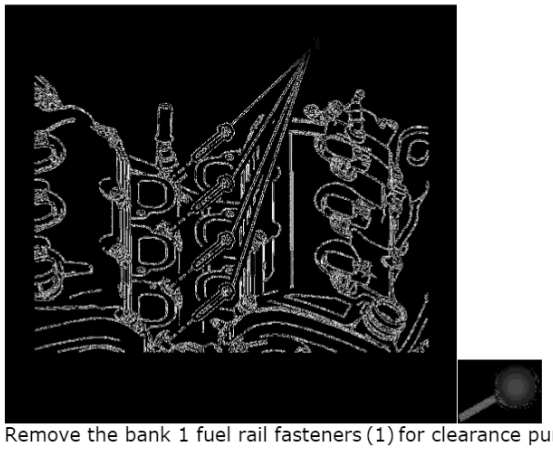
6. Cut the plastic tie strap (1).
7. Disconnect the fuel pressure sensor electrical connector (2).
8. Remove the fuel pressure sensor (3).

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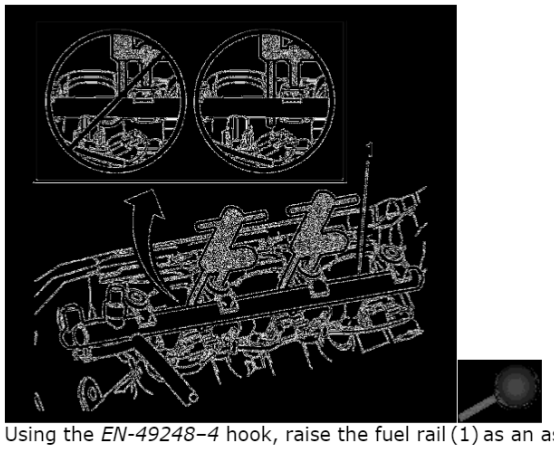
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9. Remove the bank 2 fuel rail fasteners (1).

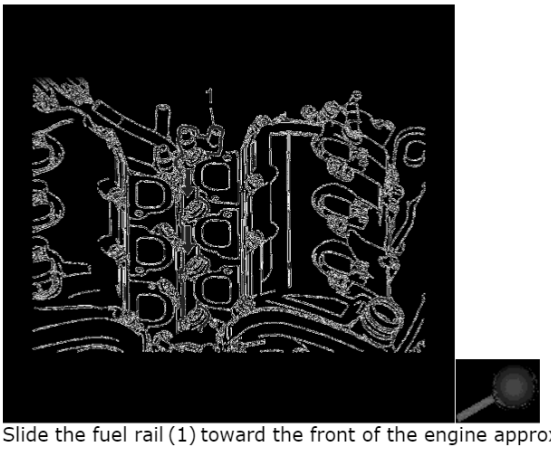


10. Remove the bank 1 fuel rail fasteners (1) for clearance purposes.



11. Using the *EN-49248–4* hook, raise the fuel rail (1) as an assembly.
12. Once the fuel rail is free, remove the *EN-49248* special tool.

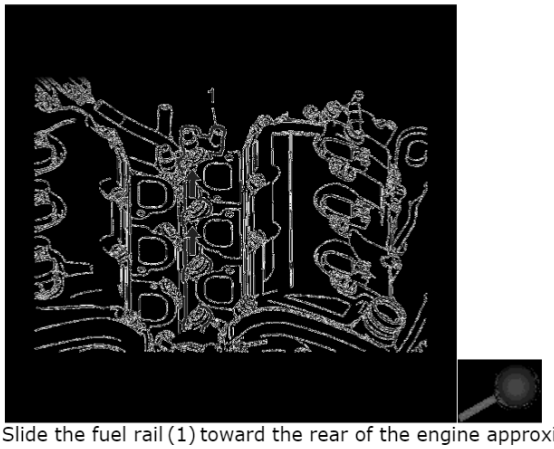
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13. Slide the fuel rail (1) toward the front of the engine approximately 1 inch (25.4 mm), in order to clear the center injector bore.

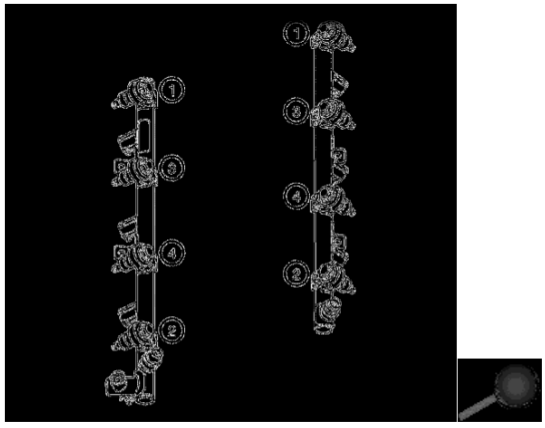
    Note: The direct fuel injectors must be rebuilt whenever the injector has been released from the fuel rail or cylinder head.
14. Once the fuel rail is removed, remove the fuel injectors and rebuild them. Refer to Fuel Rail and Injectors Cleaning and Inspection.

Installation Procedure



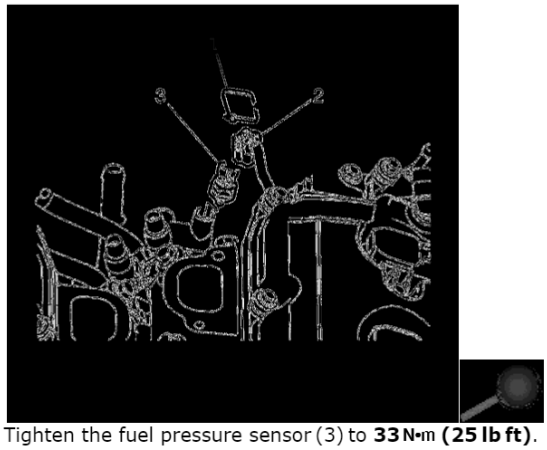
1. Slide the fuel rail (1) toward the rear of the engine approximately 1 inch (25.4 mm), in order to align the center injector bore.

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Caution: Refer to Fastener Caution.

2. Hand tighten the two outer fuel rail fasteners to seat the injectors.
3. Start and hand tighten the remaining fuel rail fasteners.
4. Tighten the fuel rail fasteners in the sequence shown above:
   4.1. First pass **12 N•m (106 lb in)**.
   4.2. Final pass **23 N•m (17 lb ft)**.



5. Tighten the fuel pressure sensor (3) to **33 N•m (25 lb ft)**.
6. Connect the fuel pressure sensor electrical connector (2) and secure it with a new plastic zip tie.
7. Install the fuel feed intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
8. Inspect for fuel leaks using the following procedure:
   8.1. Turn ON the ignition, with the engine OFF for 2 seconds.
   8.2. Turn OFF the ignition, for 10 seconds.
   8.3. Turn ON the ignition, with the engine OFF.
   8.4. Inspect for fuel leaks.
9. Install the fuel injection fuel rail noise shield to the fuel rails.
10. Install the intake manifold. Refer to Intake Manifold Replacement.
11. Install the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.

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12. Install the low side fuel pressure service port cap.
13. Install the fuel tank cap.

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Fuel Injection Fuel Rail Assembly Replacement - Bank 2 (LF1, LFW or LFX)

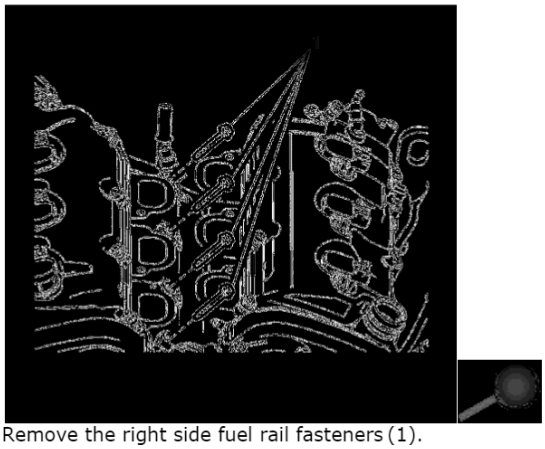
Special Tools

EN-49248 Injector Rail Assembly Remover

For equivalent regional tools, refer to Special Tools.

Removal Procedure

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
3. Remove the intake manifold. Refer to Intake Manifold Replacement.
4. Remove the fuel feed intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
5. Remove the fuel injection fuel rail noise shield from the fuel rails.



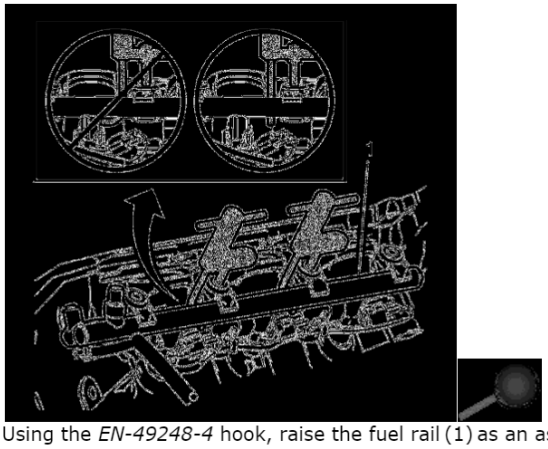
6. Remove the right side fuel rail fasteners (1).



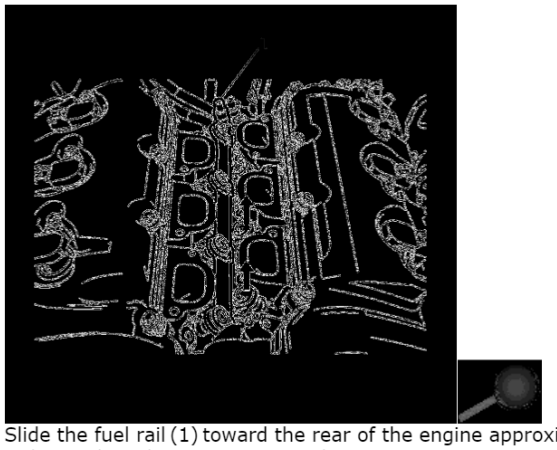
7. Remove the left side fuel rail fasteners (1) for clearance purposes.

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8. Using the *EN-49248-4* hook, raise the fuel rail (1) as an assembly.
9. Once the fuel rail is free, remove the *EN-49248* remover.

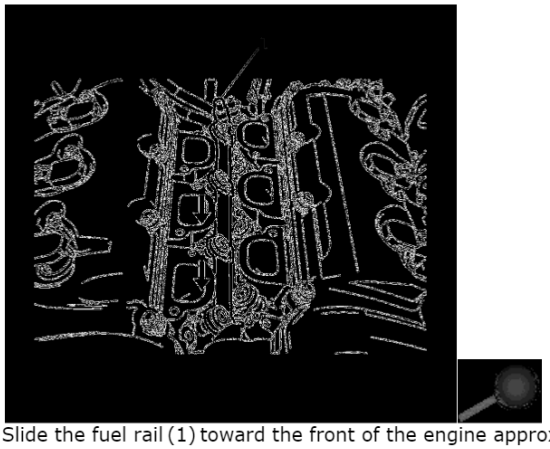


10. Slide the fuel rail (1) toward the rear of the engine approximately 1 inch (25.4 mm), in order to clear the center injector bore.

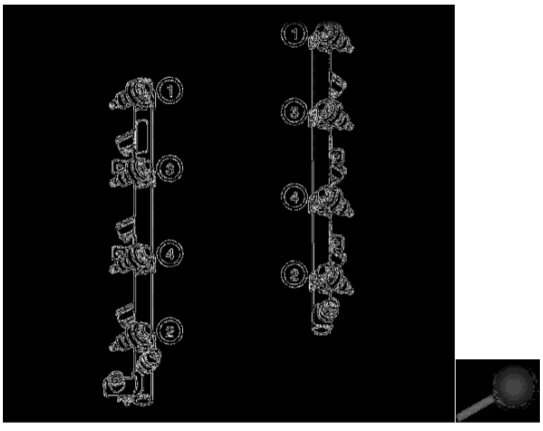
    Note: The direct fuel injectors must be rebuilt whenever the injector has been released from the fuel rail or cylinder head.
11. Once the fuel rail is removed, remove the fuel injectors and rebuild them. Refer to Fuel Rail and Injectors Cleaning and Inspection.

Installation Procedure

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1. Slide the fuel rail (1) toward the front of the engine approximately 1 inch (25.4 mm), in order to align the center injector bore.



Caution: Refer to Fastener Caution.

2. Hand tighten the two outer fuel rail fasteners to seat the injectors.
3. Start and hand tighten the remaining fuel rail fasteners.
4. Tighten the fuel rail fasteners in the sequence shown above:
   4.1. Tighten the Bank 1 fuel rail bolts first pass to **12 N•m (106 lb in)**.
   4.2. Tighten the Bank 1 fuel rail bolts a final pass to **23 N•m (17 lb ft)**.
5. Install the fuel feed intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
6. Inspect for fuel leaks using the following procedure:
   6.1. Turn ON the ignition, with the engine OFF for 2 seconds.
   6.2. Turn OFF the ignition, for 10 seconds.
   6.3. Turn ON the ignition, with the engine OFF.
   6.4. Inspect for fuel leaks.
7. Install the fuel injection fuel rail noise shield to the fuel rails.
8. Install the intake manifold. Refer to Intake Manifold Replacement.
9. Install the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
10. Install the low side fuel pressure service port cap.

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11. Install the fuel tank cap.

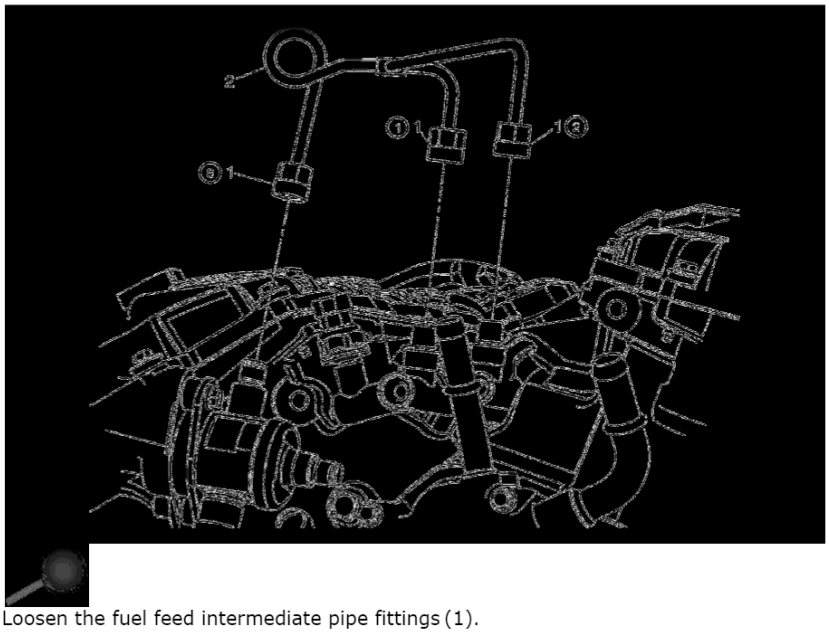
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Fuel Feed Intermediate Pipe Replacement (LFW or LFX)

Removal Procedure

Warning: Refer to Safety Glasses Warning.

1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
2. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
3. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.



4. Loosen the fuel feed intermediate pipe fittings (1).

Note: The fuel feed intermediate pipe is one time use and must be replaced.

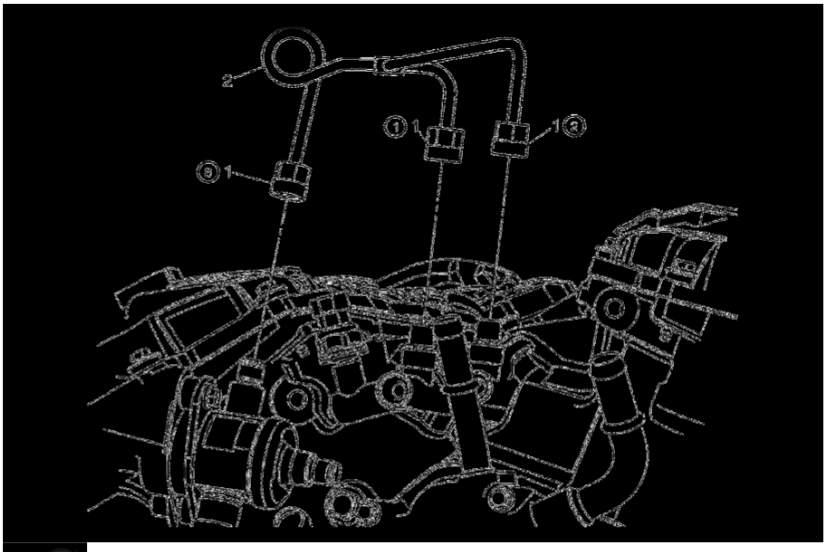
5. Remove and DISCARD the fuel feed intermediate pipe (2) from the engine.

Installation Procedure

1. Prior to installing the NEW fuel feed intermediate pipe, make sure that the following components are free of damage, clean and dry before installation. Replace any damaged components.
   - Right fuel rail high pressure fuel connection
   - Left fuel rail high pressure fuel connection
   - High pressure fuel pump high pressure fuel connection

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Note: The fuel feed intermediate pipe is one time use and must be replaced.

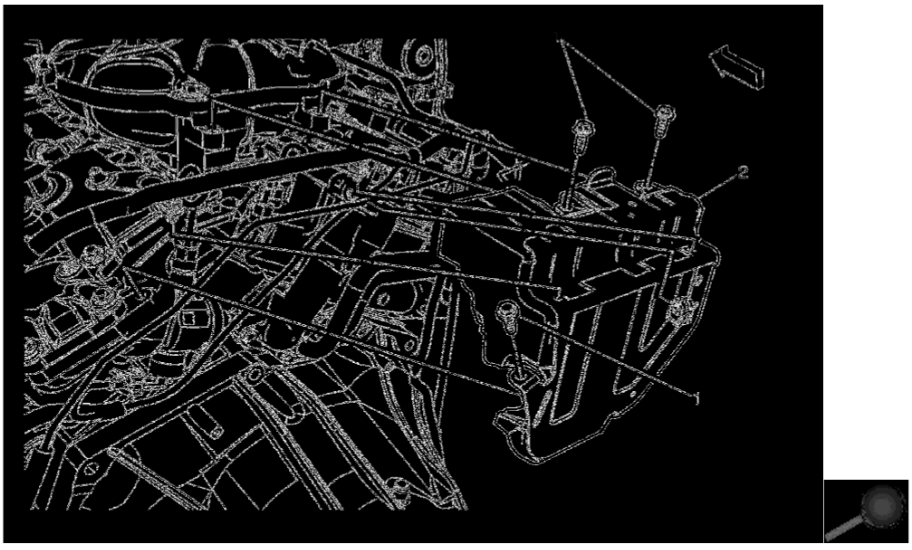
2. Lubricate the NEW intermediate fuel feed pipe fittings (1) with silicon free engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers.

   Hand start the intermediate fuel feed pipe fittings (1) in sequence as numbered 1,2,3.

   Caution: Refer to Component Fastener Tightening Caution.
3. Tighten the fuel feed intermediate pipe connections in sequence as numbered 1,2,3.
   - 3.1. Tighten the fittings first pass to **16 N•m (12 lb ft)**.
   - 3.2. Tighten the fittings final pass to **32 N•m (24 lb ft)**.
4. Inspect for leaks using the following procedure:
   - 4.1. Start the engine and run the engine for 5 seconds.
   - 4.2. Turn the engine OFF, for 10 seconds.
   - 4.3. Inspect for fuel leaks.
5. Install the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
6. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.

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Fuel Pipe Shield Replacement (LFW or LFX)



Fuel Pipe Shield Replacement

Callout	Component Name
Preliminary Procedures 1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 2. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement. 3. Disconnect the wiring harness from the fuel pipe shield.	
1	Fuel Pipe Shield Retaining Bolt **Caution:** Refer to Fastener Caution. **Tighten** 10 N•m (89 lb in)
2	Fuel Pipe Shield

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Fuel Pump Replacement (LFW or LFX)

Special Tools

EN-48896 High Pressure Fuel Pump Installation Alignment Gage

For equivalent regional tools, refer to Special Tools.

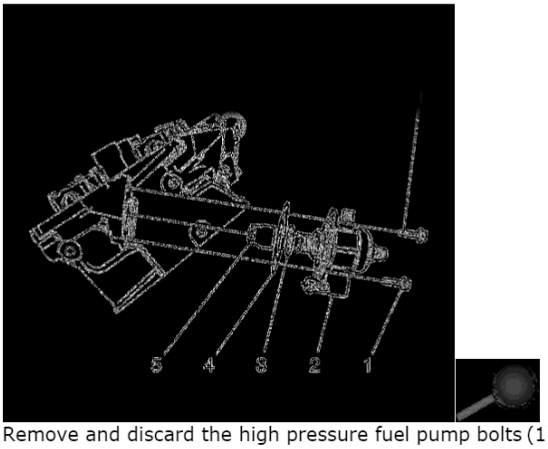
Removal Procedure

1. Relieve the high side and the low side fuel pressure. Refer to Fuel Pressure Relief.

   Warning: Refer to Gasoline/Gasoline Vapors Warning.

   Warning: Refer to Safety Glasses Warning.
2. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
3. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
4. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
5. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
6. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
7. Remove and discard the fuel feed pipe. Refer to Fuel Feed Pipe Replacement.
8. Remove and discard the fuel feed intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
9. Disconnect the engine wiring harness electrical connector from the high pressure fuel pump.

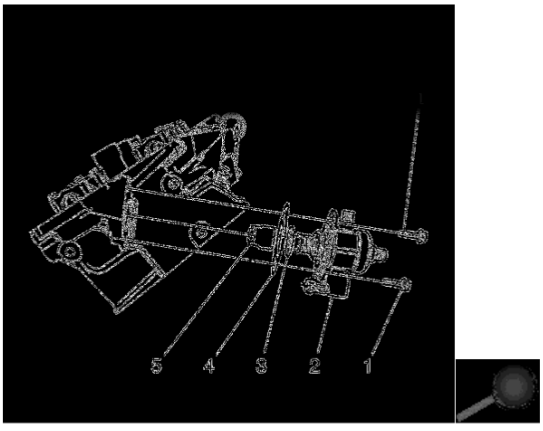


10. Remove and discard the high pressure fuel pump bolts (1).
11. Remove the high pressure fuel pump (2).
12. Remove and discard the high pressure fuel pump seal (3).
13. Remove and discard the high pressure fuel pump gasket (4).
14. Remove the high pressure fuel pump roller lifter (5).

Installation Procedure

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Note: The camshaft lobe driving the high pressure fuel pump must be in the base circle position before the high pressure fuel pump is installed. At base circle position the *EN-48896* gage will be flush with the cylinder head.

1. Use the *EN-48896* gage and set the camshaft lobe driving the high pressure fuel pump to the base circle position.
2. Lubricate the high pressure fuel pump cylinder head bore and NEW high pressure fuel pump roller lifter with lubricant. Refer to Adhesives, Fluids, Lubricants, and Sealers.
3. Install the high pressure fuel pump roller lifter (5).
4. Install a NEW high pressure fuel pump seal (3).

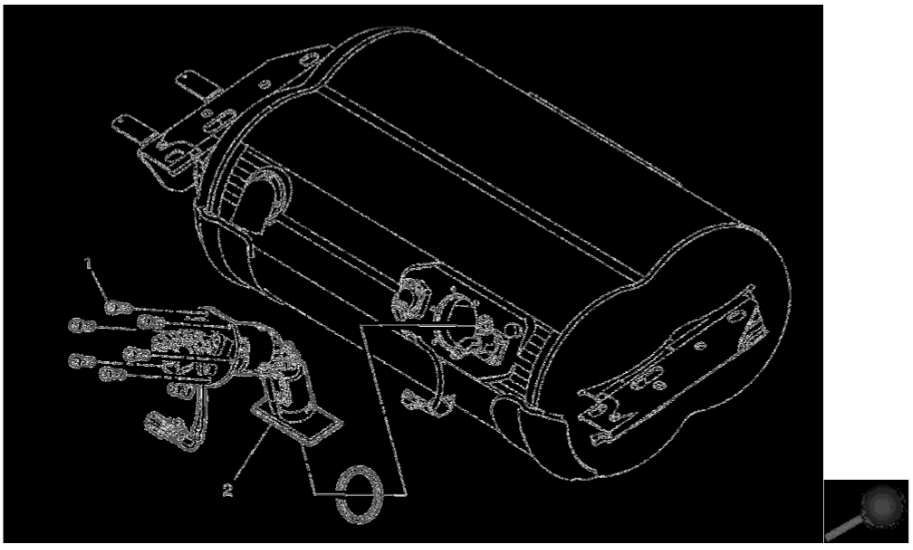
   Note: The high pressure fuel pump gasket has a retaining feature to hold the high pressure fuel pump retaining bolts in place.
5. Position the NEW high pressure fuel pump gasket (4) and bolts (1) to the fuel pump (2).

   Caution: Refer to Fastener Caution.

   Note: Hand tighten the high pressure fuel pump bolts (1) equally. Force maybe required to hand tighten the bolts.
6. Install the NEW high pressure fuel pump assembly (2) to the cylinder head.
7. Tighten the high pressure fuel pump retaining bolts to **15 N•m (11 lb ft)**.
8. Connect the engine wiring harness connector to the high pressure fuel pump (2).
9. Install a NEW fuel feed intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
10. Install a NEW fuel feed pipe to the high pressure fuel pump. Refer to Fuel Feed Pipe Replacement.
11. Inspect for leaks using the following procedure:
    11.1. Start the engine and run the engine for 5 seconds.
    11.2. Turn the engine and ignition OFF, and wait for 10 seconds.
    11.3. Inspect for fuel leaks.
12. Install the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
13. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
14. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
15. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

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Fuel Pump Replacement (LWR)



Fuel Pump Replacement

Callout	Component Name

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Preliminary Procedure

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Disconnect the electrical connectors.
4. Disconnect the LPG fuel feed hose. Refer to LPG Fuel Feed Hose Replacement
5. Remove the LPG fuel tank. Refer to Fuel Tank Replacement
6. Empty the LPG fuel tank. Refer to LPG Tank Unloading
7. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.

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Callout	Component Name
1	LPG Fuel Pump Fasteners (Qty: 6). **Caution:** Refer to Fastener Caution. **Tighten** 16 N•m (12 lb ft)
2	LPG Fuel Pump. **Procedure** 1. Remove o-ring and DISCARD, install new o-ring. 2. Replace LPG fuel filter (pump filter in tank). Refer to LPG Fuel Filter Replacement.

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Fuel Feed Pipe Elbow Replacement (Fuel Pump LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

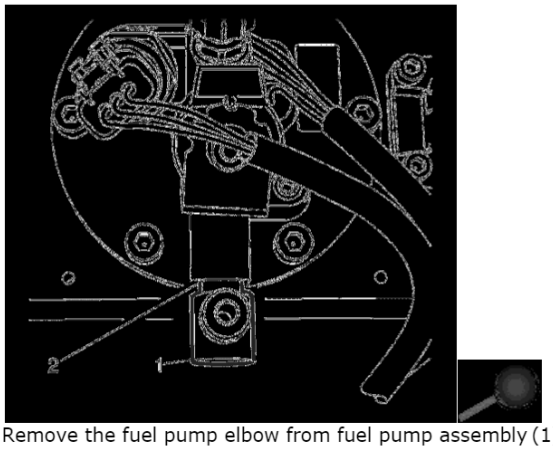
The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Note: This procedure will have to be completed at the 10 year tank inspection.

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Conduct a tank filler hose pressure relief. Refer to LPG Tank Filler Hose Pressure Relief.
3. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
4. Remove the fuel tank. Refer to Fuel Tank Replacement.



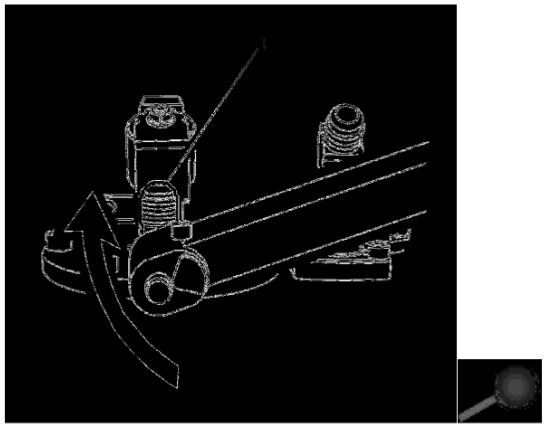
5. Remove the fuel pump elbow from fuel pump assembly (1).
6. Clean old residual epoxy left on threads (2).

Installation Procedure

1. Apply loctite to both the housing and the elbow threads. Refer to Adhesives, Fluids, Lubricants, and Sealers.

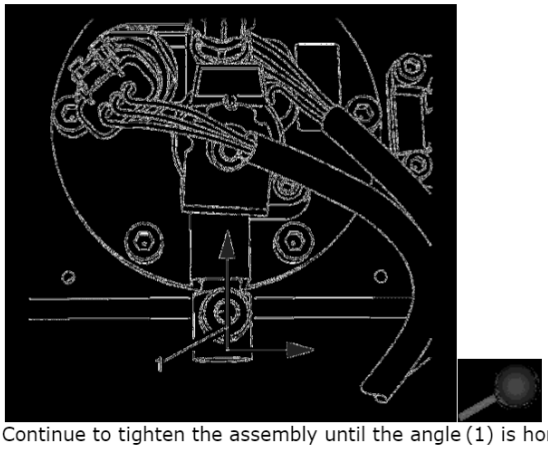
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Caution: Refer to Fastener Caution.

2. Assemble elbow to the pump assembly and tighten to **15 N•m (11 lb ft)**.



3. Continue to tighten the assembly until the angle (1) is horizontal 90 degrees.
4. Replace the fuel tank. Refer to Fuel Tank Replacement.
5. Lower the vehicle.
6. Conduct an LPG leak test after final assembly. Refer to LPG Leak Testing.

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Fuel Feed Pipe Elbow Replacement (Shutoff Valve LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

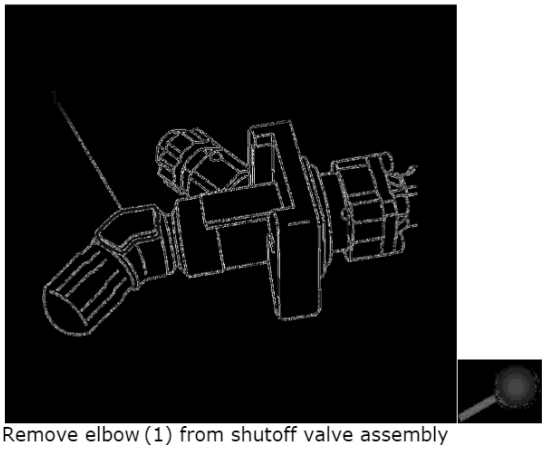
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Relive the tank filler hose pressure. Refer to LPG Tank Filler Hose Pressure Relief.
3. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
4. Disconnect the tank filler hose from the shutoff valve. Refer to LPG Tank Filler Hose Replacement.
5. Remove the fuel tank. Refer to Fuel Tank Replacement.



6. Remove elbow (1) from shutoff valve assembly
7. Clean old residual epoxy left in the threads.

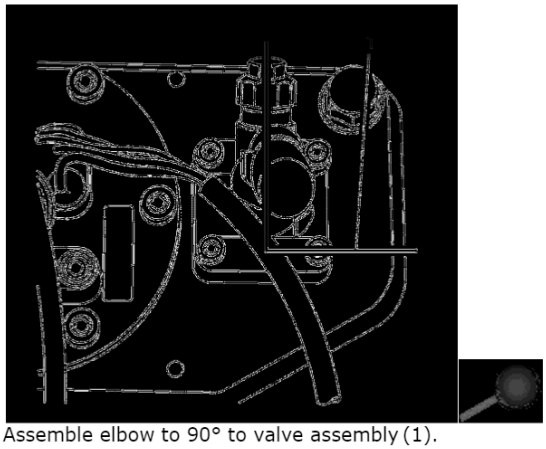
Installation Procedure

1. Apply a bead of sealant compound to the threads on the elbow.

   Caution: Refer to Fastener Caution.
2. Hand start the elbow and tighten to **25 N·m (18 lb ft)**

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3. Assemble elbow to 90° to valve assembly (1).
4. Install the fuel tank. Refer to Fuel Tank Replacement.
5. Connect the tank filler hose to the shutoff valve. Refer to LPG Tank Filler Hose Replacement.
6. Lower the vehicle.
7. Perform leak test after final assembly. Refer to LPG Leak Testing.

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Fuel Injector and Fuel Rail Replacement (LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

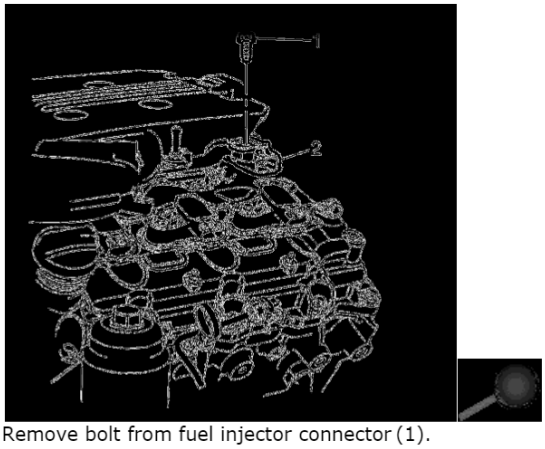
The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the LPG fuel feed hose filter to rail. Refer to LPG Fuel Feed Hose Replacement.
4. Disconnect the electrical connector at the fuel pressure service valve. Refer to Fuel Pressure Service Valve Replacement.

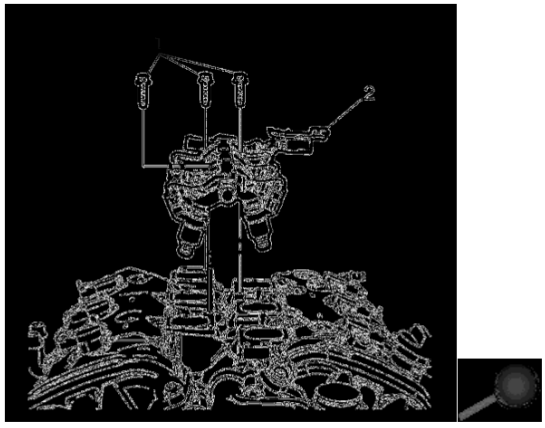


5. Remove bolt from fuel injector connector (1).
6. Disconnect the fuel injector wiring harness (2) from the engine wiring harness.
7. Remove the upper intake manifold. Refer to Upper Intake Manifold Replacement.

   Warning: Refer to Safety Glasses and Compressed Air Warning.
8. Use compressed air in order to remove debris from the area where the fuel injectors enter the intake manifold.

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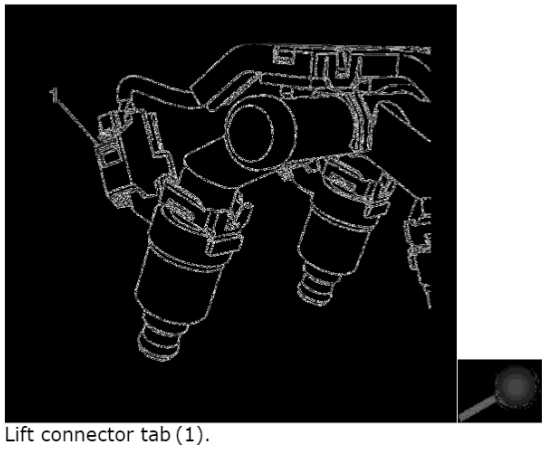
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Caution:

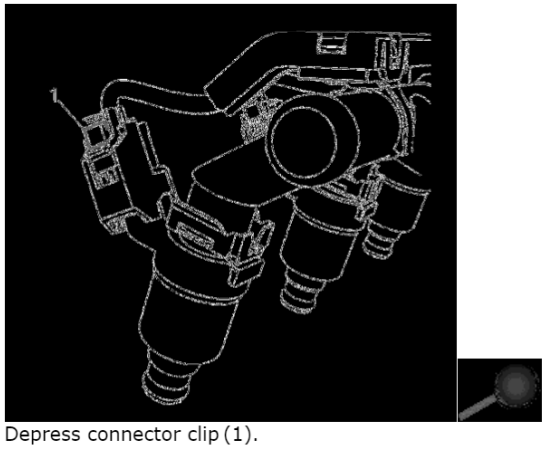
- Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
- Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.

9. Remove the fuel rail and electrical harness bolts (1) from the engine.
10. Remove the fuel rail and electrical harness (2) from the engine.

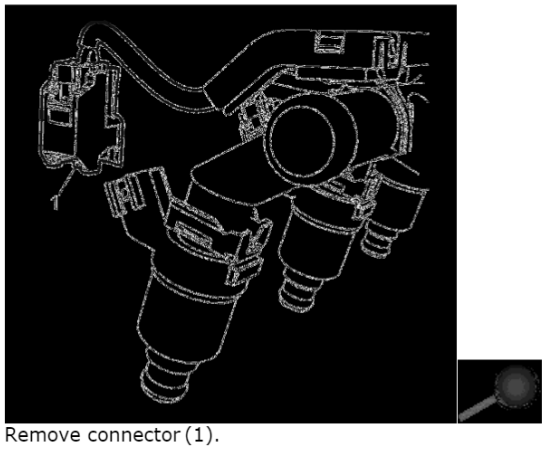


11. Lift connector tab (1).

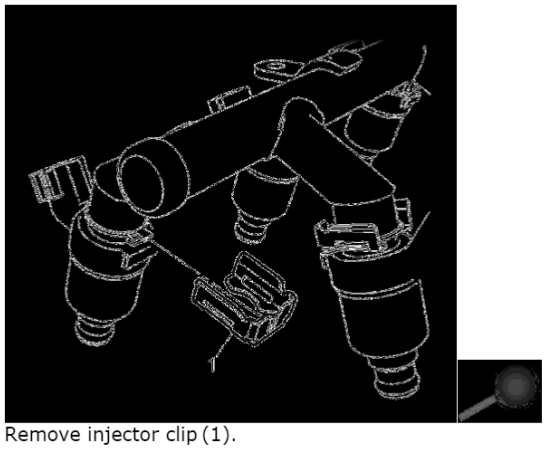
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12. Depress connector clip (1).

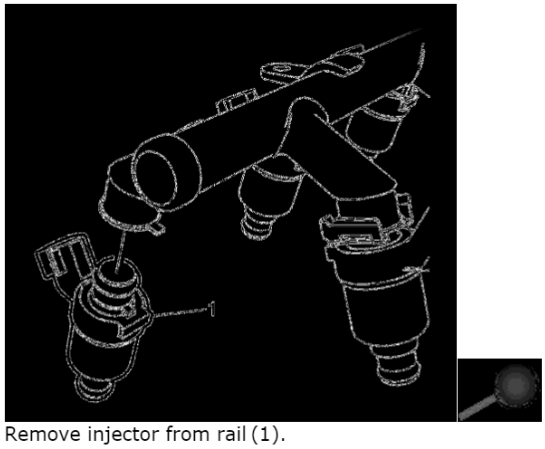


13. Remove connector (1).



14. Remove injector clip (1).

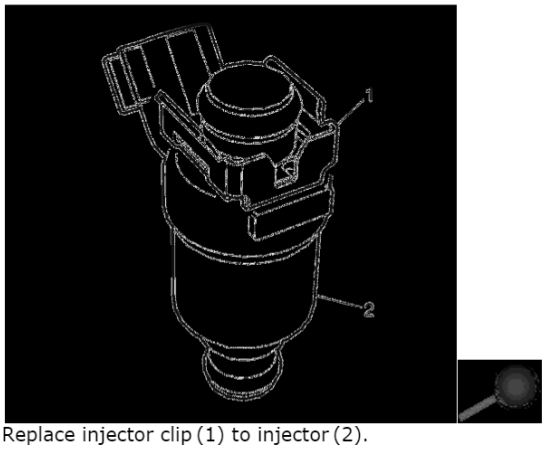
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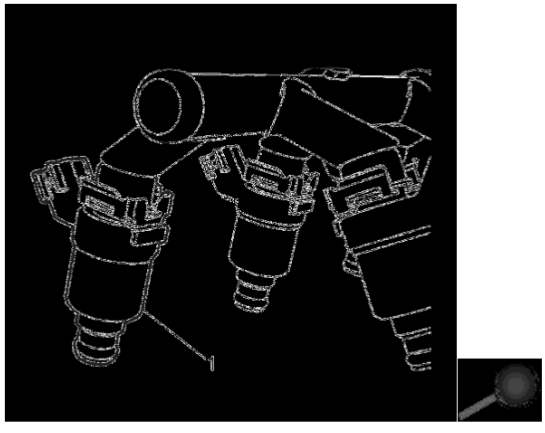
15. Remove injector from rail (1).
16. Remove and discard the fuel injector seals.

Installation Procedure

1. Install NEW fuel injector seals.

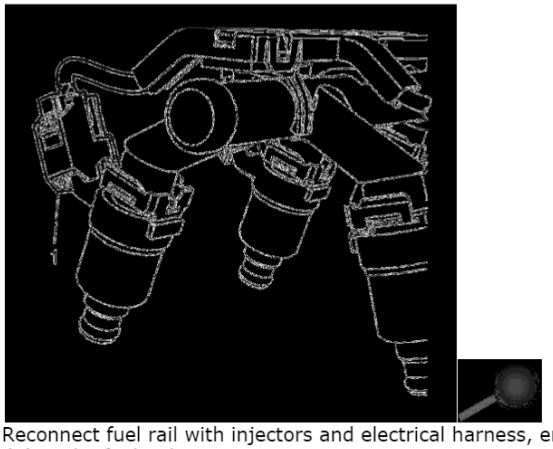


2. Replace injector clip (1) to injector (2).

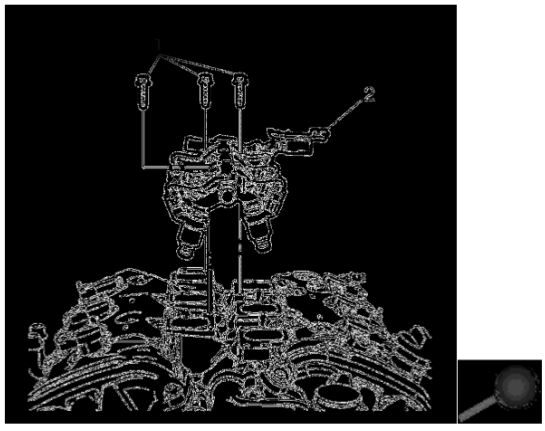


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3. Insert injector (1) to the rail, a slight audible click should be heard.



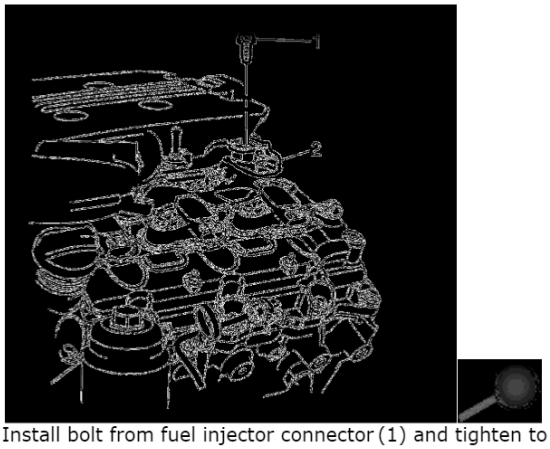
4. Reconnect fuel rail with injectors and electrical harness, engaging the electrical connectors (1) to the fuel rail.



Caution: Refer to Fastener Caution.

5. Replace fuel rail to engine (2), ensuring all loose debris from the area where the fuel injectors enter the intake manifold.
6. Install the fuel rail bolts (1) and tighten to **10 N·m (89 lb in)**.
7. Install the upper intake manifold. Refer to Upper Intake Manifold Replacement.

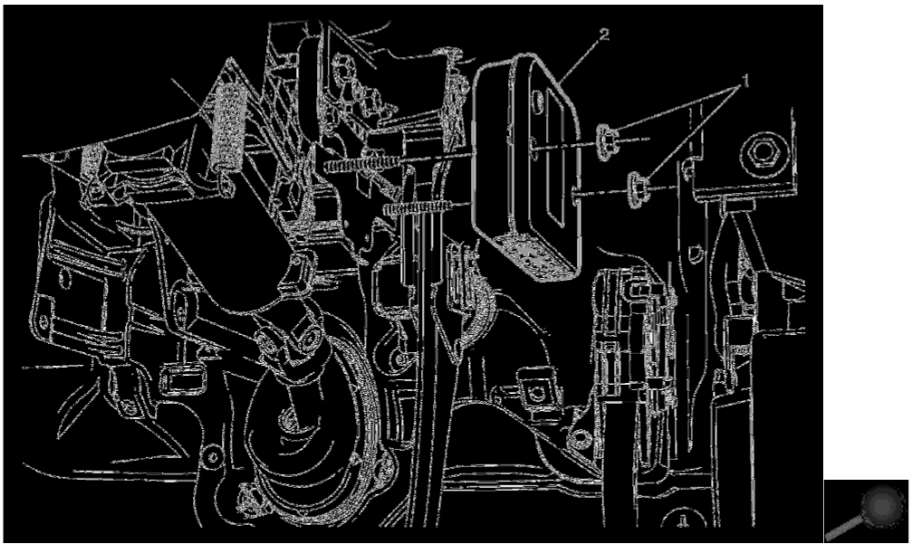
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8. Install bolt from fuel injector connector (1) and tighten to **10 N•m (89 lb in)**.
9. Connect the fuel injector wiring harness (2) from the engine wiring harness.
10. Connect the electrical connector at the fuel pressure service valve. Refer to Fuel Pressure Service Valve Replacement.
11. Install the LPG fuel feed hose filter to rail. Refer to LPG Fuel Feed Hose Replacement.
12. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
13. Apply fuel system pressure.
14. Conduct leak test. Refer to LPG Leak Testing.

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Fuel Injector Control Module Replacement (LWR)



Fuel Injector Control Module Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Preliminary Procedure** **Warning:** Refer to Battery Disconnect Warning. 1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection. 2. Remove the right side floor front air outlet duct. Refer to Floor Front Air Outlet Duct Replacement - Right Side.
1	LPG Fuel Injector Control Module Fasteners (Qty: 2) **Caution:** Refer to Fastener Caution. **Procedure Tighten** 3 N•m (27 lb in)
2	LPG Fuel Injector Control Module. **Procedure**

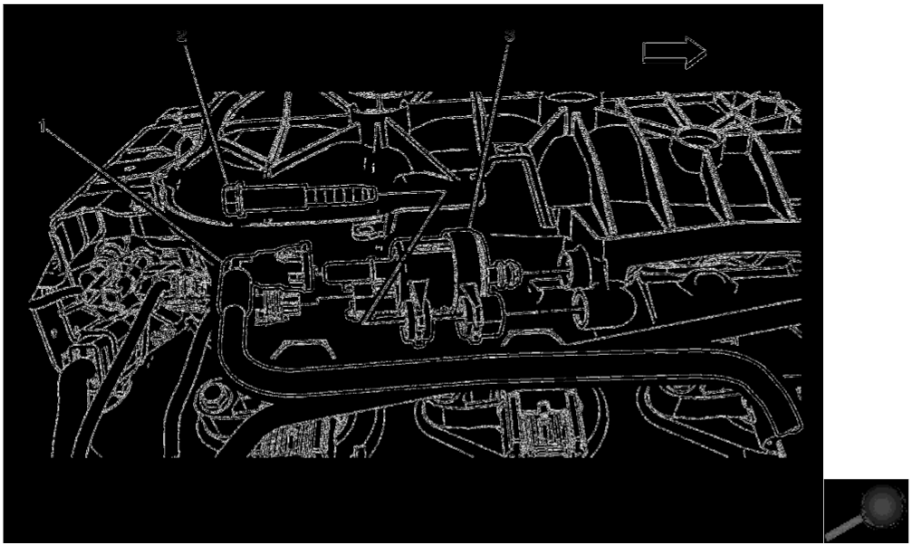
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Callout	Component Name
	Disconnect the LPG fuel injector control module electrical connector from the LPG fuel injector control module.

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Evaporative Emission Canister Purge Solenoid Valve Replacement (LFW or LFX)



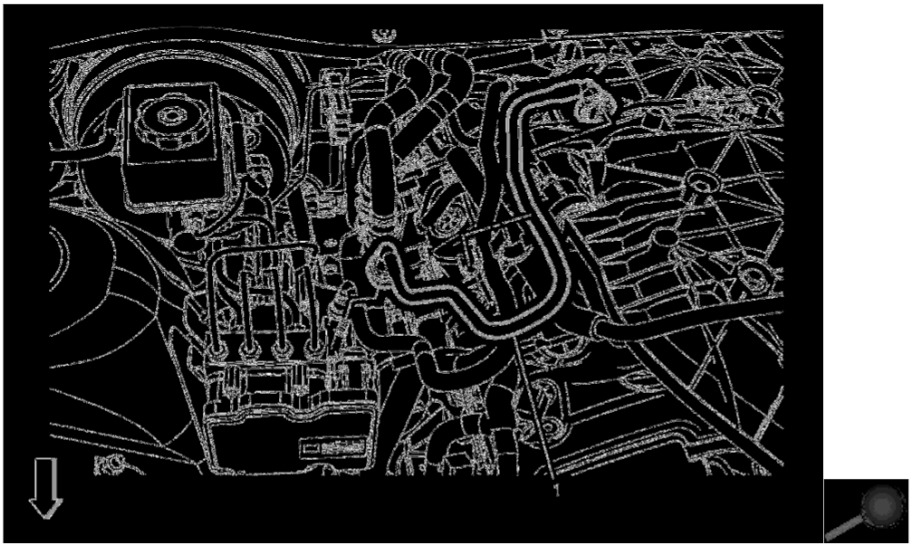
Evaporative Emission Canister Purge Solenoid Valve Replacement

Callout	Component Name
Preliminary Procedure Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.	
1	Evaporative Emission Canister Purge Pipe **Note:** To disconnect the purge pipe. Refer to Plastic Collar Quick Connect Fitting Service.
2	EVAP Emission Canister Purge Solenoid Valve to Intake Manifold Retaining Bolt **Caution:** Refer to Fastener Caution. **Tighten** 10 N•m (89 lb in)
3	Evaporative Emission Canister Purge Solenoid Valve **Procedure** 1. Disconnect the evaporative emission canister purge solenoid valve harness connector. 2. Install a NEW O-ring.

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Evaporative Emission Canister Purge Solenoid Valve Hose Replacement (LFW or LFX)



Evaporative Emission Canister Purge Solenoid Valve Hose Replacement

Callout	Component Name
	Warning: Refer to Gasoline/Gasoline Vapors Warning. **Warning:** Refer to Safety Glasses Warning. **Preliminary Procedures** Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
1	EVAP Emission Canister Purge Solenoid Valve Hose **Procedure** Disconnect the quick connect fittings. Refer to Plastic Collar Quick Connect Fitting Service.

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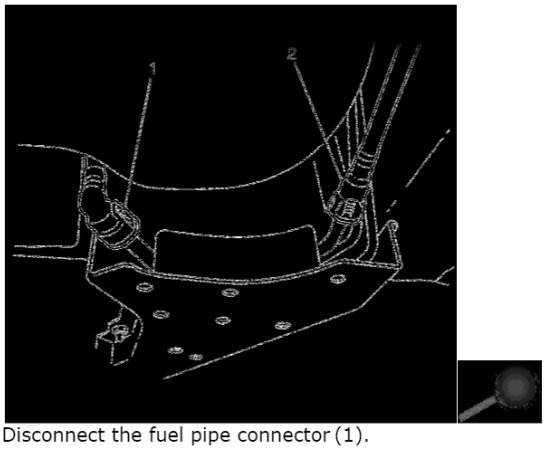
Evaporative Emission Line Replacement - Chassis (LFW or LFX)

Removal Procedure

Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

Note: The fuel system pipes can be serviceable individually or as a complete fuel/brake pipe assembly. The following is the procedure for servicing the fuel pipes individually.

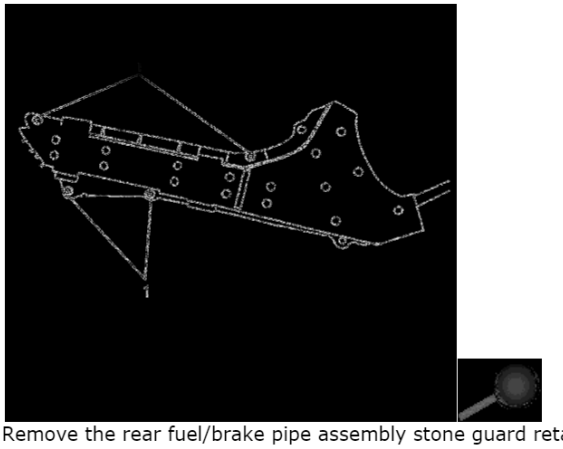
1. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Relieve the fuel system pressure. Refer to the Fuel Pressure Relief.
3. Remove the exhaust system. Refer to Exhaust System Replacement.
4. Remove the engine. Refer to Engine Replacement.
5. Remove the appropriate heat shields for access to the fuel/brake pipe assembly.



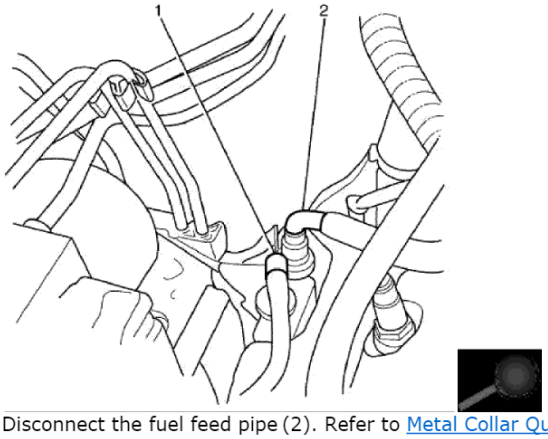
6. Disconnect the fuel pipe connector (1).

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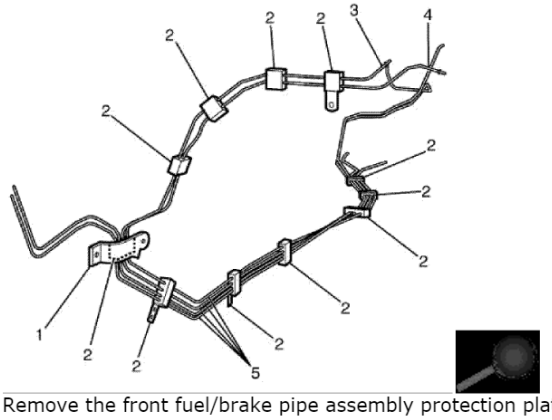
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7. Remove the rear fuel/brake pipe assembly stone guard retaining nuts (1).
8. Remove the rear fuel/brake pipe assembly stone guard from the vehicle.

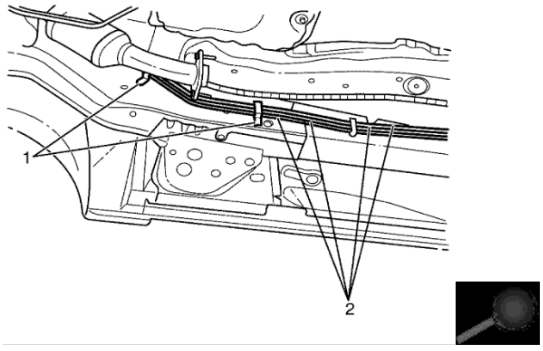


9. Disconnect the fuel feed pipe (2). Refer to Metal Collar Quick Connect Fitting Service.
10. Disconnect the EVAP pipe (1). Refer to Plastic Collar Quick Connect Fitting Service



11. Remove the front fuel/brake pipe assembly protection plate (1) from the vehicle.

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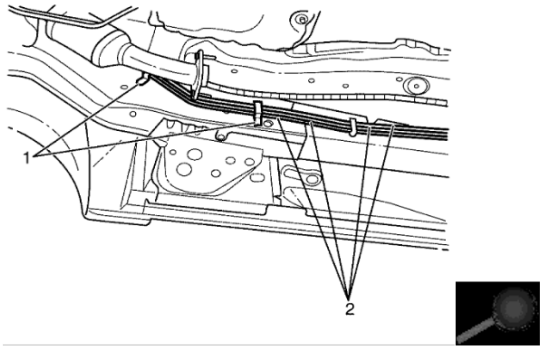


Note: Mark the positions of the fuel/brake pipe retainers (1) before removing the fuel/brake pipe retainers (1) from the fuel/brake pipes assembly.

12. Remove all the fuel/brake pipe retainers (1) from the fuel/brake pipe assembly (2).
13. Manoeuvre and remove the fuel line from the vehicle.

Installation Procedure

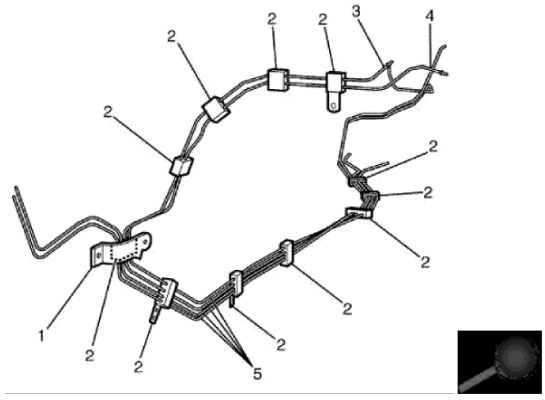
1. Manoeuvre and install the fuel line to the vehicle.



Note: Observed the marked the positions of the fuel/brake pipe retainers (1) when installing the fuel/brake pipe retainers (1) to the fuel/brake pipes assembly.

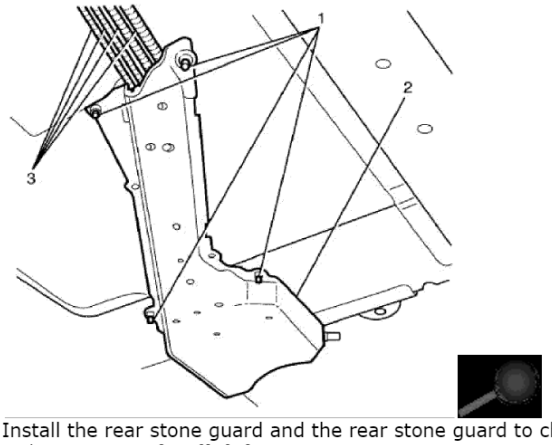
2. Install all the fuel/brake pipe retainers (1) to the fuel/brake pipe assembly (2).

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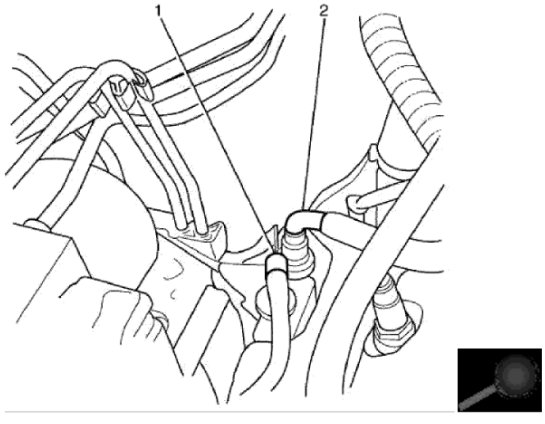


Caution: Refer to Fastener Caution.

3. Install the front fuel/brake pipe assembly protection plate (1) to the vehicle and tighten the bolts to . **22 N•m (16 lb in)**.



4. Install the rear stone guard and the rear stone guard to chassis retaining nuts (1) and tighten to **4 N•m (35 lb in)**.

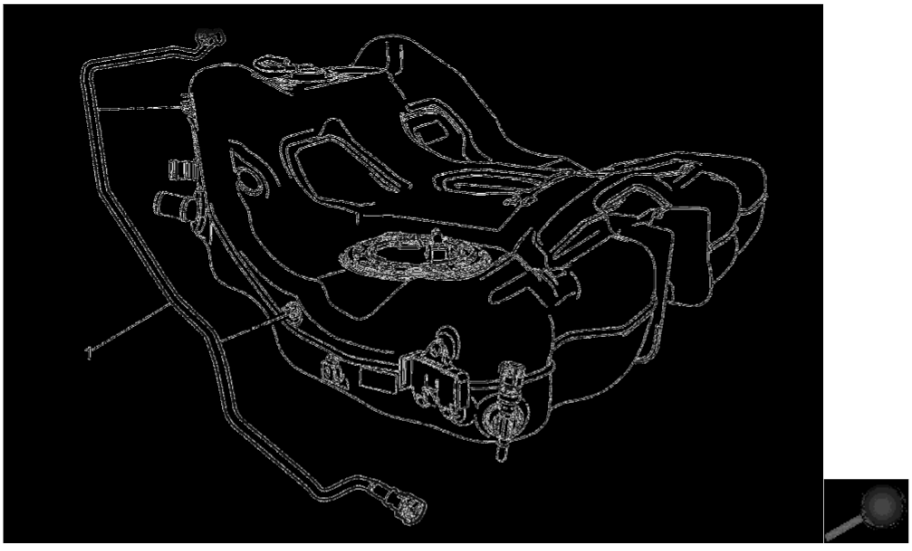


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5. Connect the fuel feed pipe (2). Refer to Metal Collar Quick Connect Fitting Service.
6. Connect the EVAP pipe (1). Refer to Plastic Collar Quick Connect Fitting Service.
7. Install the removed heat shields.
8. Install the engine. Refer to Engine Replacement.
9. Install the exhaust system. Refer to Exhaust System Replacement.
10. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.

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Evaporative Emission Canister Purge Pipe Replacement (LFW or LFX)



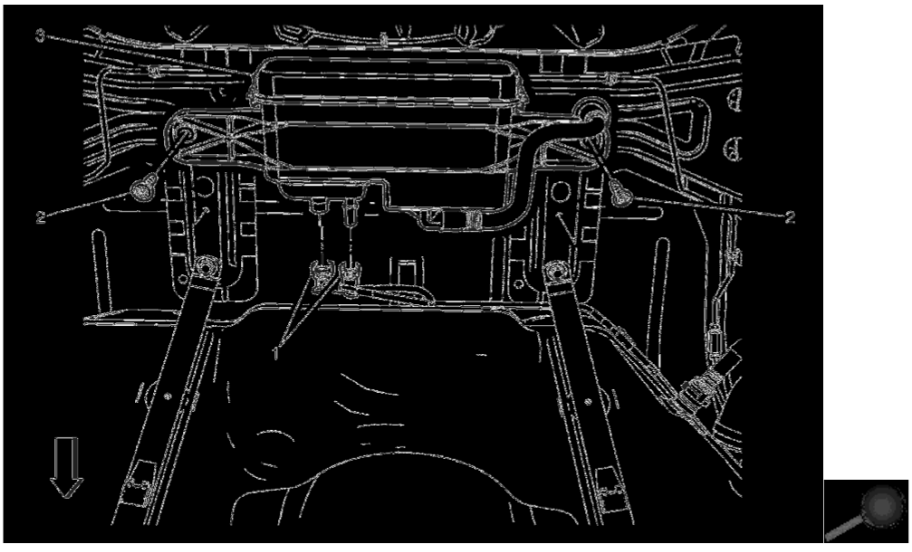
Evaporative Emission Canister Purge Pipe Replacement

Callout	Component Name
Warning: Refer to Gasoline/Gasoline Vapors Warning. **Warning:** Refer to Safety Glasses Warning. **Preliminary Procedures** Remove the fuel tank. Refer to Fuel Tank Replacement.	
1	EVAP Emission Canister Purge Pipe **Procedure** Disconnect the EVAP emission canister purge pipe from the EVAP pipe to fuel tank retaining clips.

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Evaporative Emission Canister Replacement



Evaporative Emission Canister Replacement

Callout	Component Name
Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist. **Warning:** Refer to Gasoline/Gasoline Vapors Warning. **Warning:** Refer to Safety Glasses Warning. **Preliminary Procedures** 1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle. 2. Remove the rear suspension support. Refer to Rear Suspension Support Removal and Installation.	
1	EVAP Emission Hoses **Procedure** Disconnect the EVAP hoses from the EVAP canister. Refer to Plastic Collar Quick Connect Fitting Service.
2	EVAP Emission Canister Fasteners (Qty: 2) **Caution:** Refer to Fastener Caution.
3	EVAP Emission Canister

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Evaporative Emission System Cleaning

Special Tools

GE 41413-200 Evaporative Emission System Tester

For equivalent regional tools, refer to Special Tools.

Inspection Procedure

Caution: Use the Evaporative Emission (EVAP) System Tester (EEST) GE 41413-A in order to provide a clean, dry, low pressure nitrogen gas source. Do not substitute any other pressurized source, gas or otherwise. Damage may result to the EVAP system, test equipment or cause a safety risk.

Note: Proceed with the following procedure only if referenced by an evaporative emission (EVAP) diagnostic or repair procedure.

1. Turn OFF the ignition.
2. Remove the EVAP canister purge valve. Refer to Evaporative Emission Canister Purge Solenoid Valve Replacement.
3. Lightly tap the EVAP canister purge valve on a hard surface.
4. Inspect for carbon particles exiting either of the vacuum ports.
   - If no carbon particles were detected, but a blockage was detected during a diagnostic procedure, install the original EVAP canister purge valve. Continue with the cleaning procedure.
   - If carbon particles are found during the inspection procedure, continue with the cleaning procedure.
   - If a diagnostic procedure directed you to replace the EVAP canister purge valve and no carbon particles were detected, replace the EVAP canister purge valve. Return to the published service procedure.

Cleaning Procedure

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
2. Remove the EVAP canister. Refer to Evaporative Emission Canister Replacement.
3. Turn OFF the main valve on the *GE 41413-200* evaporative emission system tester.
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.
13. Return to the diagnostic table that sent you here.

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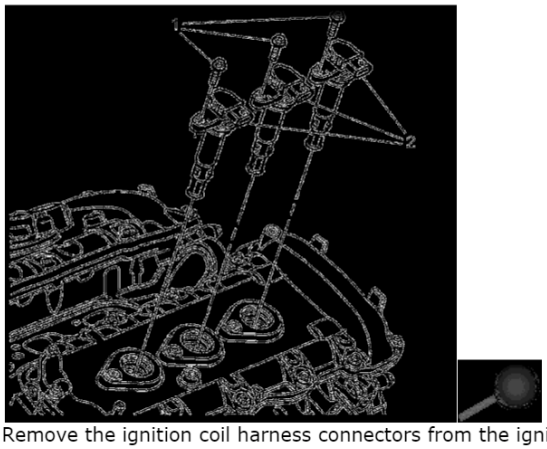
Ignition Coil Replacement - Bank 1 (LFW or LFX)

Removal Procedure

Warning: Refer to Safety Glasses and Compressed Air Warning.

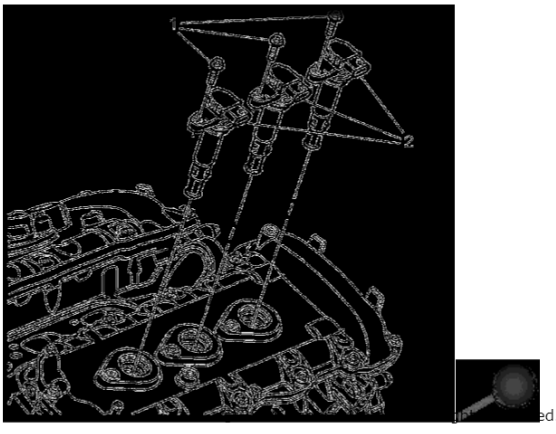
1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.



4. Remove the ignition coil harness connectors from the ignition coils.
5. Remove the ignition coil to camshaft cover retaining bolts (1).
6. Remove the ignition coils (2) from the vehicle.

Installation Procedure



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1. Install the ignition coils (2) to the vehicle.

   Caution: Refer to Fastener Caution.
2. Install the ignition coil to camshaft cover retaining bolts (1) and tighten to **10 N•m (89 lb in).**.
3. Install the ignition coil harness connectors to the ignition coils.
4. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
5. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

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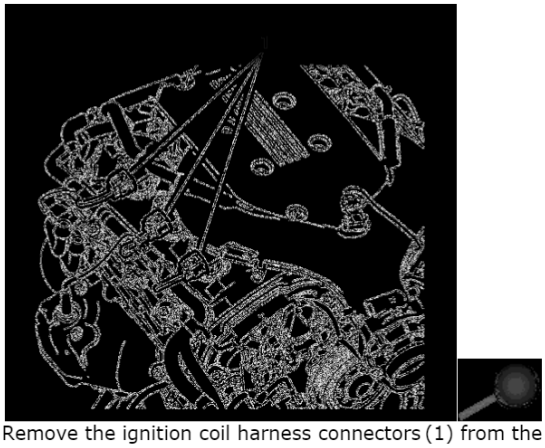
Ignition Coil Replacement - Bank 1 (LWR)

Removal Procedure

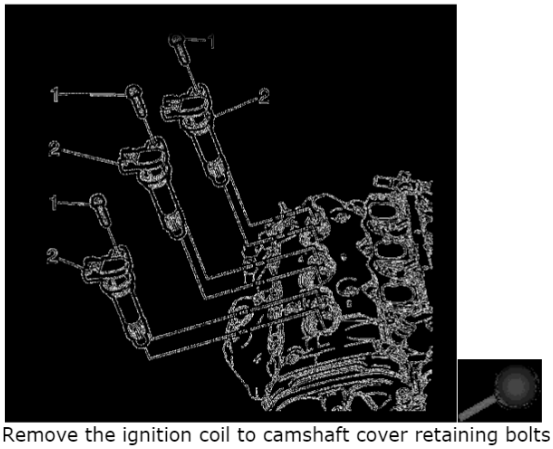
Warning: Refer to Safety Glasses and Compressed Air Warning.

1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the upper intake manifold. Refer to Upper Intake Manifold Replacement.



4. Remove the ignition coil harness connectors (1) from the ignition coils.

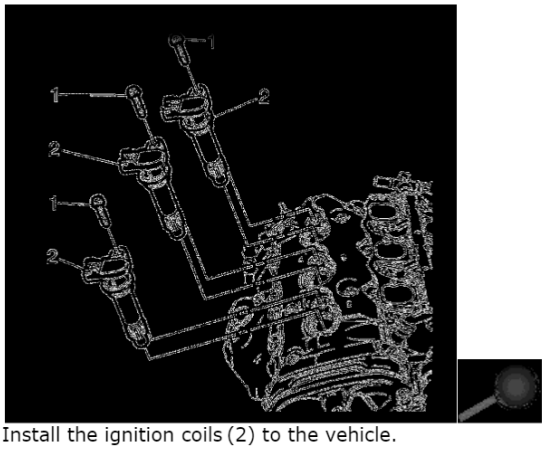


5. Remove the ignition coil to camshaft cover retaining bolts (1).
6. Remove the ignition coils (2) from the vehicle.

Installation Procedure

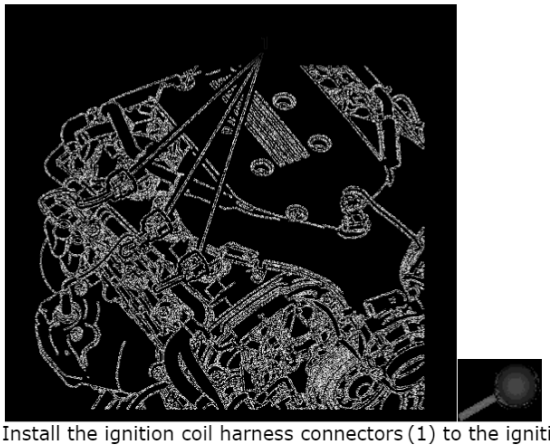
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1. Install the ignition coils (2) to the vehicle.

   Caution: Refer to Fastener Caution.
2. Install the ignition coil to camshaft cover retaining bolts (1) and tighten to **10 N•m (89 lb in).**.



3. Install the ignition coil harness connectors (1) to the ignition coils.
4. Install the upper intake manifold. Refer to Upper Intake Manifold Replacement.
5. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

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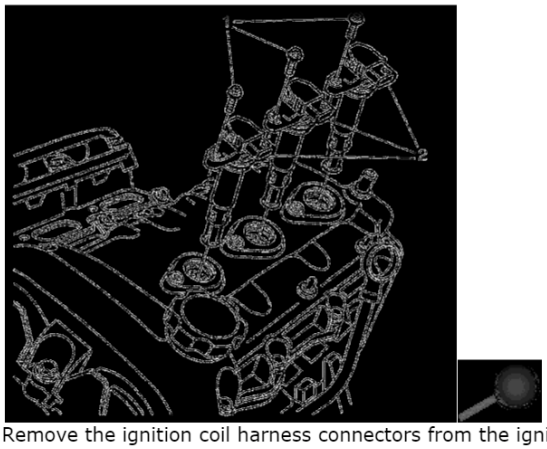
Ignition Coil Replacement - Bank 2 (LFW or LFX)

Removal Procedure

Warning: Refer to Safety Glasses and Compressed Air Warning.

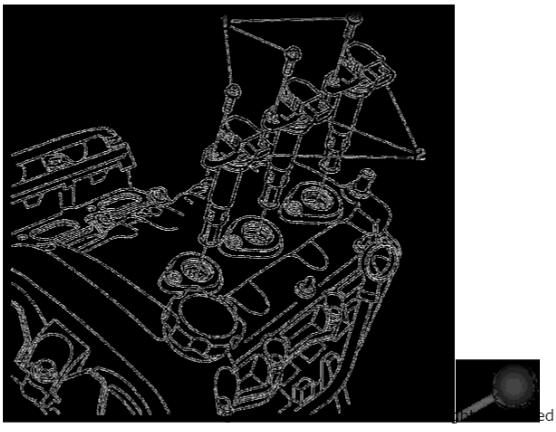
1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.



4. Remove the ignition coil harness connectors from the ignition coils.
5. Remove the ignition coil to camshaft cover retaining bolts (1).
6. Remove the ignition coils (2) from the vehicle.

Installation Procedure



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1. Install the ignition coils (2) to the vehicle.

   Caution: Refer to Fastener Caution.
2. Install the ignition coil to camshaft cover retaining bolts (1) and tighten to **10 N•m (89 lb in).**.
3. Install the ignition coil harness connectors to the ignition coils.
4. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
5. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

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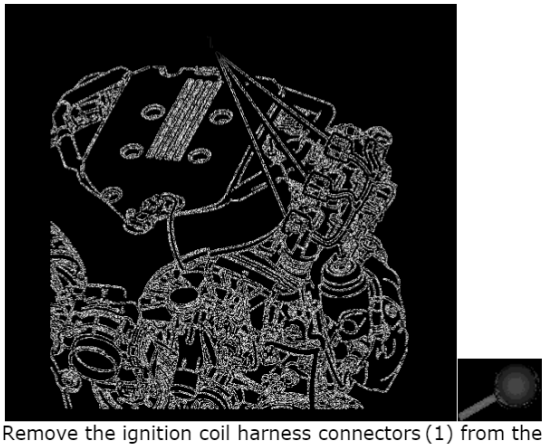
Ignition Coil Replacement - Bank 2 (LWR)

Removal Procedure

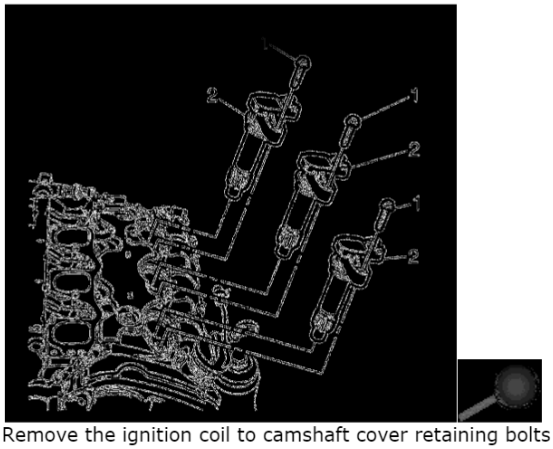
Warning: Refer to Safety Glasses and Compressed Air Warning.

1. Ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the upper intake manifold. Refer to Upper Intake Manifold Replacement.



4. Remove the ignition coil harness connectors (1) from the ignition coils.

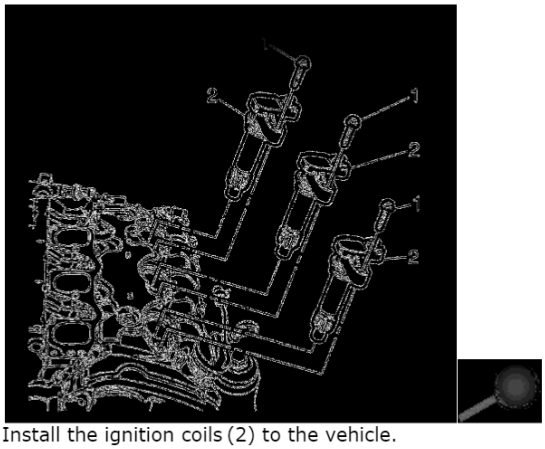


5. Remove the ignition coil to camshaft cover retaining bolts (1).
6. Remove the ignition coils (2) from the vehicle.

Installation Procedure

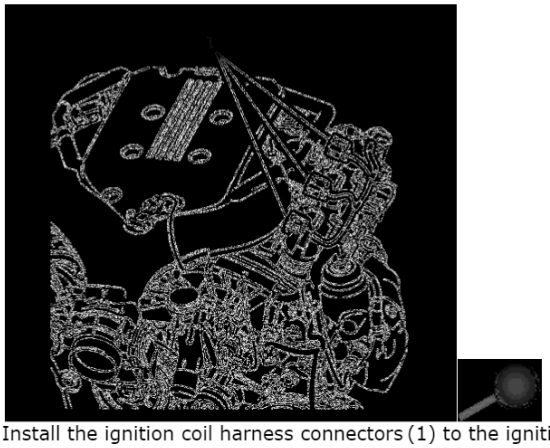
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1. Install the ignition coils (2) to the vehicle.

   Caution: Refer to Fastener Caution.
2. Install the ignition coil to camshaft cover retaining bolts (1) and tighten to **10 N•m (89 lb in).**.



3. Install the ignition coil harness connectors (1) to the ignition coils.
4. Install the upper intake manifold. Refer to Upper Intake Manifold Replacement.
5. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

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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.
  - 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.

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    - 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.

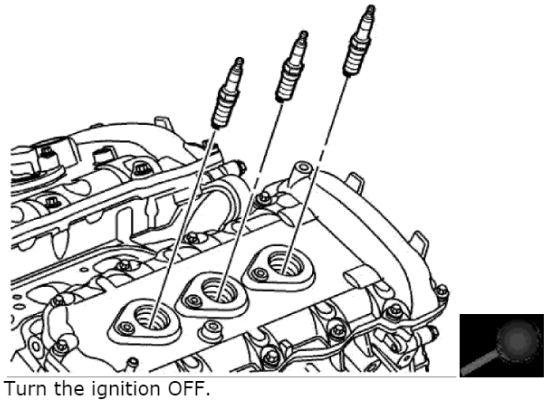
Spark Plug Visual Inspection

- 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.

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Spark Plug Replacement

Removal Procedure



1. Turn the ignition OFF.
2. Remove the ignition coil. Refer to Ignition Coil Replacement - Bank 1 and/or Ignition Coil Replacement - Bank 2.

   Warning: Refer to Safety Glasses and Compressed Air Warning.

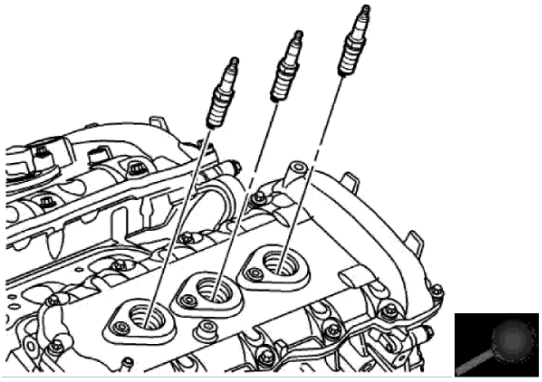
   Caution: Clean the spark plug recess area before removing the spark plug. Failure to do so could result in engine damage because of dirt or foreign material entering the cylinder head, or by the contamination of the cylinder head threads. The contaminated threads may prevent the proper seating of the new plug. Use a thread chaser to clean the threads of any contamination.
3. Use compressed air in order to remove debris from the spark plug cavity.

   Caution: Allow the engine to cool before removing the spark plugs. Attempting to remove the spark plugs from a hot engine may cause the plug threads to seize, causing damage to cylinder head threads.
4. Remove the spark plug.

Installation Procedure

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Caution: Use only the spark plugs specified for use in the vehicle. Do not install spark plugs that are either hotter or colder than those specified for the vehicle. Installing spark plugs of another type can severely damage the engine.

Caution: Check the gap of all new and reconditioned spark plugs before installation. The pre-set gaps may have changed during handling. Use a round feeler gauge to ensure an accurate check. Installing the spark plugs with the wrong gap can cause poor engine performance and may even damage the engine.

1. Ensure that the spark plug gap is equivalent to the spark plug gap specification. Refer to Ignition System Specifications.

   Caution: Be sure that the spark plug threads smoothly into the cylinder head and the spark plug is fully seated. Use a thread chaser, if necessary, to clean threads in the cylinder head. Cross-threading or failing to fully seat the spark plug can cause overheating of the plug, exhaust blow-by, or thread damage.
2. Install the spark plug and tighten to **20 N•m (15 lb ft)**.
3. Install the ignition coil. Refer to Ignition Coil Replacement - Bank 1 and/or Ignition Coil Replacement - Bank 2.

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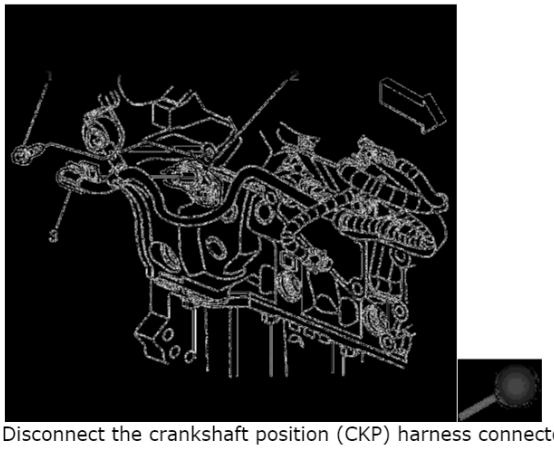
Crankshaft Position Sensor Replacement (LFW or LFX)

Removal Procedure

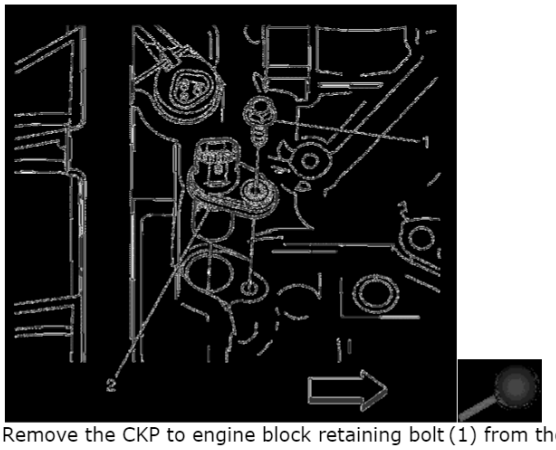
Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

Warning: Refer to Safety Glasses Warning.

1. Turn the ignition OFF.
   Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.



2. Disconnect the crankshaft position (CKP) harness connector (3) from the CKP.

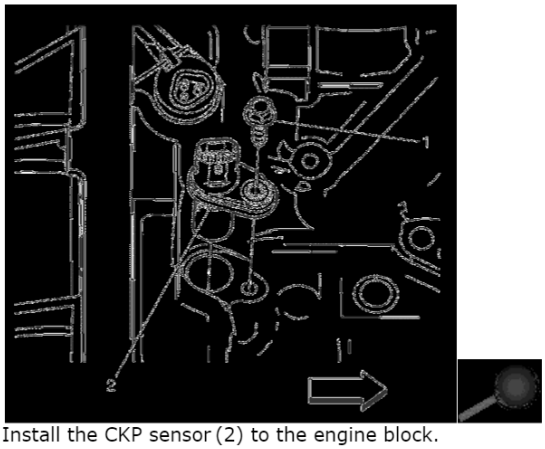


3. Remove the CKP to engine block retaining bolt (1) from the CKP sensor (2).
4. Remove the CKP sensor (2) from the engine block.

Installation Procedure

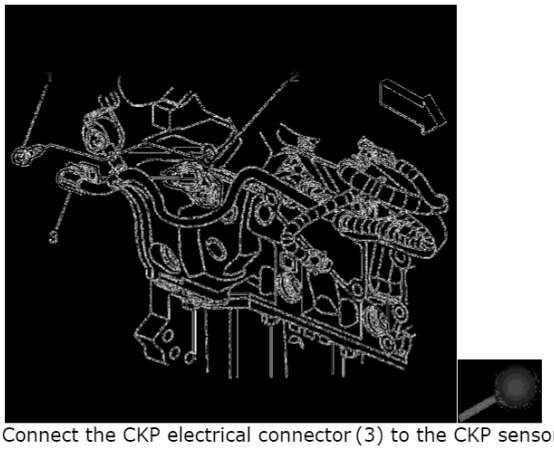
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1. Install the CKP sensor (2) to the engine block.

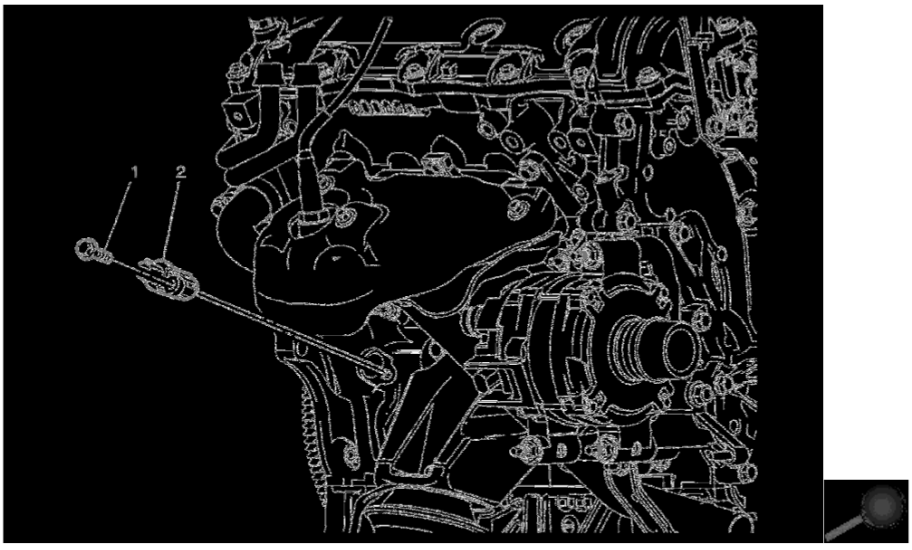
   Caution: Refer to Fastener Caution.
2. Install the CKP sensor to engine block retaining bolt (1) and tighten to **10 N•m (89 lb in)**.



3. Connect the CKP electrical connector (3) to the CKP sensor.
4. Lower the vehicle.

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Crankshaft Position Sensor Replacement (LWR)



Crankshaft Position Sensor Replacement

Callout	Component Name
Preliminary Procedure 1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle. 2. Remove the oil pan shield. Refer to Oil Pan Shield Replacement 3. Disconnect the crankshaft position sensor electrical connector.	
1	Crankshaft Position Sensor Fasteners. **Caution:** Refer to Fastener Caution. **Tighten** 10 N•m (89 lb in)
2	Crankshaft Position Sensor.

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Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust (LWR)



Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust

Callout	Component Name
Preliminary Procedure Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.	
1	Camshaft Position Sensor Fastener. **Caution:** Refer to Fastener Caution. **Procedure** Disconnect the electrical connector. **Tighten** 10 N•m (89 lb in)
2	Camshaft Position Sensor.

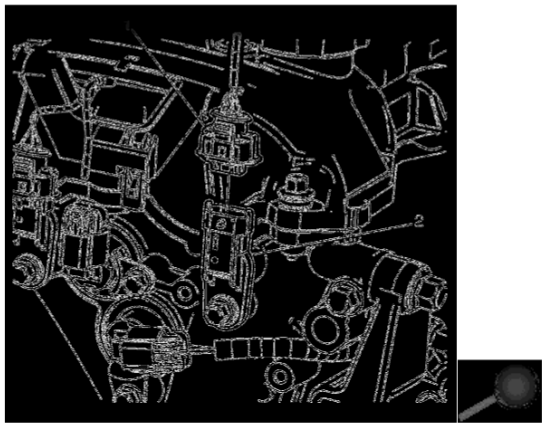
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Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust (LFW or LFX)

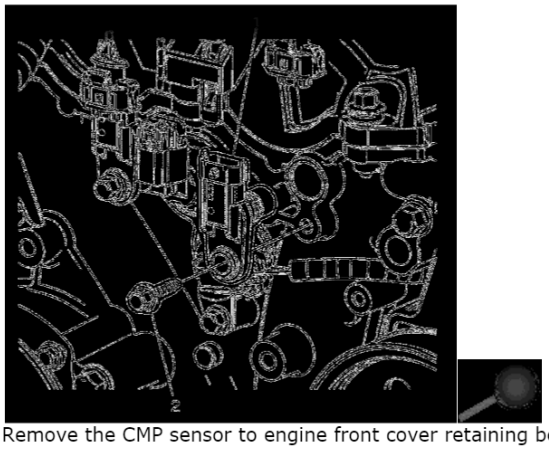
Removal Procedure

1. Ignition OFF.
2. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement.



Warning: Refer to Safety Glasses Warning.

3. Use compressed air to remove debris from the CMP sensor and surrounding cavities.
4. Remove the CMP sensor electrical connector (1) from the CMP sensor (2).

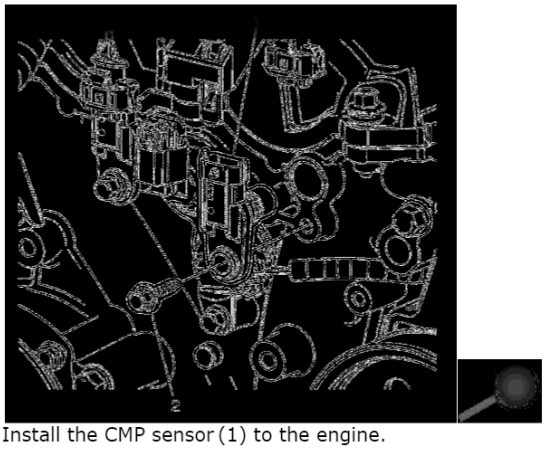


5. Remove the CMP sensor to engine front cover retaining bolt (2).
6. Remove the CMP sensor (1) from the engine.

Installation Procedure

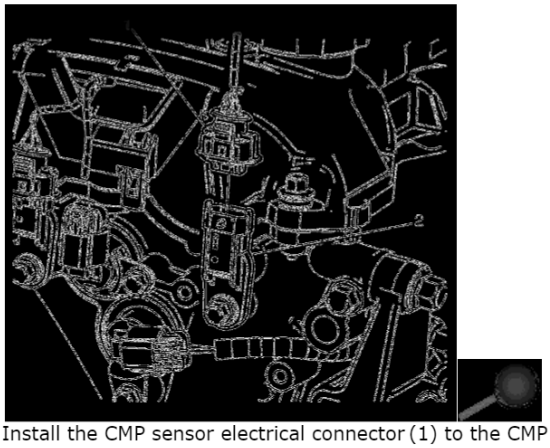
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1. Install the CMP sensor (1) to the engine.

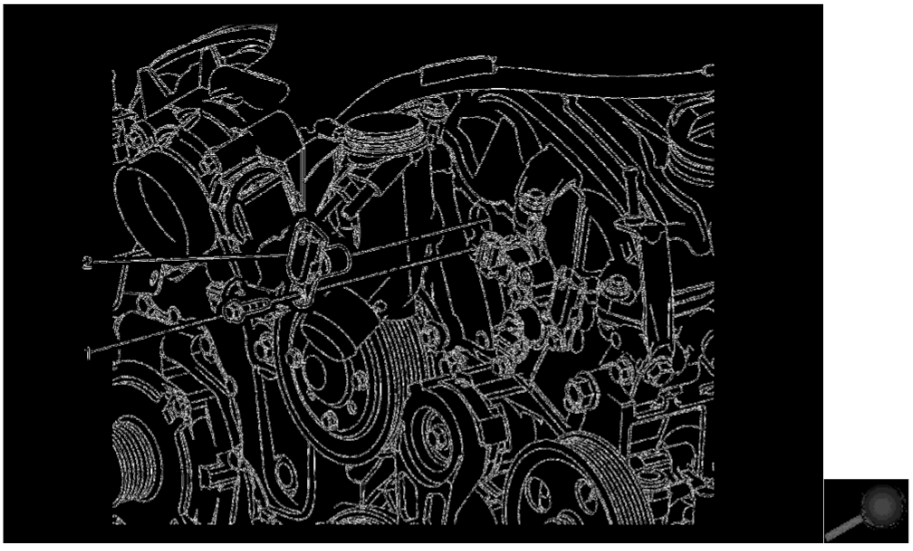
   Caution: Refer to Fastener Caution.
2. Install the CMP sensor (1) to engine front cover retaining bolt (2) and tighten to **10 N•m (89 lb in)**.



3. Install the CMP sensor electrical connector (1) to the CMP sensor (2).
4. Install the intake manifold cover. Refer to Intake Manifold Cover Replacement.

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Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake (LWR)



Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake

Callout	Component Name
Preliminary Procedure 1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 2. Remove the water outlet housing. Refer to Water Outlet Replacement	
1	Camshaft Position Sensor Fastener. **Caution:** Refer to Fastener Caution. **Procedure** Disconnect the electrical connector. **Tighten** 10 N•m (89 lb in)
2	Camshaft Position Sensor.

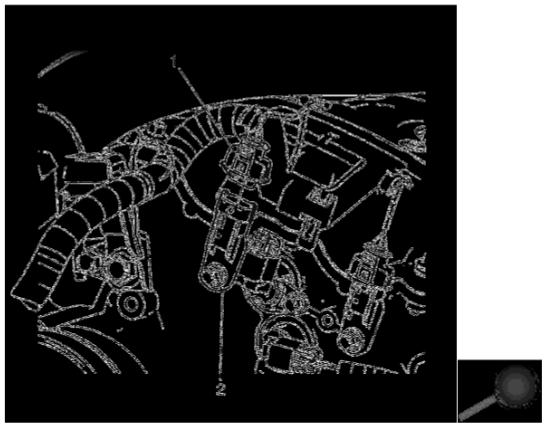
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Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake (LFW or LFX)

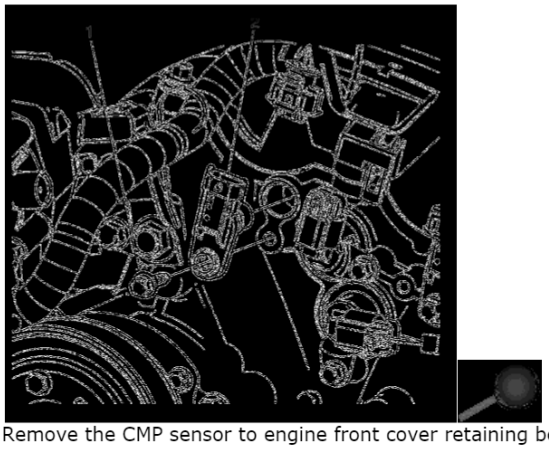
Removal Procedure

1. Ignition OFF.
2. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement.



Warning: Refer to Safety Glasses Warning.

3. Use compressed air to remove debris from the CMP sensor and surrounding cavities.
4. Remove the camshaft position (CMP) sensor electrical connector (1) from the CMP sensor (2).

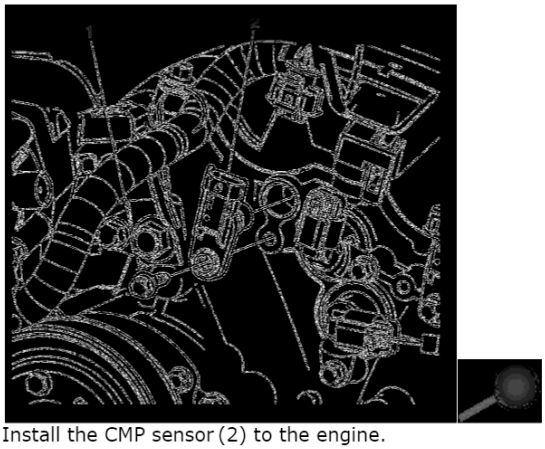


5. Remove the CMP sensor to engine front cover retaining bolt (1).
6. Remove the CMP sensor (2) from the engine.

Installation Procedure

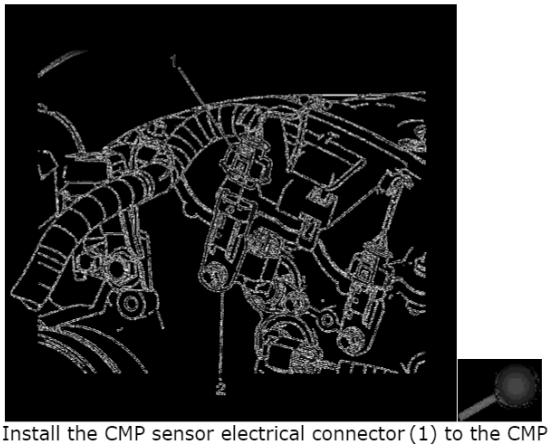
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1. Install the CMP sensor (2) to the engine.

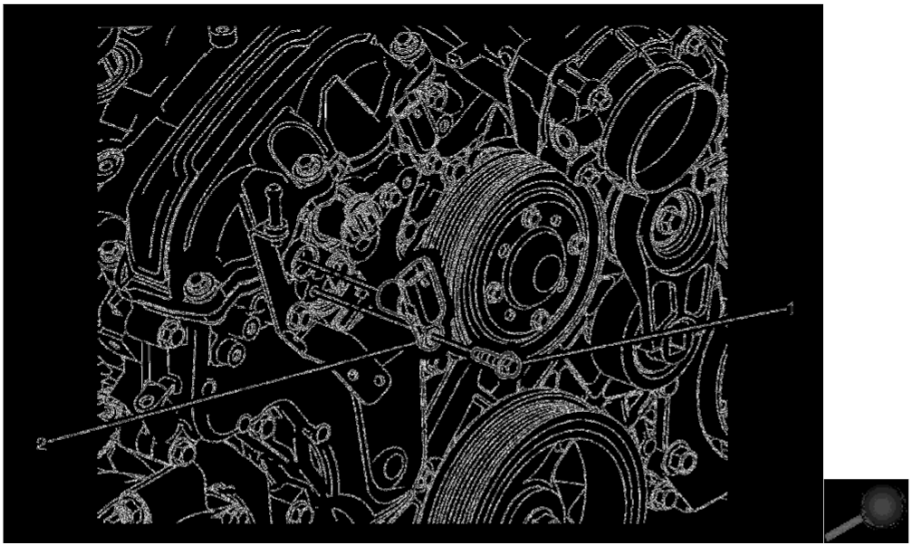
   Caution: Refer to Fastener Caution.
2. Install the CMP sensor to engine front cover retaining bolt (1) and tighten to **10 N•m (89 lb in)**.



3. Install the CMP sensor electrical connector (1) to the CMP sensor (2).
4. Install the intake manifold cover. Refer to Intake Manifold Cover Replacement.

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Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust (LWR)



Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust

Callout	Component Name
Preliminary Procedure Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.	
1	Camshaft Position Sensor Fastener. **Caution:** Refer to Fastener Caution. **Procedure** Disconnect the electrical connector. **Tighten** 10 N•m (89 lb in)
2	Camshaft Position Sensor.

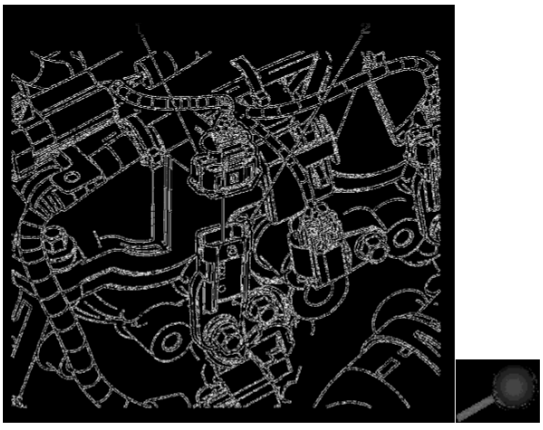
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Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust (LFW or LFX)

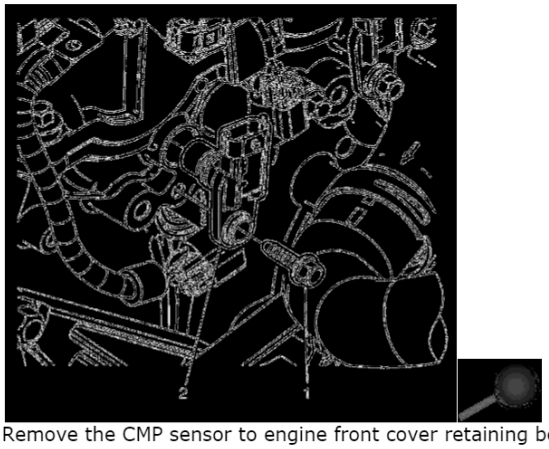
Removal Procedure

1. Turn the ignition OFF.
2. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement.
3. Reposition the vacuum brake booster hose.



Warning: Refer to Safety Glasses Warning.

4. Use compressed air to remove debris from the CMP sensor and surrounding cavities.
5. Remove the camshaft position (CMP) sensor electrical connector (1) from the CMP sensor (2).

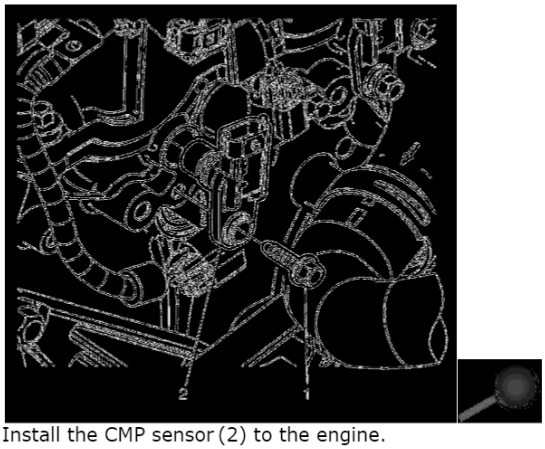


6. Remove the CMP sensor to engine front cover retaining bolt (1).
7. Remove the CMP sensor (2) from the engine.

Installation Procedure

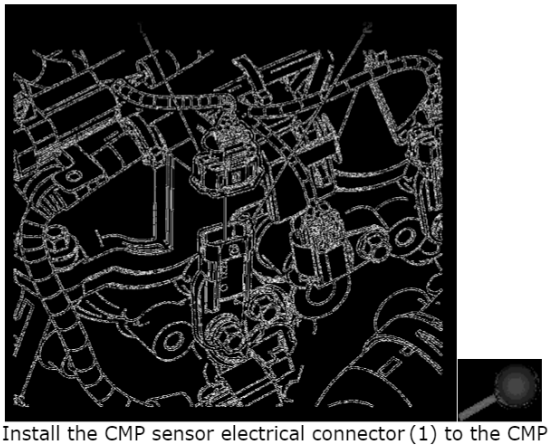
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1. Install the CMP sensor (2) to the engine.

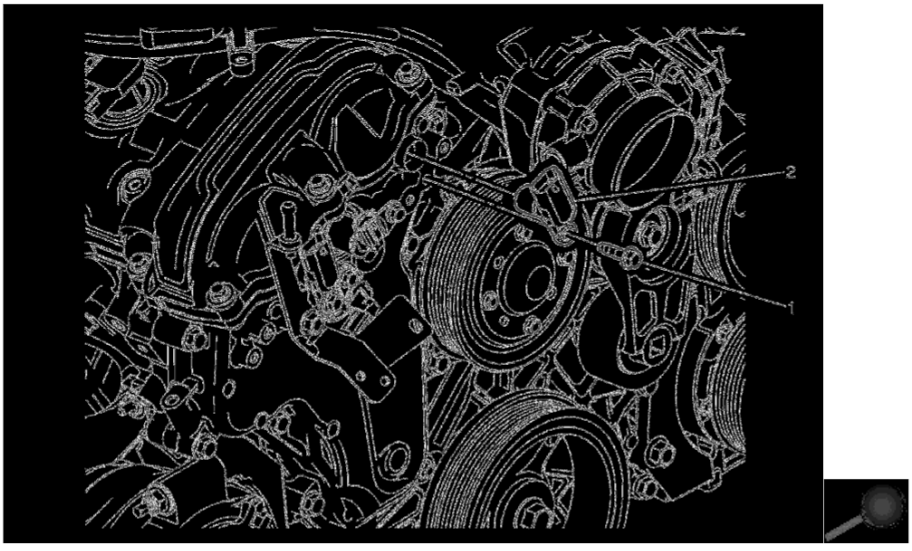
   Caution: Refer to Fastener Caution.
2. Install the CMP sensor to engine front cover retaining bolt (1) and tighten to **10 N•m (89 lb in)**.



3. Install the CMP sensor electrical connector (1) to the CMP sensor (2).
4. Reposition the vacuum brake booster hose.
5. Install the intake manifold cover. Refer to Intake Manifold Cover Replacement.

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Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake (LWR)



Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake

Callout	Component Name
Preliminary Procedure Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.	
1	Camshaft Position Sensor Fastener. **Caution:** Refer to Fastener Caution. **Procedure** Disconnect the electrical connector. **Tighten** 10 N•m (89 lb in)
2	Camshaft Position Sensor.

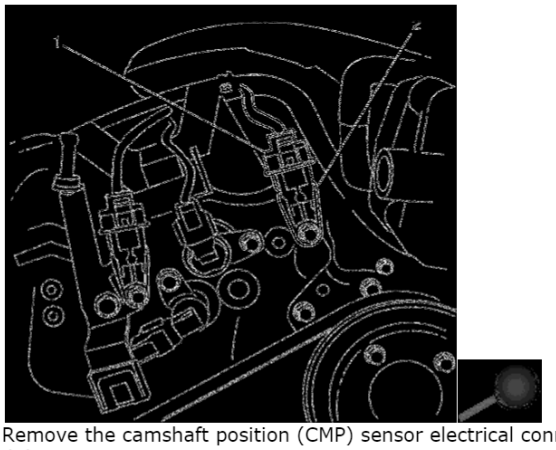
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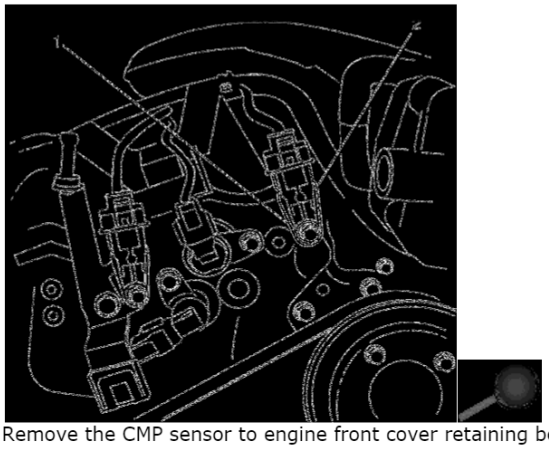
Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake (LFW or LFX)

Removal Procedure

1. Turn the ignition OFF.
2. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement.
3. Reposition the vacuum brake booster hose.



4. Remove the camshaft position (CMP) sensor electrical connector (1) from the CMP sensor (2).

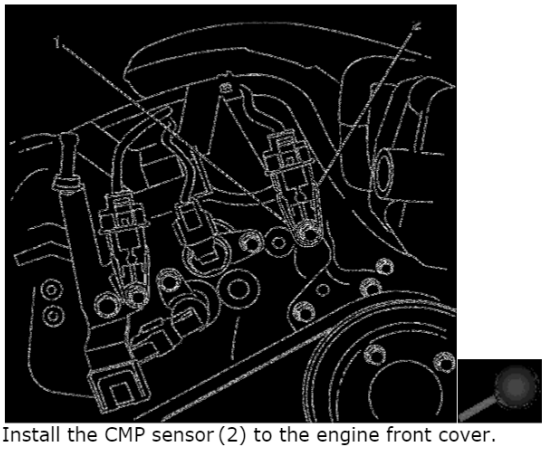


5. Remove the CMP sensor to engine front cover retaining bolt (1).
6. Remove the CMP sensor from the engine front cover.

Installation Procedure

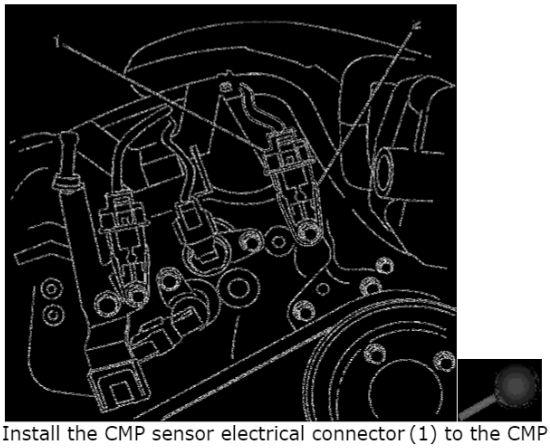
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1. Install the CMP sensor (2) to the engine front cover.

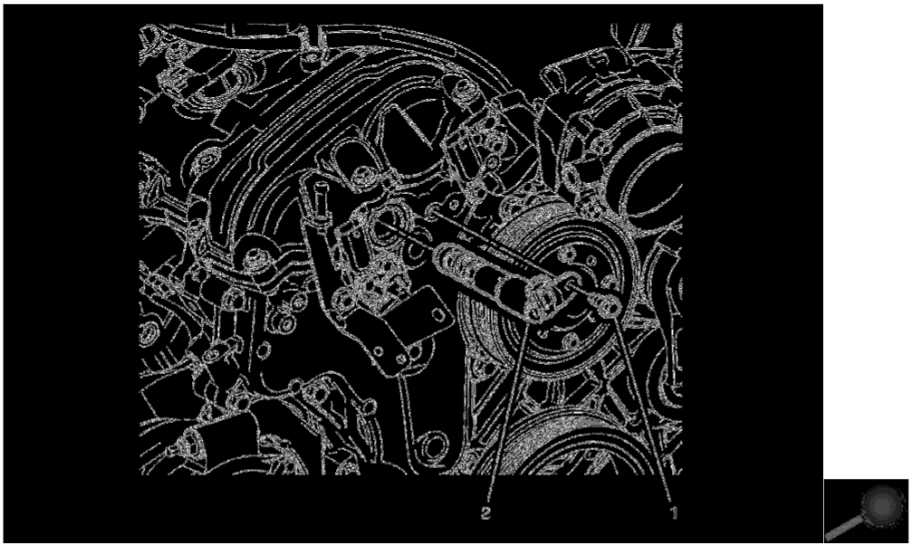
   Caution: Refer to Fastener Caution.
2. Install the CMP sensor to engine front cover retaining bolt (1) and tighten to **10 N•m (89 lb in)**.



3. Install the CMP sensor electrical connector (1) to the CMP sensor.
4. Reposition the vacuum brake booster hose.
5. Install the intake manifold cover. Refer to Intake Manifold Cover Replacement.

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Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LWR)



Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake

Callout	Component Name
Preliminary Procedure 1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 2. Reposition intake manifold sight shield bracket.	
1	Camshaft Position Actuator Solenoid Valve Fastener. **Caution:** Refer to Fastener Caution. **Procedure** Disconnect the electrical connector. **Tighten** 10 N•m (89 lb in)
2	Camshaft Position Actuator Solenoid Valve.

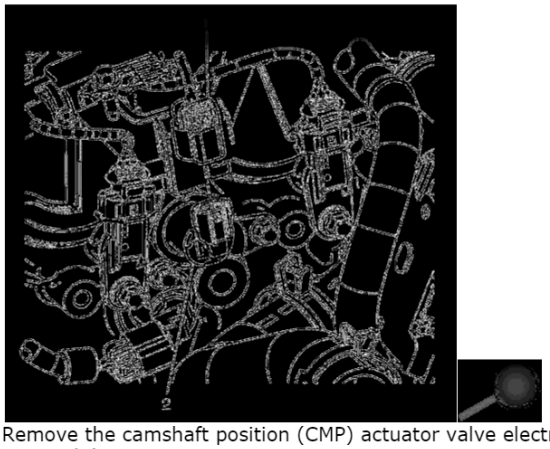
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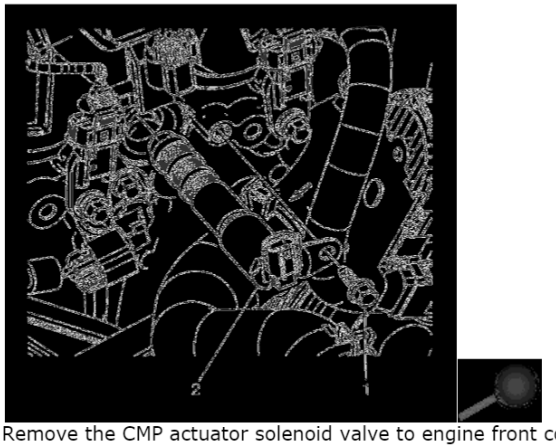
Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LFW or LFX)

Removal Procedure

1. Turn the ignition OFF.
2. Remove the power brake booster auxiliary pump. Refer to Power Brake Booster Pump Replacement.



3. Remove the camshaft position (CMP) actuator valve electrical connector (1) from the CMP sensor (2).



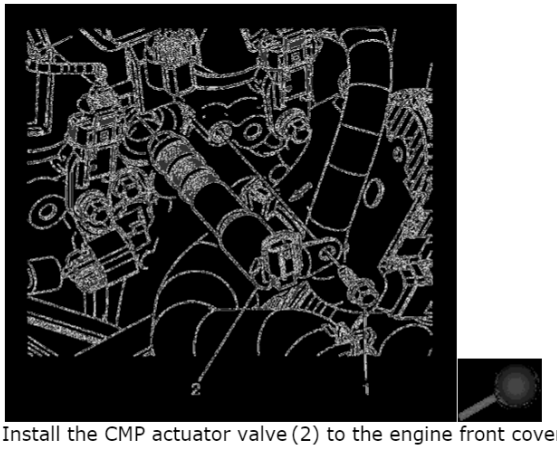
4. Remove the CMP actuator solenoid valve to engine front cover retaining bolt (1).
5. Remove the CMP actuator valve (2) from the engine front cover.
6. Inspect the CMP actuator valve seal and replace as necessary.

Installation Procedure

1. Inspect the CMP actuator valve seal for damage. Replace the seal if necessary.

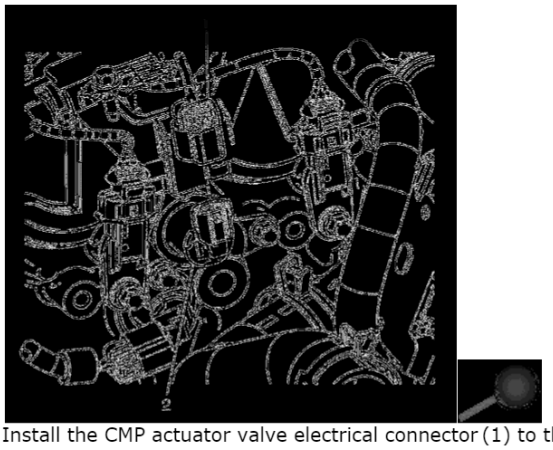
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2. Install the CMP actuator valve (2) to the engine front cover.

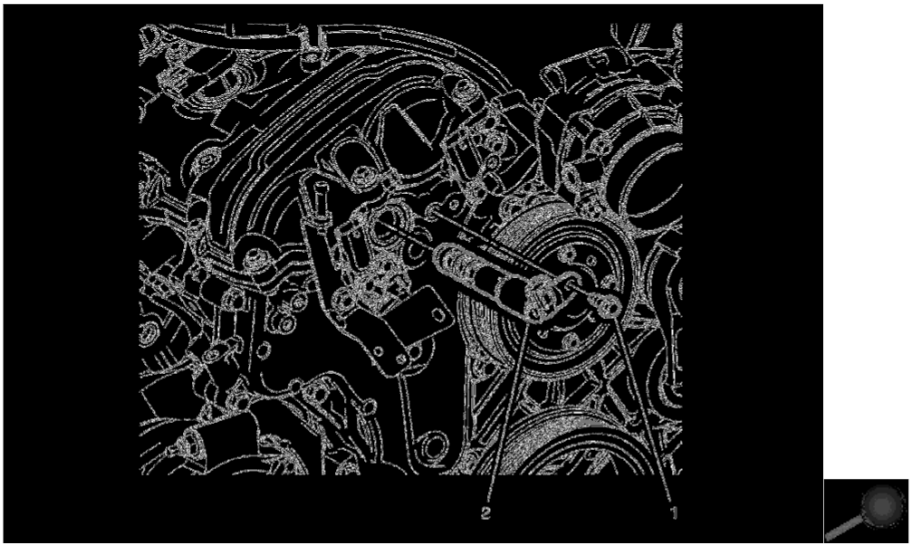
   Caution: Refer to Fastener Caution.
3. Install the CMP actuator solenoid valve to engine front cover retaining bolt (1) and tighten to **9 N•m (80 lb in)**.



4. Install the CMP actuator valve electrical connector (1) to the CMP sensor (2).
5. Install the power brake booster auxiliary pump. Refer to Power Brake Booster Pump Replacement.

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Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LWR)



Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust

Callout	Component Name
Preliminary Procedure 1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 2. Reposition intake manifold sight shield bracket.	
1	Camshaft Position Actuator Solenoid Valve Fastener. **Caution:** Refer to Fastener Caution. **Procedure** Disconnect the electrical connector. **Tighten** 10 N•m (89 lb in)
2	Camshaft Position Actuator Solenoid Valve.

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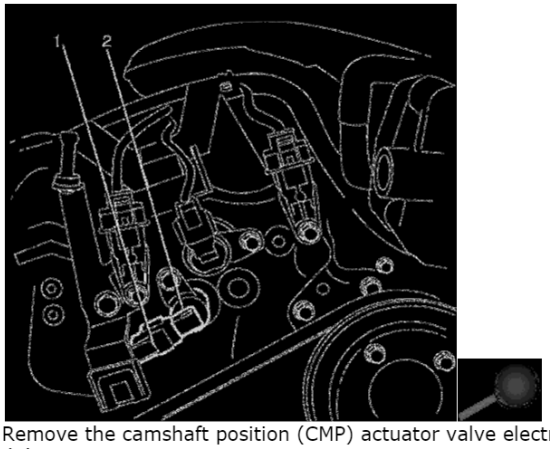
Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LFW or LFX)

Removal Procedure

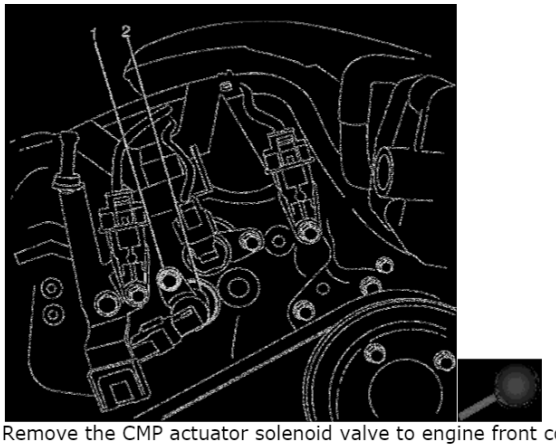
Warning: Refer to Safety Glasses Warning.

1. Turn the ignition OFF.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the power brake booster auxiliary pump. Refer to Power Brake Booster Pump Replacement.



4. Remove the camshaft position (CMP) actuator valve electrical connector (1) from the CMP (2).



5. Remove the CMP actuator solenoid valve to engine front cover retaining bolt (1).

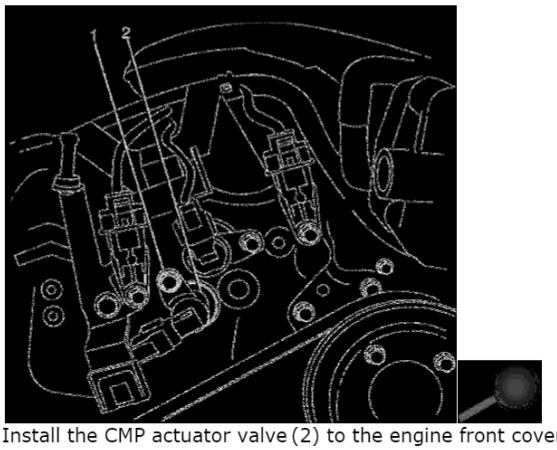
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6. Remove the CMP actuator valve (2).
7. Inspect the CMP actuator valve seal and replace as necessary.

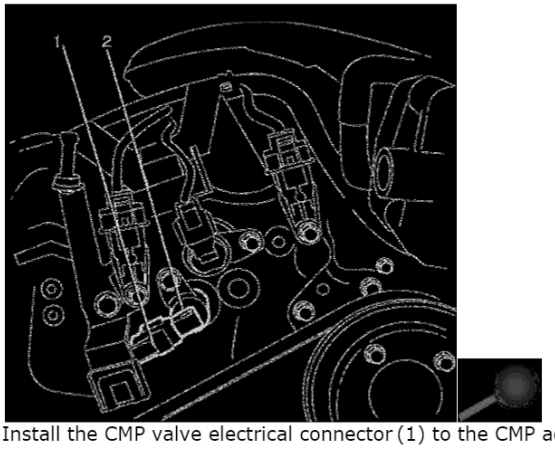
Installation Procedure

1. Inspect the CMP actuator valve seal for damage. Replace the seal if necessary.



2. Install the CMP actuator valve (2) to the engine front cover.

   Caution: Refer to Fastener Caution.
3. Install the CMP actuator solenoid valve to engine front cover retaining bolt (1).
   Tighten
   Tighten the bolt to 9 N•m (80 lb in).



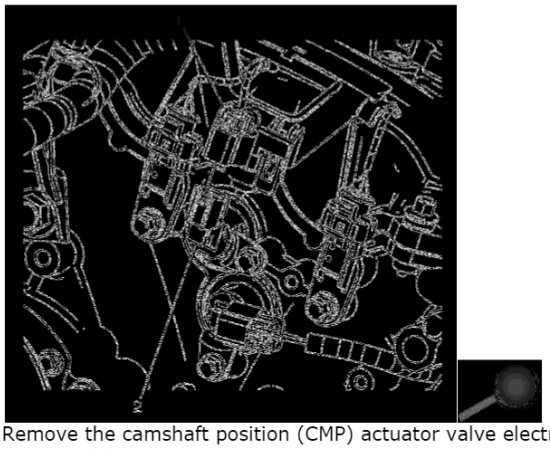
4. Install the CMP valve electrical connector (1) to the CMP actuator valve.
5. Install the power brake booster auxiliary pump. Refer to Power Brake Booster Pump Replacement.
6. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

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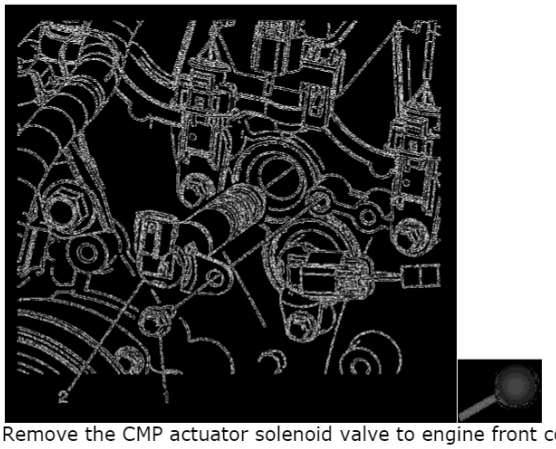
Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LFW or LFX)

Removal Procedure

1. Turn the ignition OFF.
2. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement.



3. Remove the camshaft position (CMP) actuator valve electrical connector (1) from the CMP actuator (2).



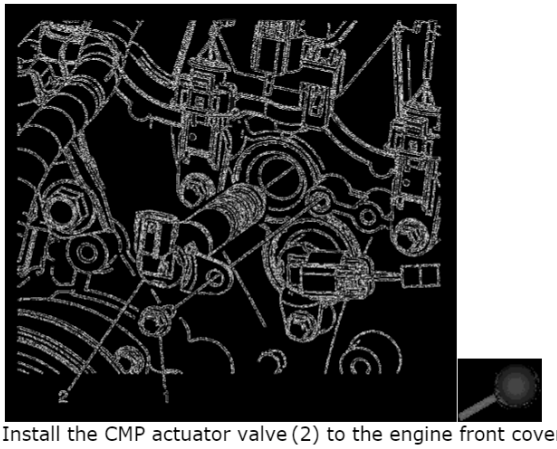
4. Remove the CMP actuator solenoid valve to engine front cover retaining bolt (1).
5. Remove the CMP actuator valve (2) from the engine front cover.
6. Inspect the CMP actuator valve seal for damage and replace as necessary.

Installation Procedure

1. Inspect the CMP actuator valve seal for damage. Replace the seal if necessary.

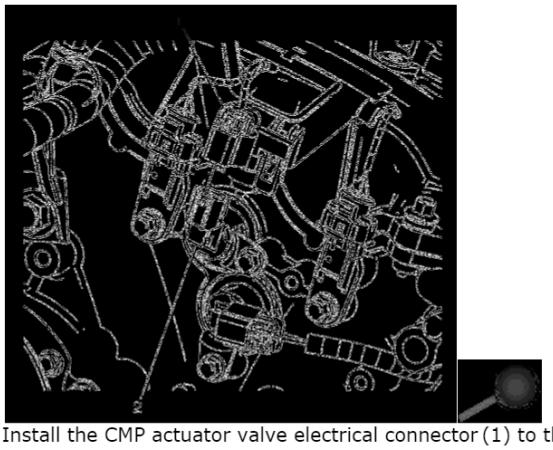
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2. Install the CMP actuator valve (2) to the engine front cover.

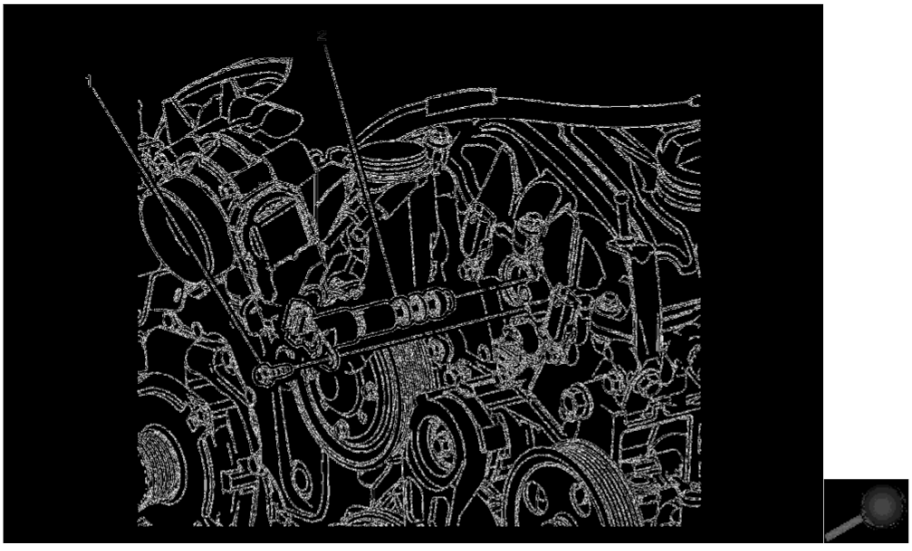
   Caution: Refer to Fastener Caution.
3. Install the CMP actuator solenoid valve to engine front cover retaining bolt (1) and tighten to **9 N•m (80 lb in)**.



4. Install the CMP actuator valve electrical connector (1) to the CMP actuator valve (2).
5. Install the intake manifold cover. Refer to Intake Manifold Cover Replacement.

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Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LWR)



Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake

Callout	Component Name
Preliminary Procedure Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.	
1	Camshaft Position Actuator Solenoid Valve Fastener. **Caution:** Refer to Fastener Caution. **Procedure** Disconnect the electrical connector. **Tighten** 10 N•m (89 lb in)
2	Camshaft Position Actuator Solenoid Valve.

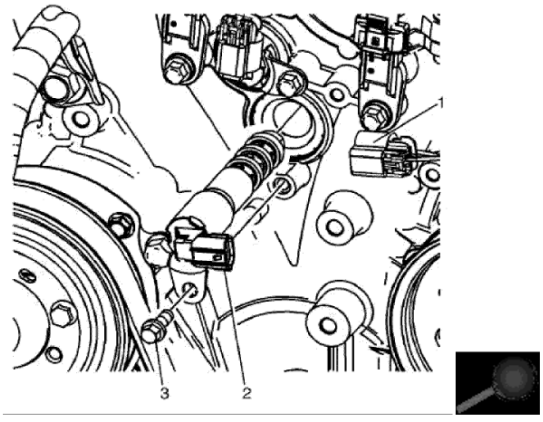
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Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LFW or LFX)

Removal Procedure

1. Ignition OFF.
2. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement.



Warning: Refer to Safety Glasses Warning.

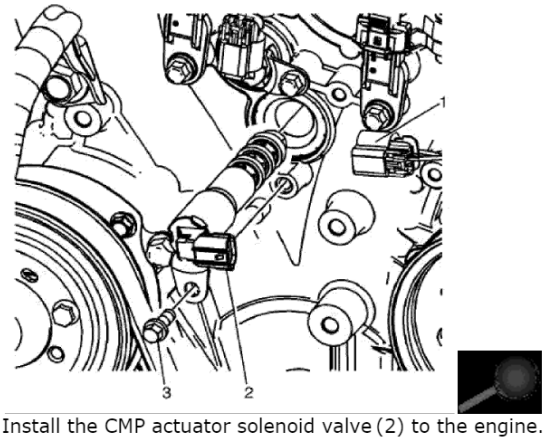
3. Use compressed air to remove debris from the camshaft position (CMP) actuator solenoid valve and surrounding cavities.
4. Remove the CMP actuator solenoid valve electrical connector (1) from the CMP actuator solenoid valve (2).
5. Remove the CMP actuator solenoid valve to engine front cover retaining bolt (3).
6. Remove the CMP actuator solenoid valve (2) from the engine.

Installation Procedure

1. Inspect the CMP actuator solenoid valve seal for damage. Replace the CMP actuator solenoid valve seal if necessary.

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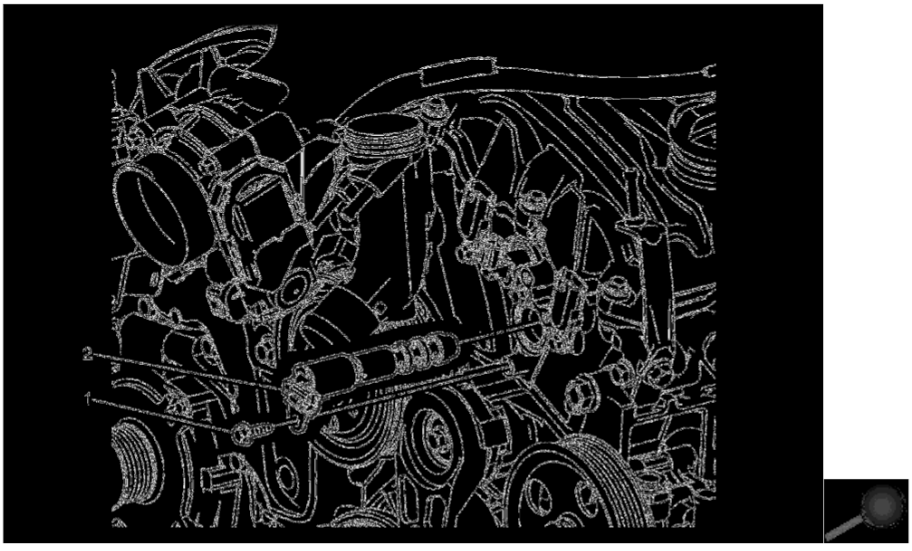


2. Install the CMP actuator solenoid valve (2) to the engine.

   Caution: Refer to Fastener Caution.
3. Install the CMP actuator solenoid valve to engine front cover retaining bolt (3) and tighten to **9 N•m (80 lb in)**.
4. Connect the CMP actuator solenoid valve electrical connector (1) to the CMP actuator solenoid valve (2).
5. Install the intake manifold cover. Refer to Intake Manifold Cover Replacement.

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Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LWR)



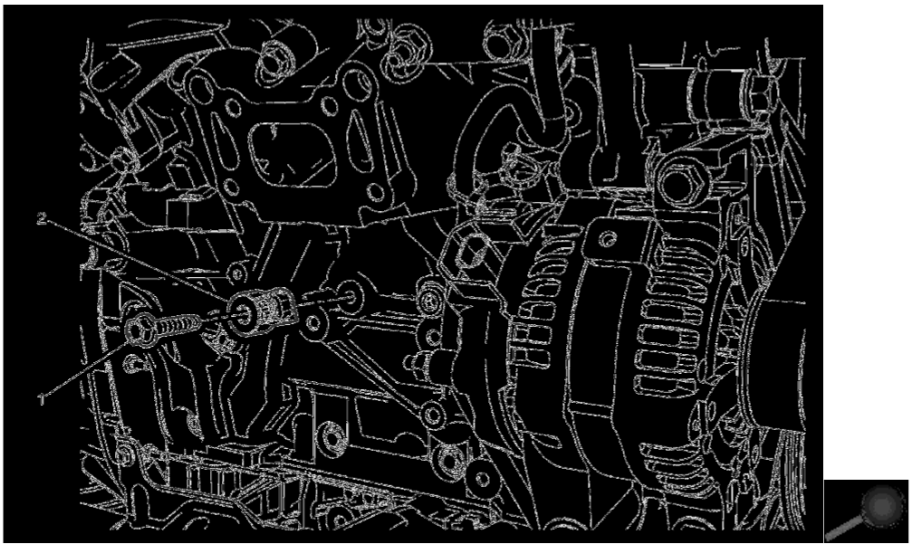
Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust

Callout	Component Name
Preliminary Procedure Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.	
1	Camshaft Position Actuator Solenoid Valve Fastener. **Caution:** Refer to Fastener Caution. **Procedure** Disconnect the electrical connector. **Tighten** 10 N•m (89 lb in)
2	Camshaft Position Actuator Solenoid Valve.

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Knock Sensor Replacement - Bank 1



Knock Sensor Replacement - Bank 1

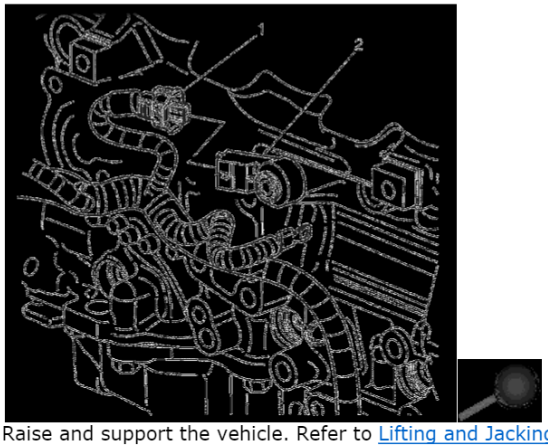
Callout	Component Name
Preliminary Procedures 1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle. 2. Remove the right side catalytic converter. Refer to Catalytic Converter Replacement - Right Side.	
1	Knock Sensor Fastener **Tighten** 23 N•m (17 lb ft)
2	Knock Sensor **Procedure** Disconnect the knock sensor electrical connector.

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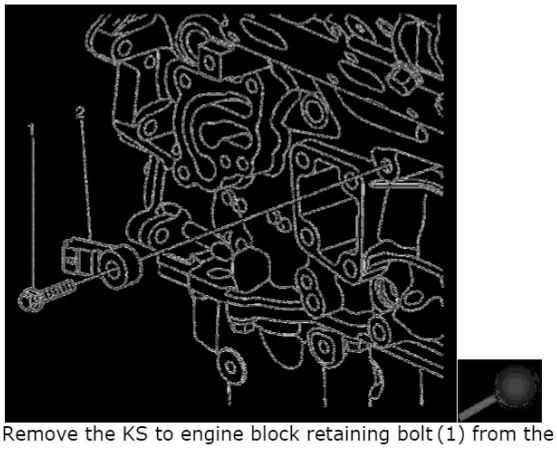
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Knock Sensor Replacement - Bank 2 (LFW or LFX)

Removal Procedure



1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
2. Remove the knock sensor (KS) electrical connector (1) from the KS (2).

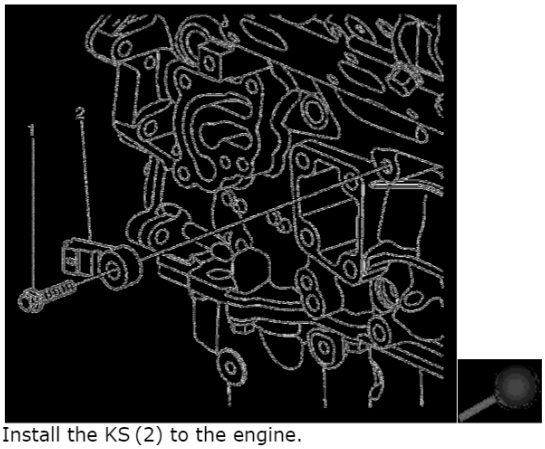


3. Remove the KS to engine block retaining bolt (1) from the KS.
4. Remove the KS (2) from the engine.

Installation Procedure

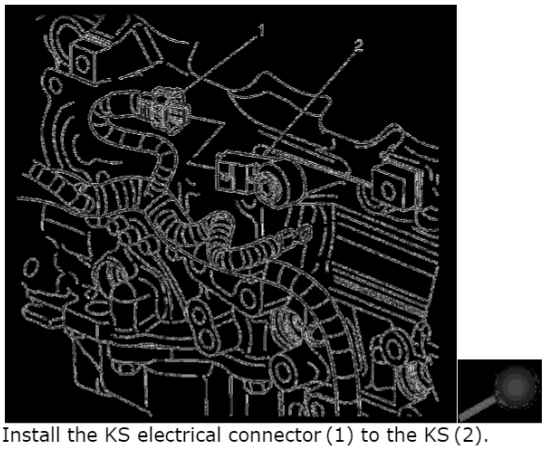
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1. Install the KS (2) to the engine.

   Caution: Refer to Fastener Caution.
2. Install the KS to engine block retaining bolt (1) and tighten to **23 N•m (17 lb ft)**.



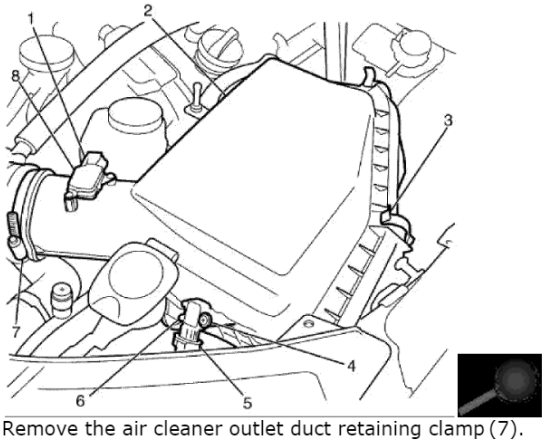
3. Install the KS electrical connector (1) to the KS (2).
4. Lower the vehicle.

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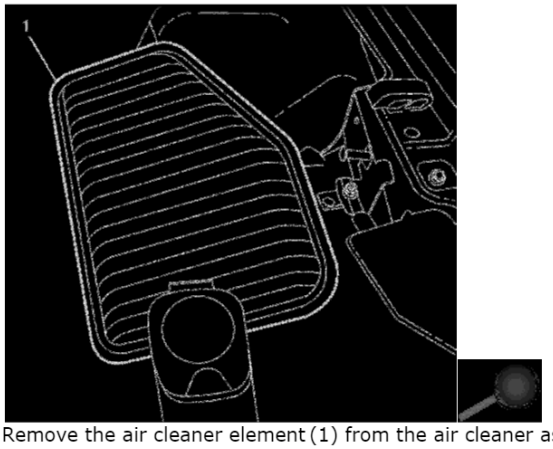
Air Cleaner Element Replacement (LWR)

Removal Procedure

1. Ignition OFF.



2. Remove the air cleaner outlet duct retaining clamp (7).
3. Disconnect the mass air flow (MAF) sensor harness connector (1) from the MAF sensor (8).
4. Disconnect the throttle intake absolute pressure (TIAP) sensor harness connector (5) from the TIAP sensor (6).
5. Detach all the air cleaner lower housing retaining clips (3) from the air cleaner upper housing (2).
6. Remove the air cleaner upper housing (2) from the air cleaner assembly.

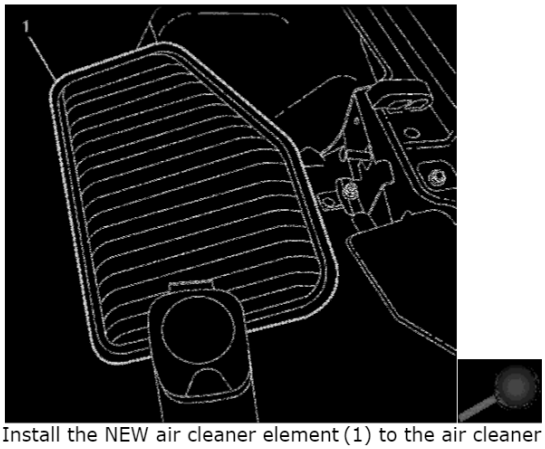


7. Remove the air cleaner element (1) from the air cleaner assembly.

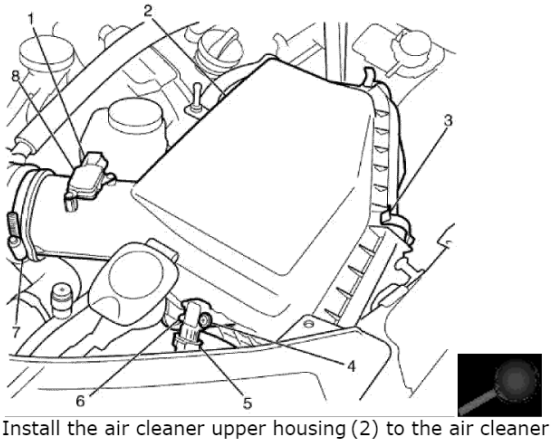
Installation Procedure

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1. Install the NEW air cleaner element (1) to the air cleaner assembly.



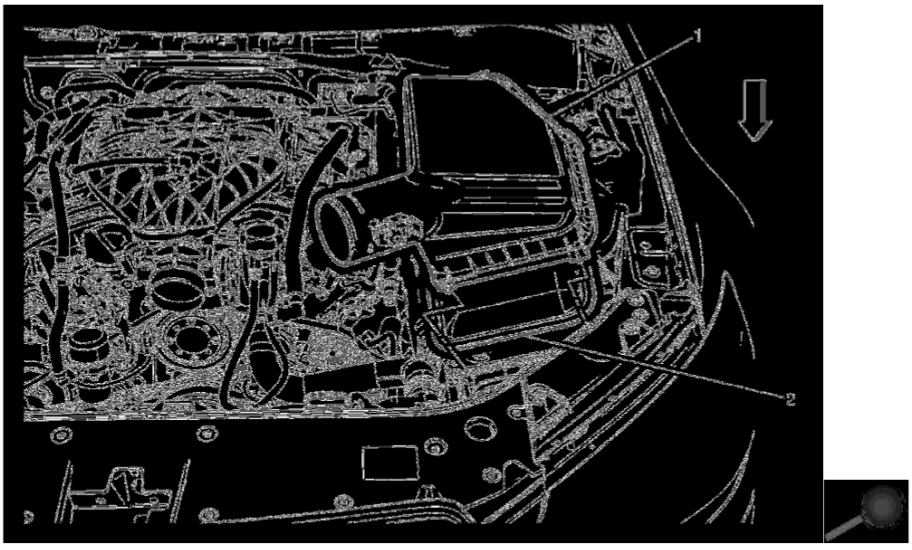
2. Install the air cleaner upper housing (2) to the air cleaner assembly.

   Note: Listen for an audible click to confirm correct installation of the air cleaner lower housing retaining clips (3).
3. Install the air cleaner lower housing retaining clips (3) to the upper air cleaner housing (2).
4. Connect the TIAP sensor harness connector (5) to the TIAP sensor (6).
5. Connect the MAF sensor harness connector (1) to the MAF sensor (8).

   Caution: Refer to Fastener Caution.
6. Install the air cleaner outlet duct retaining clamp (7) and tighten to **2 N•m (18 lb in)**.

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Air Cleaner Element Replacement (LFW or LFX)



Air Cleaner Element Replacement

Callout	Component Name
Preliminary Procedures 1. Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement. 2. Disconnect the electrical connector.	
1	Air Cleaner Upper Housing **Procedure** Detach all the air cleaner lower housing retaining clips from the air cleaner upper housing.
2	Air Cleaner Element

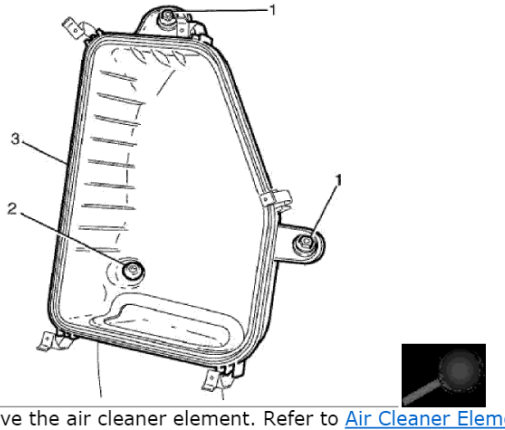
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Air Cleaner Assembly Replacement

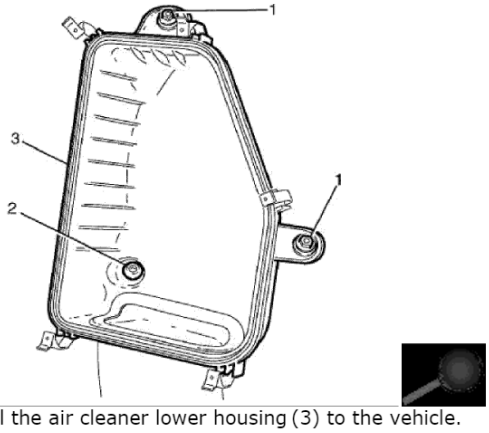
Removal Procedure

1. Ignition OFF.



2. Remove the air cleaner element. Refer to Air Cleaner Element Replacement.
3. Remove the air cleaner assembly to chassis retaining bolts (1).
4. Apply suitable upward pressure to the air cleaner lower housing (3) to release the retainer (2).
5. Remove the air cleaner lower housing (3) from the vehicle.

Installation Procedure



1. Install the air cleaner lower housing (3) to the vehicle.
2. Apply suitable downward pressure to the air cleaner lower housing (3) to engage the retainer (2).

   Caution: Refer to Fastener Caution.
3. Install the air cleaner to chassis retaining bolts (1) and tighten to **10 N•m (89 lb in)**.

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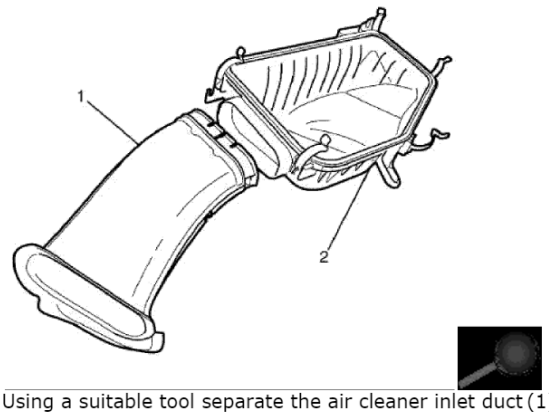
4. Install the air cleaner element Refer to Air Cleaner Element Replacement.

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Air Cleaner Inlet Duct Replacement

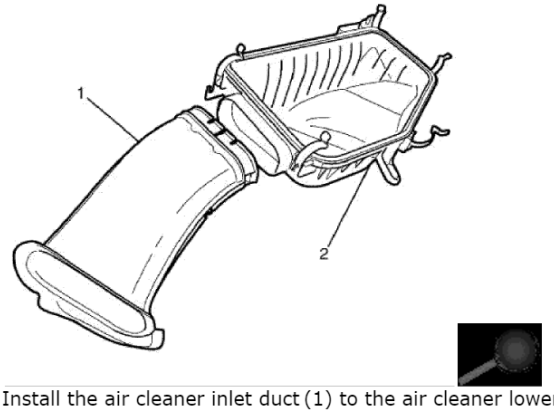
Removal Procedure

1. Ignition OFF.
2. Remove the air cleaner assembly from the vehicle. Refer to Air Cleaner Assembly Replacement.



3. Using a suitable tool separate the air cleaner inlet duct (1) from the air cleaner lower housing (2)

Installation Procedure



1. Install the air cleaner inlet duct (1) to the air cleaner lower housing (2).
   Listen for an audible click to confirm correct installation.
2. Install the air cleaner assembly to the vehicle. Refer to Air Cleaner Assembly Replacement.

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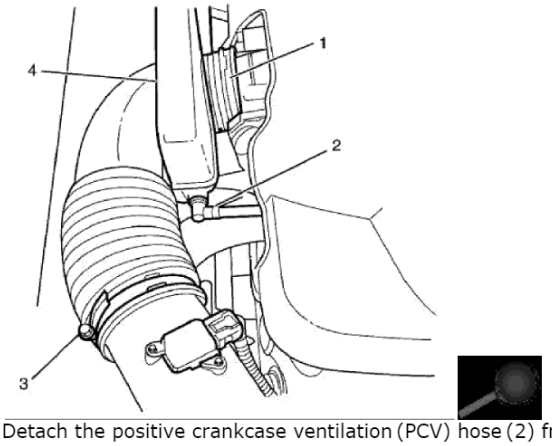
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Air Cleaner Outlet Duct Replacement (LWR)

Removal Procedure

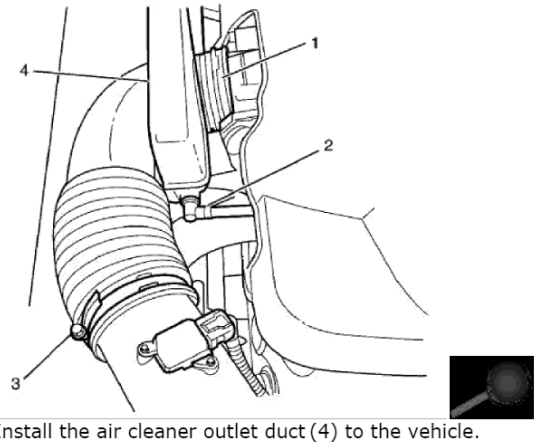
Warning: Refer to Safety Glasses Warning.

1. Ignition OFF.



2. Detach the positive crankcase ventilation (PCV) hose (2) from the air cleaner outlet duct (4). Refer to Plastic Collar Quick Connect Fitting Service.
3. Remove the air cleaner outlet duct to throttle body retaining clamp (1).
4. Remove the air cleaner outlet duct to air cleaner assembly clamp (3).
5. Remove the air cleaner outlet duct (4) from the vehicle.

Installation Procedure



1. Install the air cleaner outlet duct (4) to the vehicle.

   Caution: Refer to Fastener Caution.
2. Position the air cleaner outlet duct to air cleaner assembly clamp (3) and tighten to **2 N·m (18 lb in)**.

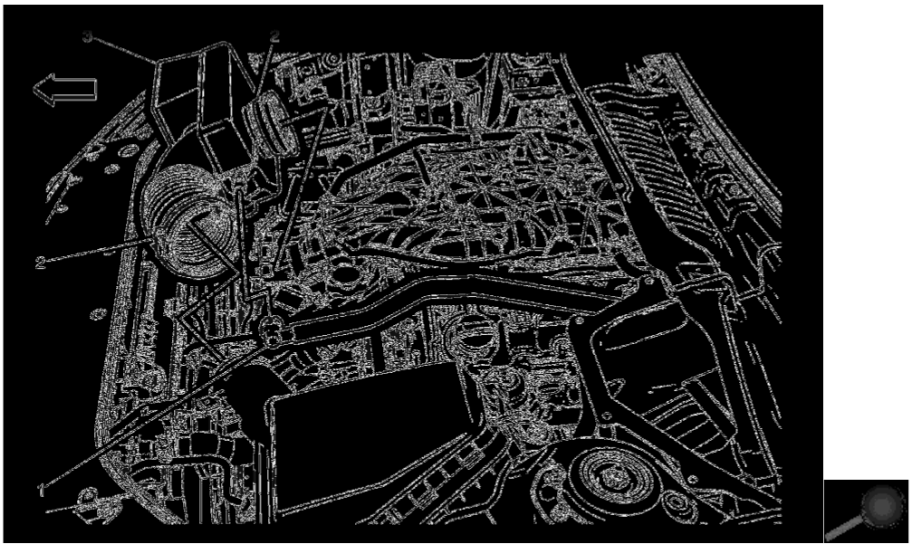
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3. Position the air cleaner outlet duct to throttle body retaining clamp (1) and tighten to **2 N•m (18 lb in)**.
4. Install the positive crankcase ventilation (PCV) hose (2) to the air cleaner outlet duct (4). Refer to Plastic Collar Quick Connect Fitting Service.

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Air Cleaner Outlet Duct Replacement (LFW or LFX)



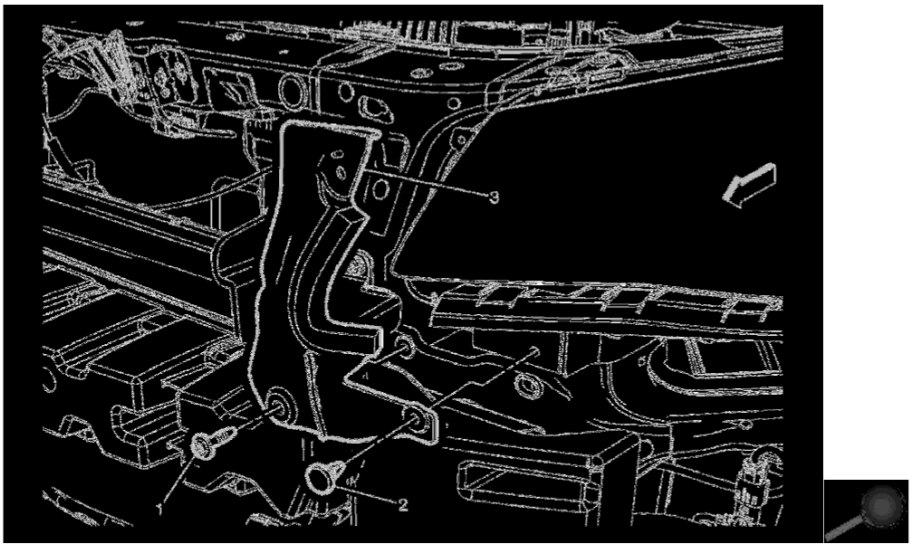
Air Cleaner Outlet Duct Replacement

Callout	Component Name
1	PCV Tube Quick Connect Fitting
2	Air Cleaner Outlet Duct Clamps (Qty: 2) **Caution:** Refer to Fastener Caution.
3	Air Cleaner Outlet Duct

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Intake Air Baffle Replacement



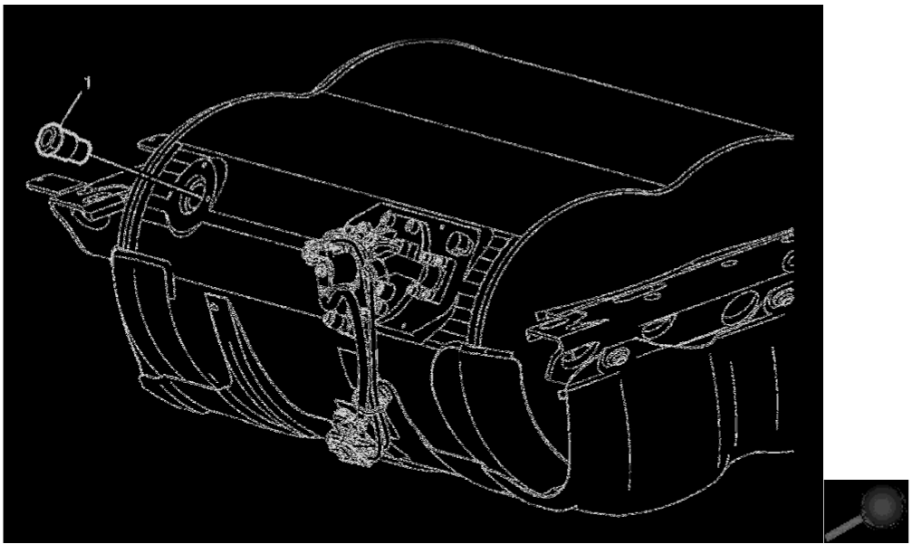
Intake Air Baffle Replacement

Callout	Component Name
Preliminary Procedure **Remove the radiator air upper baffle and deflector. Refer to Radiator Air Upper Baffle and Deflector Replacement.**	
1	Intake Air Baffle Fastener **Caution:** Refer to Fastener Caution. **Tighten** 4.5 N•m (40 lb in)
2	Intake Air Baffle Retainer
3	Intake Air Baffle

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LPG Tank Pressure Relief Valve Replacement (LWR)



LPG Tank Pressure Relief Valve Replacement

Callout	Component Name

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Preliminary Procedure

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Unload the LPG fuel tank. Refer to LPG Tank Unloading.
3. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
4. Remove the LPG fuel tank. Refer to Fuel Tank Replacement.
5. Remove the fuel pressure relief valve housing. Refer to Fuel Pressure Relief Valve Housing Replacement.

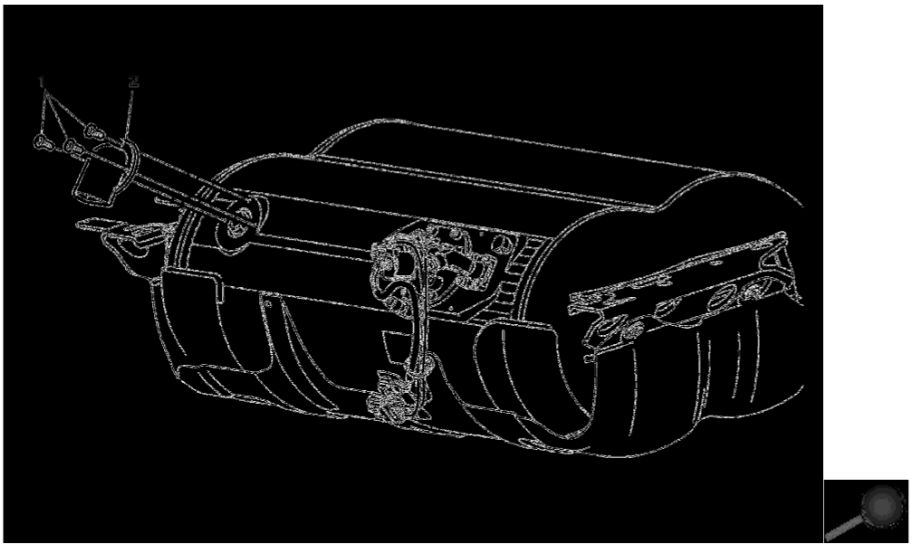
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Callout	Component Name
1	Fuel Pressure Relief Valve. **Procedure** 1. Apply a coating of loctite 700 to both sides of the threads. Refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Hand start the valve then tighten to **60 N•m (44 lb ft)**. 3. Perform leak test after final assembly. Refer to LPG Leak Testing.

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Fuel Pressure Relief Valve Housing Replacement (LWR)



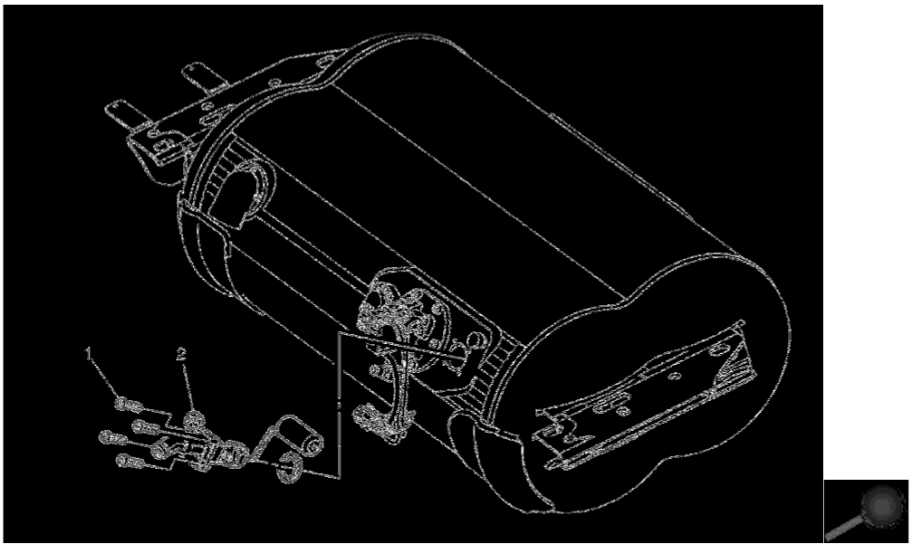
Fuel Pressure Relief Valve Housing Replacement

Callout	Component Name
1	Fuel Pressure Relief Valve Housing Retainers (Qty: 3). **Warning:** All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Caution:** Refer to Fastener Caution. **Tighten** 2.5 N•m (22 lb in)

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LPG Shutoff Valve Replacement (LWR)



LPG Shutoff Valve Replacement

Callout	Component Name

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Preliminary Procedure

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Disconnect the LPG fuel feed hose. Refer to LPG Fuel Feed Hose Replacement
4. Disconnect the electrical connectors.
5. Remove the LPG fuel tank. Refer to Fuel Tank Replacement
6. Empty the LPG fuel tank. Refer to LPG Tank Unloading
7. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.

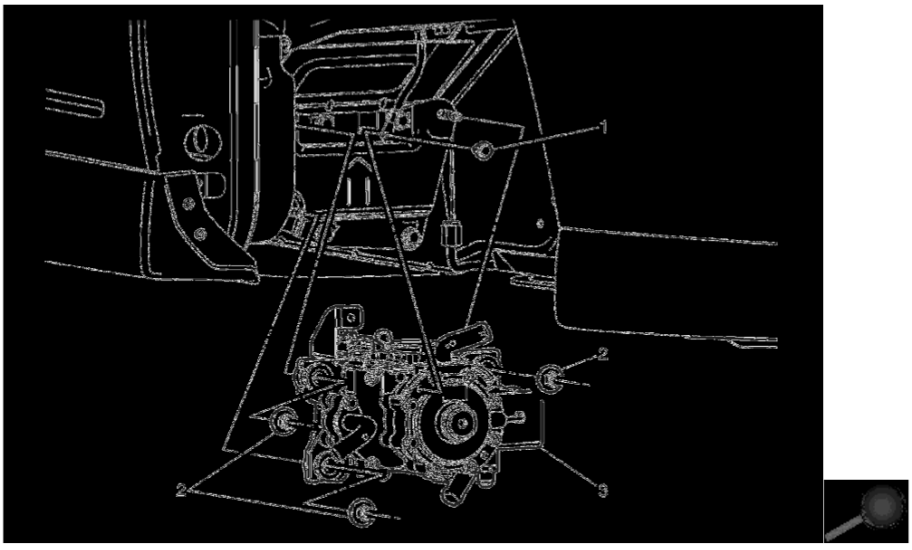
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Callout	Component Name
1	LPG Shutoff Valve Fasteners (Qty: 4). **Caution:** Refer to Fastener Caution. **Tighten** 6 N•m (53 lb in)
2	LPG Shutoff Valve. **Procedure** Remove o-ring and DISCARD, install new o-ring.

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LPG Vaporizer Replacement (LWR)



LPG Vaporizer Replacement

Callout	Component Name

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Preliminary Procedure

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Remove the front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement
4. Disconnect the liquefied petroleum gas vaporizer electrical connector.
5. Disconnect the fuel heater outlet hose. Refer to Fuel Heater Outlet Hose Replacement.
6. Disconnect the fuel heater inlet hose. Refer to Fuel Heater Inlet Hose Replacement.
7. Disconnect the LPG fuel feed front pipe. Refer to LPG Fuel Feed Front Pipe Replacement.

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Callout	Component Name
8. Disconnect the LPG fuel feed pipe. Refer to Liquefied Petroleum Gas Fuel Feed Pipe Fitting Replacement 9. Disconnect earth lead bolt on the vaporizer.	
1	Earth Strap Fastener. **Caution:** Refer to Fastener Caution. **Procedure** After removal of vaporizer from vehicle, return earth strap bolt to its original location in the vaporizer. **Tighten** 6 N•m (53 lb in)
2	Liquefied Petroleum Gas Vaporizer Nuts (Qty: 3). **Tighten** 20 N•m (15 lb ft)
3	Liquefied Petroleum Gas Vaporizer. **Procedure** Perform LPG leak test after final assembly. Refer to LPG Leak Testing

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Differential Fuel Rail Pressure Adjustment (LWR)

Special Tools

7000086I Scan Tool

For equivalent regional tools. Refer to Special Tools.

Preliminary Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

1. Vehicle requires to be at operating temperature (coolant temperature requires to be above 85° C).
2. Connect scan tool to car.
   On scan tool select
   - Engine Control Module
   - Data Display
   - Fuel System Data and monitor Alternative Fuel Rail Pressure Sensor kPa.

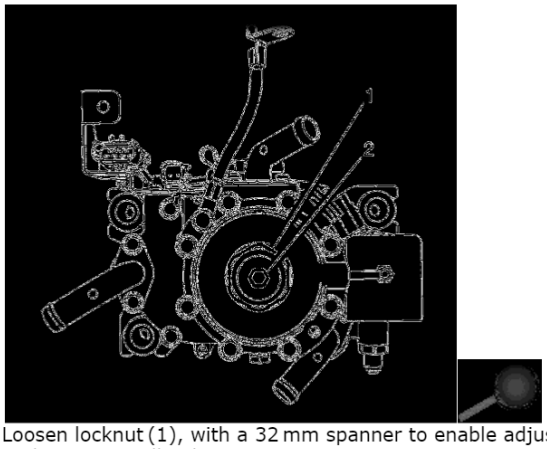
   Note: The Alternative Fuel Rail Pressure is 110 +/- 1 Kpa.
3. Confirm alternative fuel rail pressure sensor readings displayed on scan tool, is to specification if outside recommended values, continue with procedure.

Procedure

1. Remove the right front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement.

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2. Loosen locknut (1), with a 32 mm spanner to enable adjustment of the adjust screw (2) with an 8 mm allen key.
3. Turn adjusting screw (2) clockwise to increase pressure, and anticlockwise to decrease pressure.
4. Check alternative fuel rail pressure while adjustments are taking place by the use of the scan tool.

   Note: The target alternative rail pressure is 110 +/- 1 Kpa.
5. Once alternative fuel rail pressure is to specification, tighten lock nut.
6. Conduct 4 throttle blips (throttle blips are quick stabs of accelerator) to ensure vaporizer spring does not bind.
7. Install the right front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement.

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LPG Vaporizer Bolt Replacement (Drain Plug LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

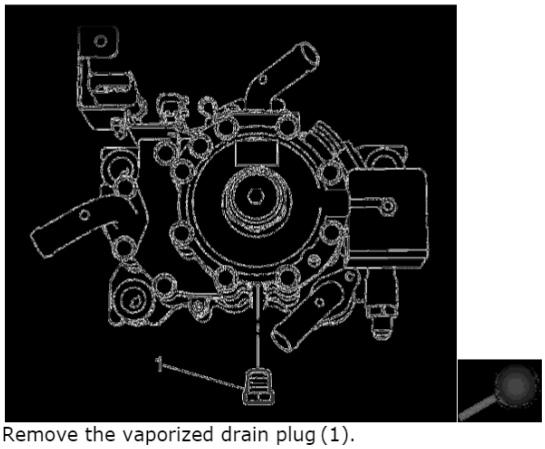
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

1. Remove the right front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement.
2. Relieve to fuel system pressure. Refer to Fuel Pressure Relief.
3. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.

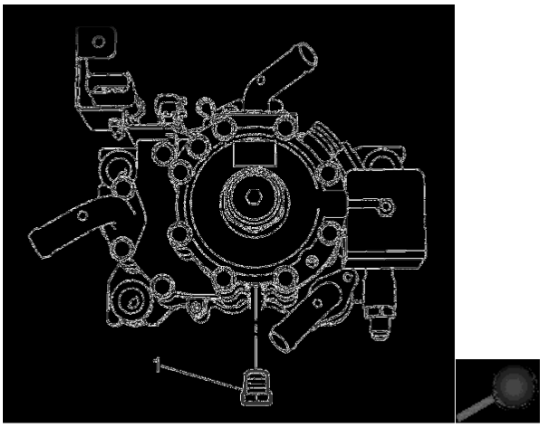


4. Remove the vaporized drain plug (1).

Installation Procedure

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Note: Recognised LPG thread sealer on the vaporizer drain plug.

1. Install the vaporized drain plug (1) and tighten to **10 N•m (89 lb in)**.
2. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.
3. Install the right front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement.

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LPG Vaporizer Solenoid Replacement (LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

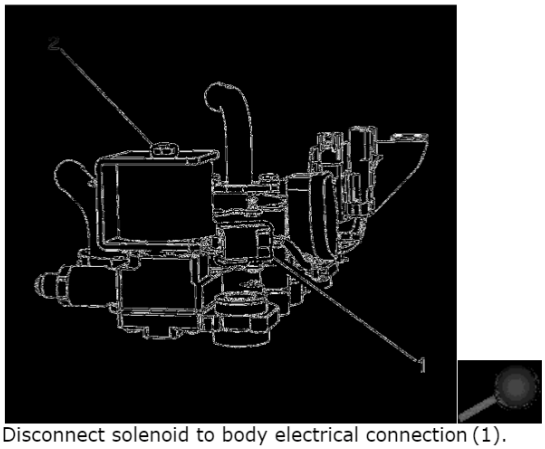
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

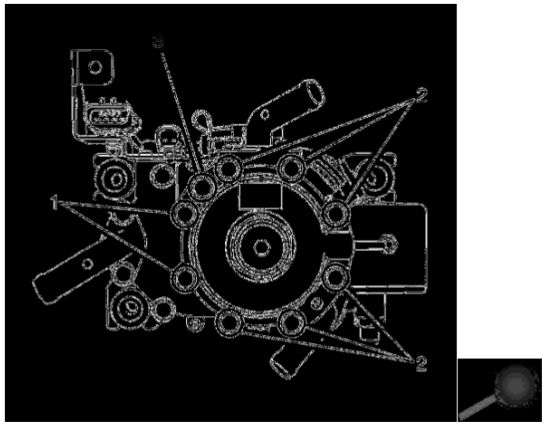
1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Remove the LPG vaporizer. Refer to LPG Vaporizer Replacement.



4. Disconnect solenoid to body electrical connection (1).
5. Remove vaporizer solenoid nut (2).

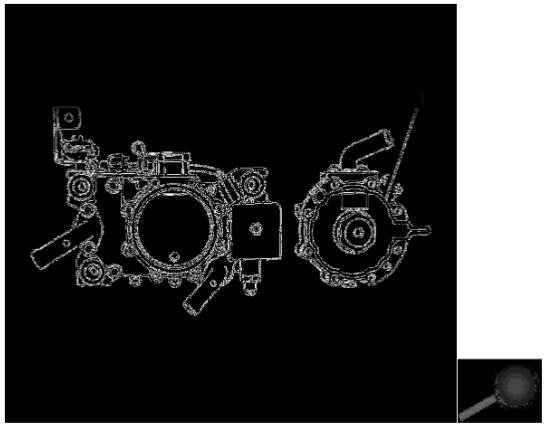
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Note: Bolt required to maintain internal spring in its casing.

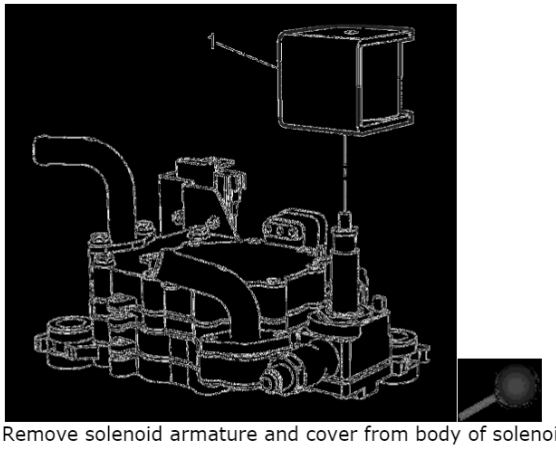
6. Replace earth lead bolt M6 X 14mm long (3) and insert same size bolt supplied with kit to Vaporiser head / diaphragm cover clamping hole (A). Ensure that maximum torque applied to these two bolts not to be above 6 NM.
7. Remove 8 x vaporizer body bolts 6 x M6 x 110 mm long (2), 2 x M6 x 60 mm long (1).



Note: Items under heavy spring pressure.

8. Remove top of vaporizer (1), containing spring and diaphragm from the main body of vaporizer.

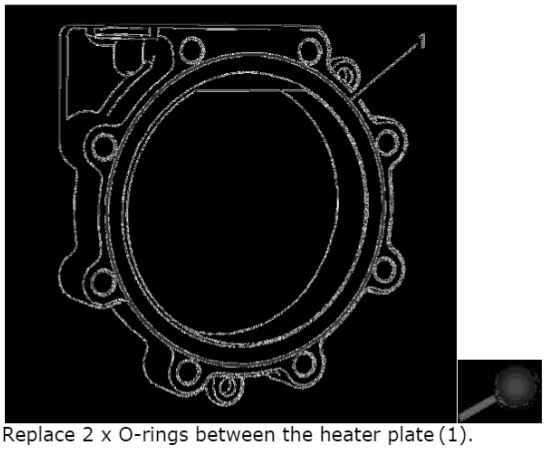
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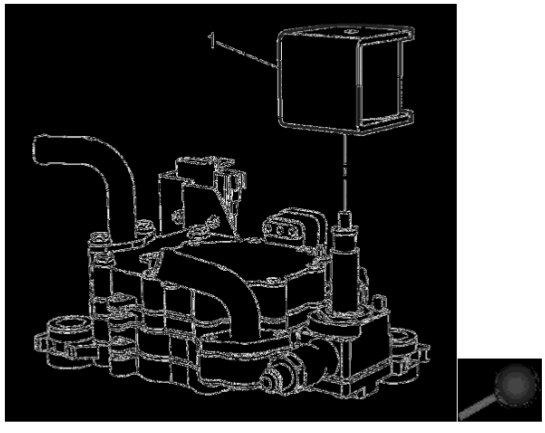
9. Remove solenoid armature and cover from body of solenoid (1).
10. Dispose of old armature.

Installation Procedure

1. Replace solenoid with new armature inside the steel cover.

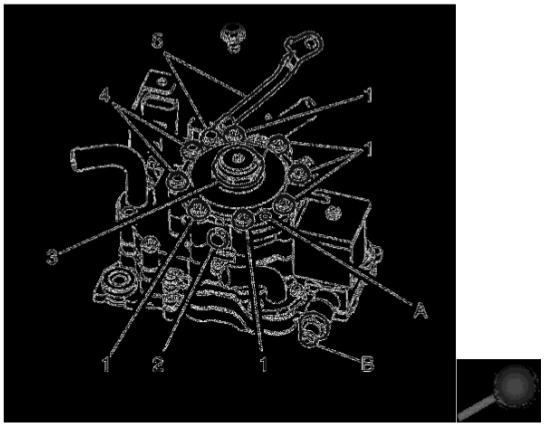


2. Replace 2 x O-rings between the heater plate (1).



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3. Install solenoid armature and cover from body of solenoid (1).



Note:

Ensure that all work carried out is done in a clean environment away from petrol and other such contaminants, as these may affect rubber and / or resin parts.

Ensure that you use the correct tool for the correct job.

Ensure that care is taken when working with the fuel inlet connector as it is susceptible to damage.

Do not reuse components which have been contaminated by foreign material.

3.1. Bolt M6 X 110mm long (Qty: 6)

3.2. Bolt, Vaporizer drain plug

3.3. Diaphragm spring adjustment screw and lock nut

3.4. Bolt M6 X 60mm long (Qty: 2)

3.5. Bolt M6 X 14mm and vaporizer earth lead

3.6. (A) Vaporizer head / diaphragm cover clamping hole

3.7. (B) Fuel Inlet

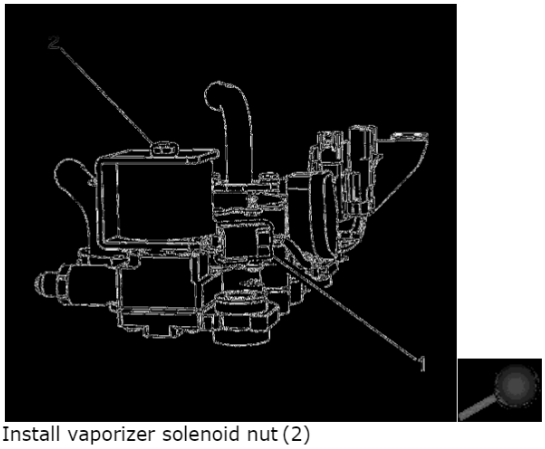
Caution: Refer to Fastener Caution.

4. Assemble diaphragm complete body assembly to the rest of the vaporiser, Tighten (4) and (1) bolts ensuring they are tighten equally (simultaneously) to **6 N•m (53 lb in)**.

Note: Items under heavy spring pressure.

5. Ensure that all O-rings are properly seated.
6. Remove additionally supplied bolt from its locking location (A).
7. Carry out the tests to the High Pressure Circuit and to the primary Chamber. High pressure circuit 1.97 mPa x 5 min by using air or nitrogen gas from gas inlet no leaks allowed. Primary chamber 130 kPa x 1 min by using air or nitrogen gas from gas outlet no leaks allowed.
8. Carry out the test to the water passage leaks test. water passage 300 kPa x 30 sec by using nitrogen gas or air from water connector no leaks allowed.

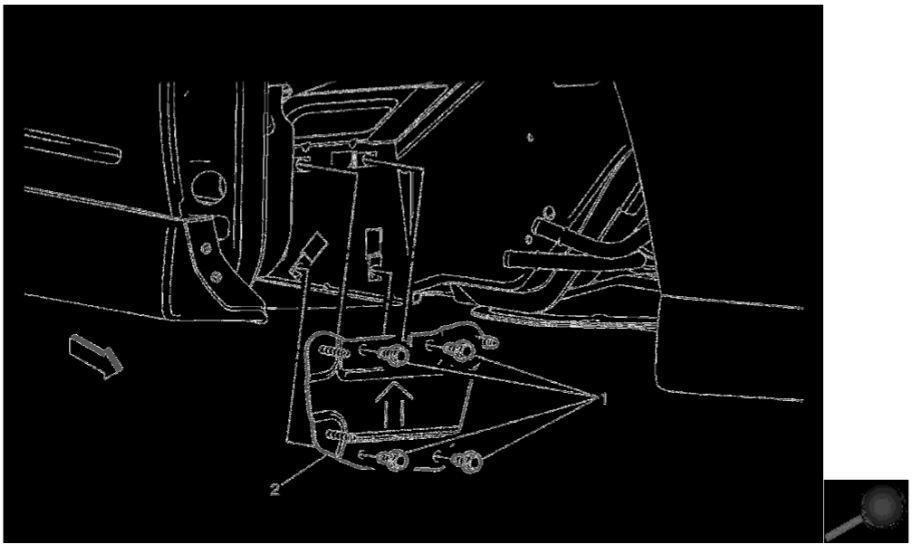
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9. Install vaporizer solenoid nut (2)
10. Connect solenoid to body electrical connection (1).
11. Install the LPG vaporizer. Refer to LPG Vaporizer Replacement.
12. Perform the differential fuel rail pressure adjustment. Refer to Differential Fuel Rail Pressure Adjustment.
13. Lower the vehicle.
14. Perform leak test after final assembly. Refer to LPG Leak Testing.
15. Perform rail pressure adjustment procedure.

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LPG Vaporizer Bracket Replacement (LWR)



Liquefied Petroleum Gas Vaporizer Bracket Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** Remove the LPG vaporizer. Refer to LPG Vaporizer Replacement.
1	LPG Vaporizer Bracket Bolts (Qty: 4). **Caution:** Refer to Fastener Caution. **Tighten** 22 N•m (16 lb ft)
2	LPG Vaporizer Bracket

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LPG Vaporizer Heater Replacement (LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

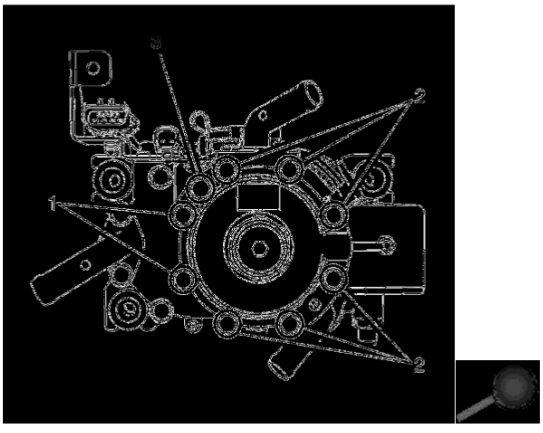
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Remove the LPG vaporizer. Refer to LPG Vaporizer Replacement.

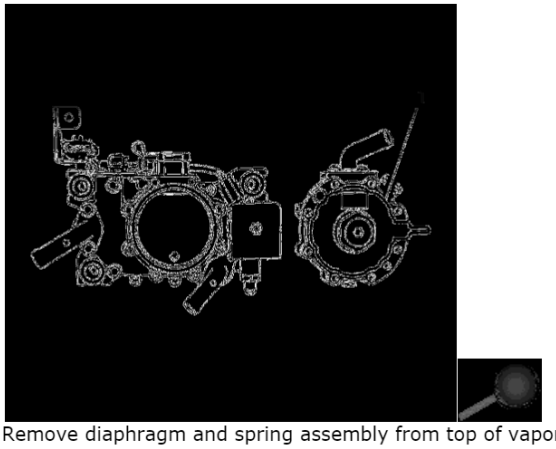


Note: Bolt required to maintain internal spring and vaporizer diaphragm in its casing.

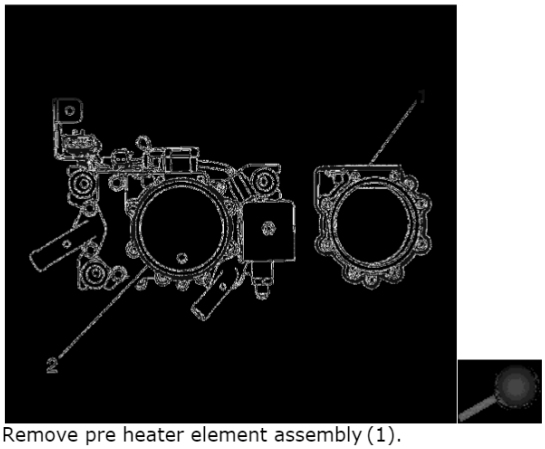
4. Replace earth lead bolt M6 X 14mm long (3) and insert same size bolt supplied with kit to Vaporiser head / diaphragm cover clamping hole (A). Ensure that maximum torque applied to these two bolts not to be above 6 NM.
5. Remove 8 x vaporizer body bolts 6 x M6 x 110 mm long (2), 2 x M6 x 60 mm long (1).

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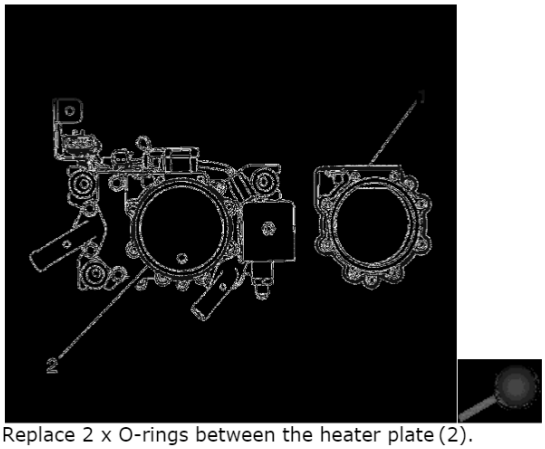
6. Remove diaphragm and spring assembly from top of vaporizer (1).



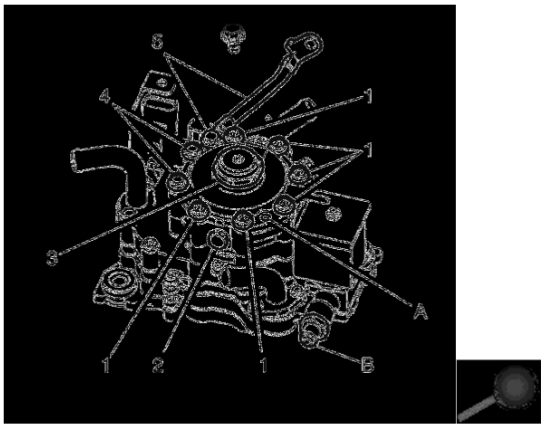
7. Remove pre heater element assembly (1).
8. Remove o-ring (2) from main body.
9. Clean as necessary.

Installation Procedure

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1. Replace 2 x O-rings between the heater plate (2).
2. Place new heather element assembly into the body (1).



Note:

Ensure that all work carried out is done in a clean environment away from petrol and other such contaminants, as these may affect rubber and / or resin parts.

Ensure that you use the correct tool for the correct job.

Ensure that care is taken when working with the fuel inlet connector as it is susceptible to damage.

Do not reuse components which have been contaminated by foreign material.

2.1. Bolt M6 X 110mm long (Qty: 6)

2.2. Bolt, Vaporizer drain plug

2.3. Diaphragm spring adjustment screw and lock nut

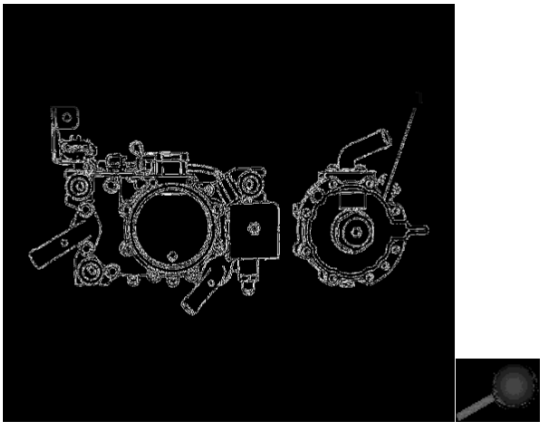
2.4. Bolt M6 X 60mm long (Qty: 2)

2.5. Bolt M6 X 14mm and vaporizer earth lead

2.6. (A) Vaporizer head / diaphragm cover clamping hole

2.7. (B) Fuel Inlet

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Caution: Refer to Fastener Caution.

3. Assemble diaphragm complete body assembly to the rest of the vaporiser, Tighten (4) and (1) bolts ensuring they are tighten equally (simultaneously) to **6 N•m (53 lb in)**.

Note: Items under heavy spring pressure.

4. Ensure that all O-rings are properly seated.
5. Carry out the tests to the High Pressure Circuit and to the primary Chamber. High pressure circuit 1.97 mPa x 5 min by using air or nitrogen gas from gas inlet no leaks allowed. Primary chamber 130 kPa x 1 min by using air or nitrogen gas from gas outlet no leaks allowed.
6. Carry out the test to the water passage leaks test. water passage 300 kPa x 30 sec by using nitrogen gas or air from water connector no leaks allowed.
7. Install the LPG vaporizer. Refer to LPG Vaporizer Replacement.
8. Perform the differential fuel rail pressure adjustment. Refer to Differential Fuel Rail Pressure Adjustment.
9. Lower the vehicle.
10. Perform leak test after final assembly. Refer to LPG Leak Testing.
11. Perform rail pressure adjustment procedure.

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LPG Vaporizer Diaphragm Replacement (LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

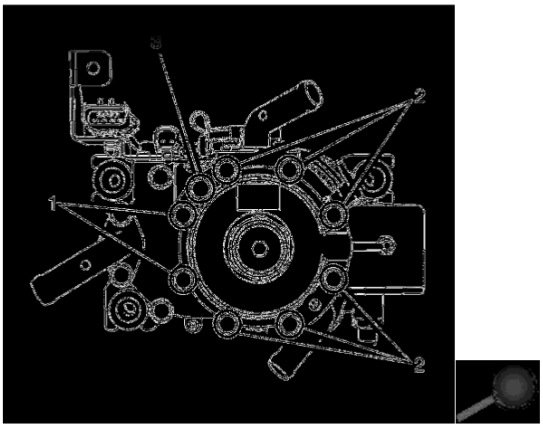
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Remove the LPG vaporizer. Refer to LPG Vaporizer Replacement.



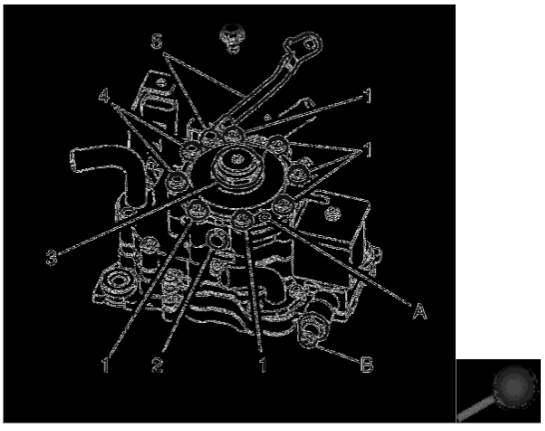
Note: Bolt required to maintain internal spring in its casing.

4. Replace earth lead bolt M6 X 14mm long (3).

Disassembly Of Vaporizer

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Note:

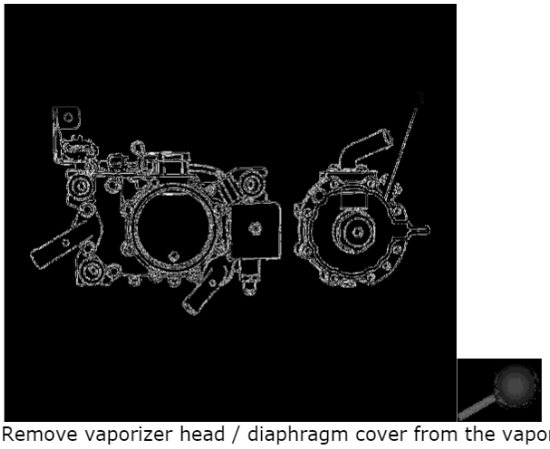
1. Ensure that all work carried out is done in a clean environment away from petrol and other such contaminants, as these may affect rubber and / or resin parts.
2. Ensure that care is taken when working with the fuel inlet connector as it is susceptible to damage (B).
3. Do not reuse components which have been contaminated by foreign material.

1. Bolt M6 X 110mm long (Qty: 6).
2. Bolt, Vaporizer drain plug.
3. Diaphragm spring adjustment screw and lock nut.
4. Bolt M6 X 60mm long (Qty: 2).
5. Bolt M6 X 14mm and vaporizer earth lead.
6. (A) Vaporizer head / diaphragm cover clamping hole.
7. (B) Fuel Inlet.

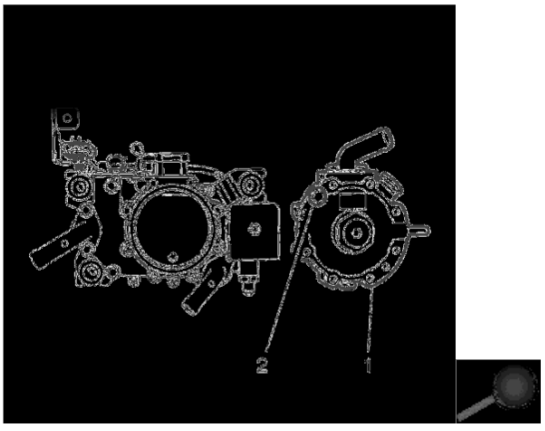
Method

1. Loosen Diaphragm spring adjustment screw and lock nut (3), to relieve some of the spring pressure on diaphragm springs.
2. Replace M6 x 14 mm bolt to the vaporizer head / diaphragm cover (5). Use second M6 x 14 mm bolt on vaporizer head / diaphragm cover clamping hole (A). Ensure that maximum torque applied to these two bolts is to be below 6 Nm.
3. Remove all other M6 bolts (1 and 4) from the vaporizer.

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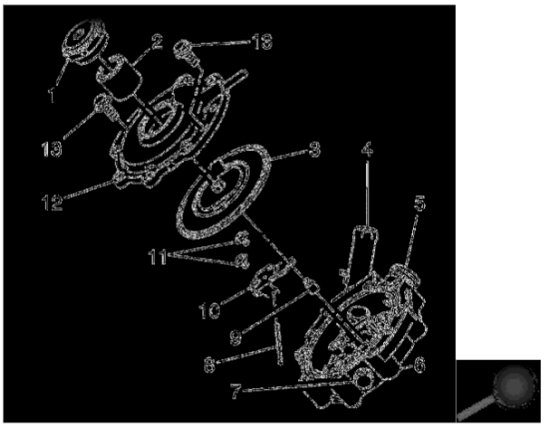
4. Remove vaporizer head / diaphragm cover from the vaporizer main body (1)



Note: Items under heavy spring pressure.

5. Disassembled items, body complete main (2), diaphragm assembly (1), bolt M6 X 14mm long (3), main spring diaphragm (4), assist spring diaphragm (5), cover assembly (6).

Note: ,to prevent damage to the balance diaphragm (A) ensure that the bottom remains elevated away from other surfaces by the use of (B) workshop material.



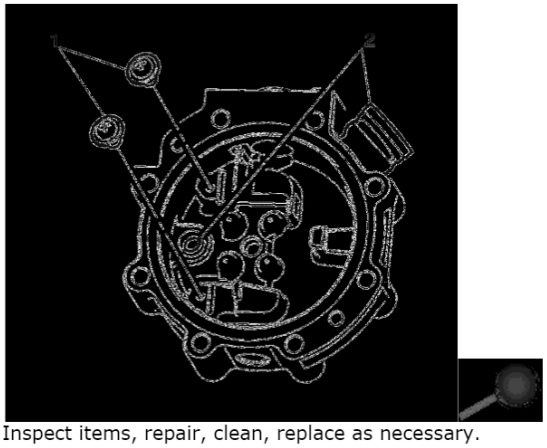
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1. Vaporizer Adjustment Screw and Lock Nut.
2. Pressure Setting Diaphragm Springs.
3. LPG Vaporizer Diaphragm Assembly.
4. Fuel Outlet Pipe.
5. Vaporizer Diaphragm Housing Pressure Valve.
6. Vaporizer Diaphragm Housing.
7. Bolt, Vaporizer Drain Plug.
8. Lever Pin.
9. Balance Pin.
10. Lever.
11. Lever Screws.
12. Vaporizer Cover.
13. Bolt M6 X 14mm.

Method

1. Remove (1) Vaporizer Adjustment Screw and Lock Nut.
2. Remove (2) Pressure Setting Diaphragm Springs.
3. Remove (13) Bolt M6 X 14mm L.
4. Remove (12) Vaporizer Cover.
5. Remove (3) LPG Vaporizer Diaphragm Assembly.
6. Remove (11) Lever Screws.
7. Remove (10) Lever.
8. Remove (8) Lever Pin.
9. Remove (9) Balance Pin.

Cleaning of Vaporizer Diaphragm Housing

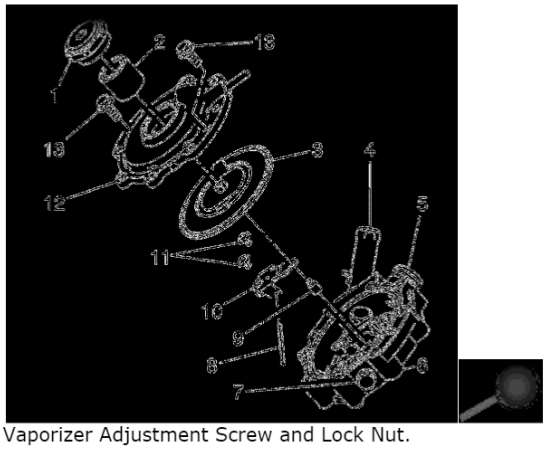


1. Inspect items, repair, clean, replace as necessary.

   Note: Although cleaning of item is required, when doing so the highest caution must be observed in order to ensure that no damage occurs to the housing especially to areas which are set to a specific dimension (2).
2. Clean out (1) with tap and die to the size of M4 X 0.7 (JIS B 205 / ISO 261).

Installation Procedure

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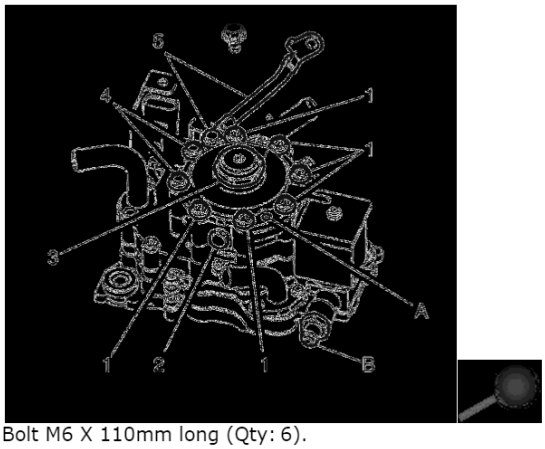
1. Vaporizer Adjustment Screw and Lock Nut.
2. Pressure Setting Diaphragm Springs.
3. LPG Vaporizer Diaphragm Assembly.
4. Fuel Outlet Pipe.
5. Vaporizer Diaphragm Housing Pressure Valve.
6. Vaporizer Diaphragm Housing.
7. Bolt, Vaporizer Drain Plug.
8. Lever Pin.
9. Balance Pin.
10. Lever.
11. Lever Screws.
12. Vaporizer Cover.
13. Bolt M6 X 14mm.

Method of Assembly

1. Insert balance pin (9) to the balance diaphragm in the body (6).
2. Assemble the valve into the lever as per (10).
3. Assemble the lever pin into the lever (8) to (10).
4. Add thread sealant TB1303N or equivalent to screws (11) to the body (6).
5. Place lever assembly with rod (8, 9 and 10) on the body and tighten to the body (6) with two screws (11) and tighten to 1.0 - 2.9 Nm.
6. Carry out the following valve leak test. 0.3 MPa pressure added at primary valve from gas inlet. No leaks allowed of primary valve.
7. Ensure that the diaphragm (3) engages in its slot of the diagram assembly (8, 9 and 10) ensuring that when assembled that new diaphragm is not caught between the body (6) and the cover (12).
8. Assemble body (6) and cover (12) by the use screws (13) Tighten screws to 6 NM of torque.
9. Apply MOLYKOTE 663 or equivalent to the upper surface of the new diaphragm assembly trough the vaporiser adjustment screw and lock nut (1) hole in the vaporiser cover (12).
10. Apply MOLYKOTE 663 or equivalent to the first 3 threads of the vaporiser adjustment screw and lock nut (1) .Insert springs (2) into their aperture and engage the vaporiser adjustment screw and lock nut (1). Lock nut tightening torque is to be 15.0 to 30 NM.

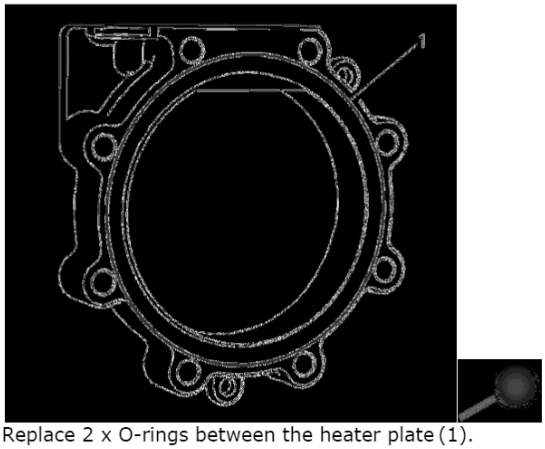
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Ensuring that when the lock nut is being tightened that the adjustment screw does not move.



1. Bolt M6 X 110mm long (Qty: 6).
2. Bolt, Vaporizer drain plug.
3. Diaphragm spring adjustment screw and lock nut.
4. Bolt M6 X 60mm long (Qty: 2).
5. Bolt M6 X 14mm and vaporizer earth lead.
6. (A) Vaporizer head / diaphragm cover clamping hole.
7. (B) Fuel Inlet.

Assembly of Vaporizer Diaphragm Housing



1. Replace 2 x O-rings between the heater plate (1).
2. Assemble diaphragm complete body assembly to the rest of the vaporizer, Tighten (4) and (1) bolts ensuring they are tighten equally (simultaneously) to **6 N•m (53 lb in)**.
3. Ensure that all O-rings are properly seated.
4. Remove additionally supplied bolt from its locking location (A).
5. Carry out the tests to the High Pressure Circuit and to the Primary Chamber. High pressure circuit 1.97 MPa x 5 min by using air or nitrogen gas from gas inlet, no leaks allowed. Primary chamber 130 KPA x 1 min by using air or nitrogen gas from gas outlet, no leaks allowed.

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6. Carry out the test to the water passage leaks test. 300 KPA x 30 sec by using nitrogen gas or air from water connector no leaks allowed.
7. Install the LPG vaporizer. Refer to LPG Vaporizer Replacement.
8. Perform the differential fuel rail pressure adjustment. Refer to Differential Fuel Rail Pressure Adjustment.
9. Lower the vehicle. Refer to Lifting and Jacking the Vehicle.
10. Perform leak test after final assembly. Refer to LPG Leak Testing.

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Solenoid Valve Coil Replacement (Fuel Pump LWR)

Special Tools

- *EL-38125-553* Terminal Release Tool
- *EL-35616–5* Test Probe

For equivalent regional tools, Refer to Special Tools.

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

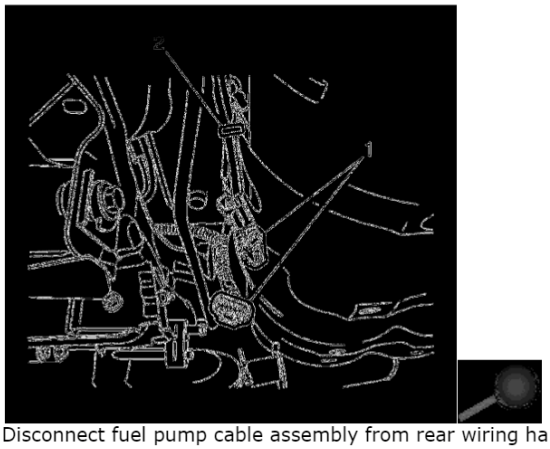
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

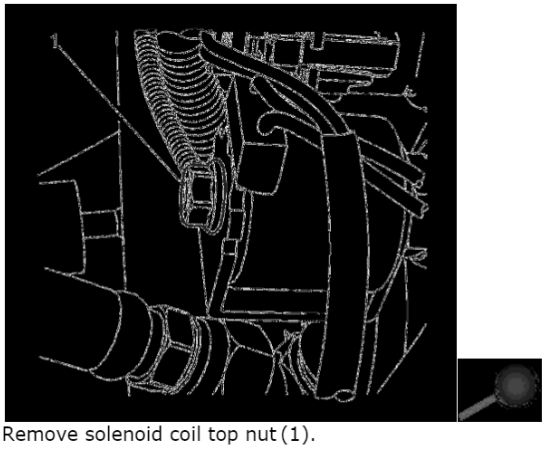
1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.



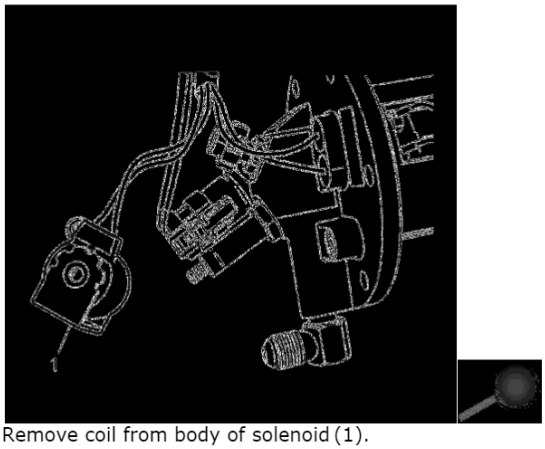
3. Disconnect fuel pump cable assembly from rear wiring harness (1).
4. Unclip fuel pump harness tank shield holding clip (2).

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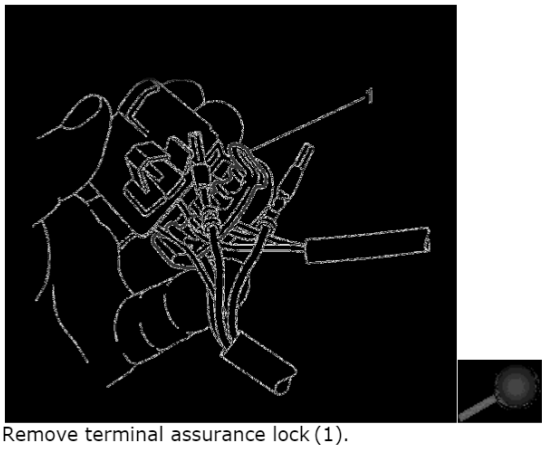
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5. Remove solenoid coil top nut (1).

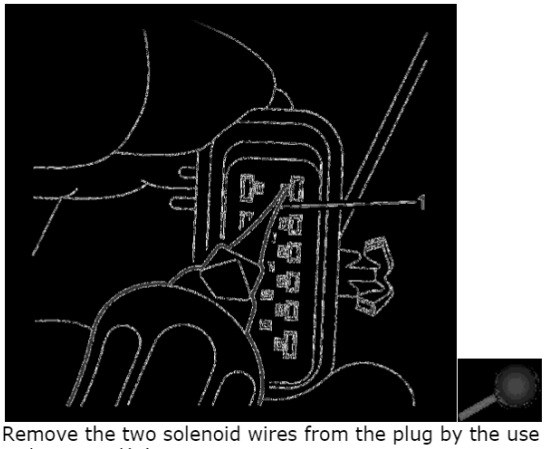


6. Remove coil from body of solenoid (1).

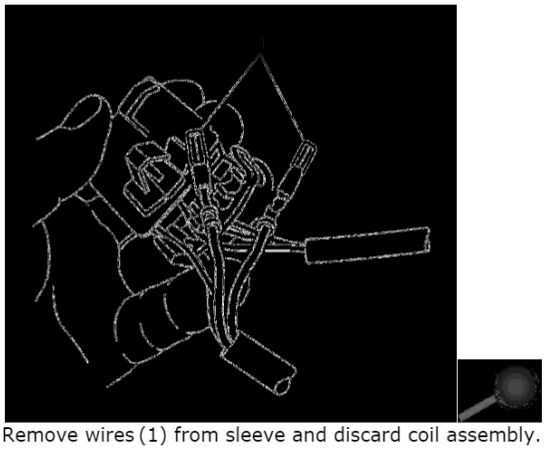


7. Remove terminal assurance lock (1).

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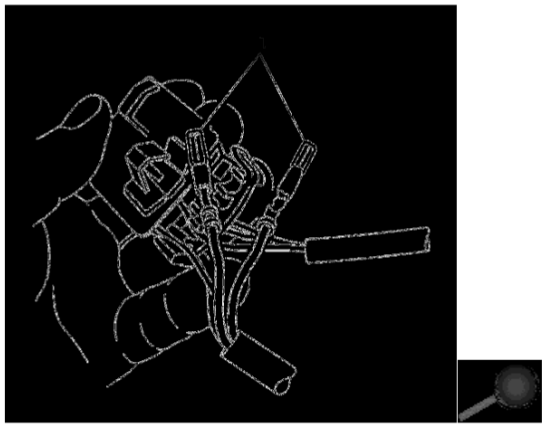


8. Remove the two solenoid wires from the plug by the use of *EL-38125-553* Terminal Release Tool(1).



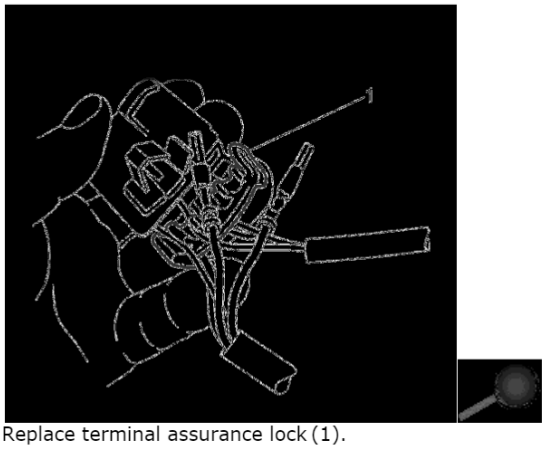
9. Remove wires (1) from sleeve and discard coil assembly.

Installation Procedure



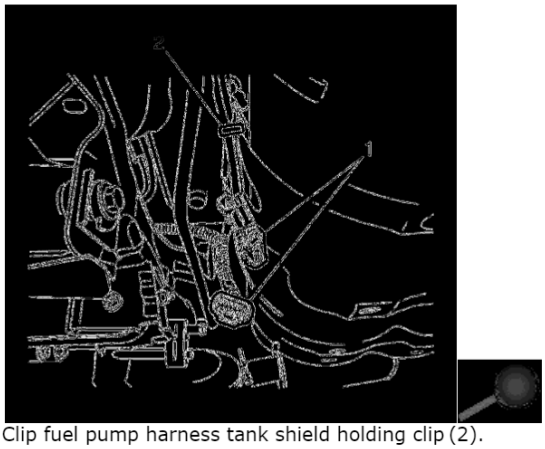
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1. Install NEW coil assembly.
2. Push wires (1) trough sleeve.
3. Replace terminals into plug.
4. Test terminals with test probe *EL-35616-5* Test Probe.



5. Replace terminal assurance lock (1).

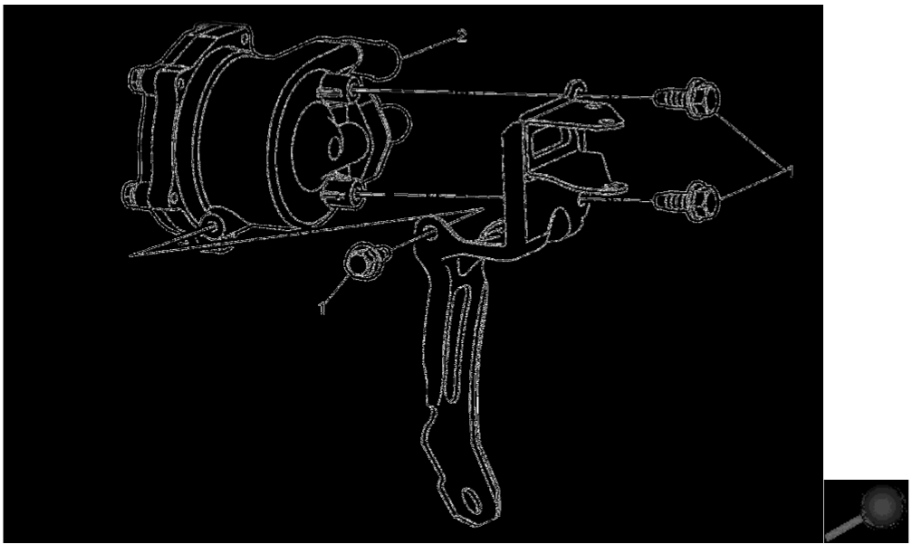
   Caution: Refer to Fastener Caution.
6. Replace coil into the body of the solenoid and tighten to **4.5 N•m (40 lb in)**.



7. Clip fuel pump harness tank shield holding clip (2).
8. Connect fuel pump cable assembly to rear wiring harness (1).
9. Lower the vehicle.

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LPG Fuel Filter Replacement (LWR)



LPG Fuel Filter Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Relive the fuel system pressure. Refer to Fuel Pressure Relief 2. Remove the fuel filter bracket. Refer to Fuel Filter Bracket Replacement.
1	LPG Fuel Filter Bolts (Qty: 3). **Caution:** Refer to Fastener Caution. **Tighten** 9 N•m (80 lb in)

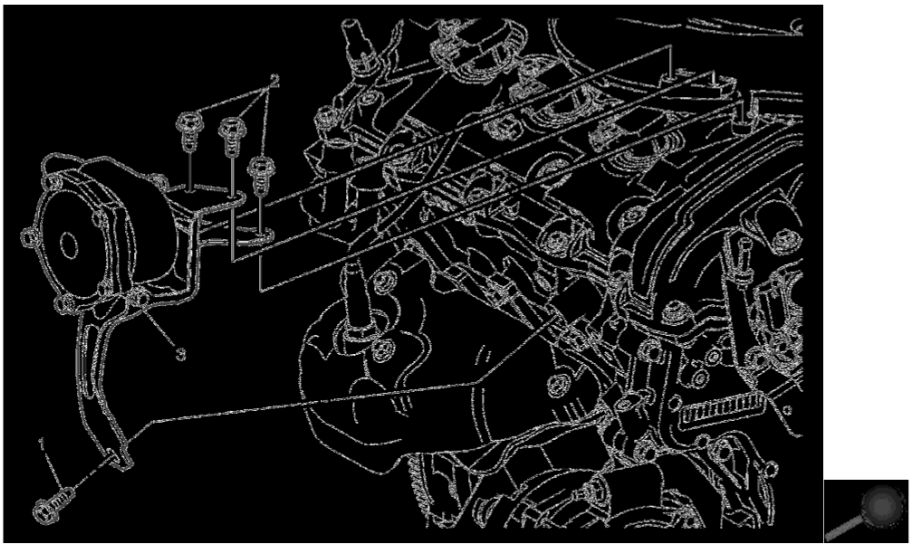
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Callout	Component Name
2	LPG Fuel Filter **Procedure** Perform leak testing after final assembly. Refer to LPG Leak Testing.

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Fuel Filter Bracket Replacement (LWR)



Fuel Filter Bracket Replacement

Callout	Component Name
Preliminary Procedure 1. Relive the fuel system pressure. Refer to Fuel Pressure Relief. 2. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement. 3. Remove the LPG fuel feed hose pipe to filter. Refer to LPG Fuel Feed Hose Replacement. 4. Remove the LPG fuel feed hose filter to rail. Refer to LPG Fuel Feed Hose Replacement.	
1	Fuel Filter Bracket Bolt **Caution:** Refer to Fastener Caution. **Tighten** 20 N•m (15 lb lb)
2	Fuel Filter Bracket Bolt (Qty: 3) **Tighten** 9 N•m (80 lb in)
3	Fuel Filter Bracket **Procedure** 1. Remove the tar filter housing with bracket from the engine. 2. Remove the tar filter housing from the bracket. Refer to LPG Fuel Filter Replacement.

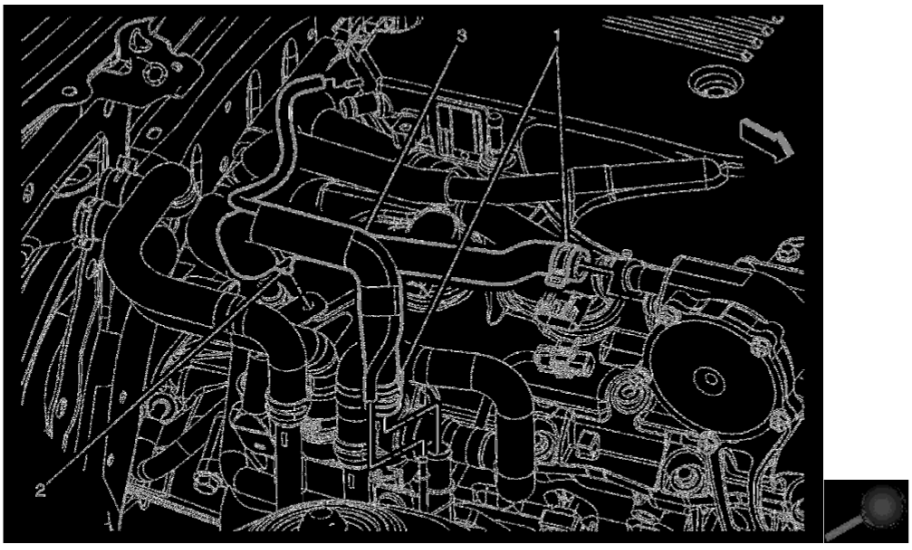
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Callout	Component Name
	3. Perform leak test after final assembly. Refer to LPG Leak Testing.

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LPG Fuel Feed Hose Replacement (Pipe to Filter LWR)



LPG Fuel Feed Hose Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief. 2. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
1	Fuel Feed Hose Clamp (Qty: 2) **Procedure** Disconnect the fuel feed hose at both ends using *BO-38185* Hose Clamp Pliers.

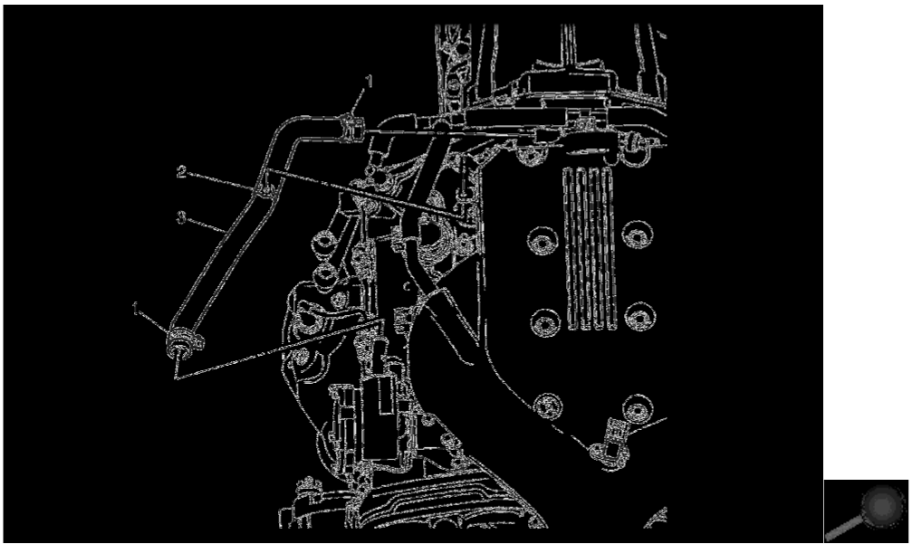
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Callout	Component Name
	Note: Clamps are glued to hose. **Special Tools** *BO-38185* Hose Clamp Pliers For equivalent regional tools, refer to Special Tools
2	Fuel Feed Hose Retainer **Procedure** Disconnect the fuel feed hose retainer from the bracket.
3	Fuel Feed Hose Vacuum Line **Procedure** 1. Disconnect the fuel feed hose vacuum line from the intake manifold and the fuel feed front pipe. 2. Perform leak test after final assembly. Refer to LPG Leak Testing. **Note:** Hose and clamps are a matched set if theses come apart or there is a requirement to replace either of them, these come as an assembly.

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LPG Fuel Feed Hose Replacement (Filter to Rail LWR)



LPG Fuel Feed Hose Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief 2. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
1	Fuel Feed Hose Clamp (Qty: 2) **Procedure** Disconnect the fuel feed hose clamps using *BO-38185* Hose Clamp Pliers.

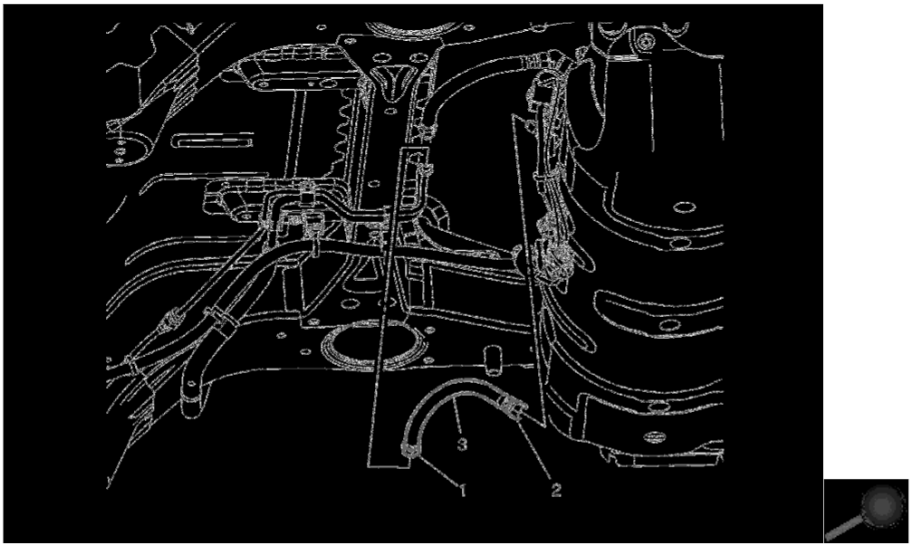
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Callout	Component Name
	Special Tools *BO-38185* Hose Clamp Pliers For equivalent regional tools, refer to Special Tools
2	Fuel Feed Hose Retainer **Procedure** Disconnect the fuel feed hose retainer from the intake manifold.
3	Fuel Feed Hose **Procedure** Perform leak test after final assembly. Refer to LPG Leak Testing. **Note:** Hoses and clamps are a matched set, if replacement is required for eaither of these items they are to be replaced as an assembly.

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LPG Fuel Feed Hose Replacement (Rear Pipe to Fuel Pump LWR)



LPG Fuel Feed Hose Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief. 2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
1	Hose Connection Nut. **Tighten** 30 N•m (22 lb ft)

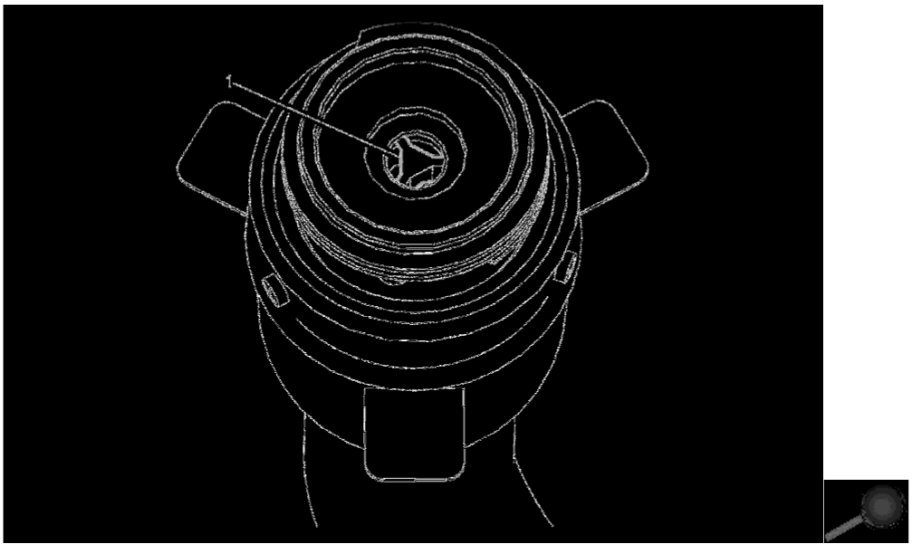
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Callout	Component Name
2	Hose Connection Nut. **Tighten** 40 N•m (30 lb ft)
3	LPG Rear Pipe. **Procedure** 1. Remove the LPG fuel feed hose from the LPG rear pipe and the fuel pump. 2. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.

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LPG Tank Filler Hose Pressure Relief (LWR)



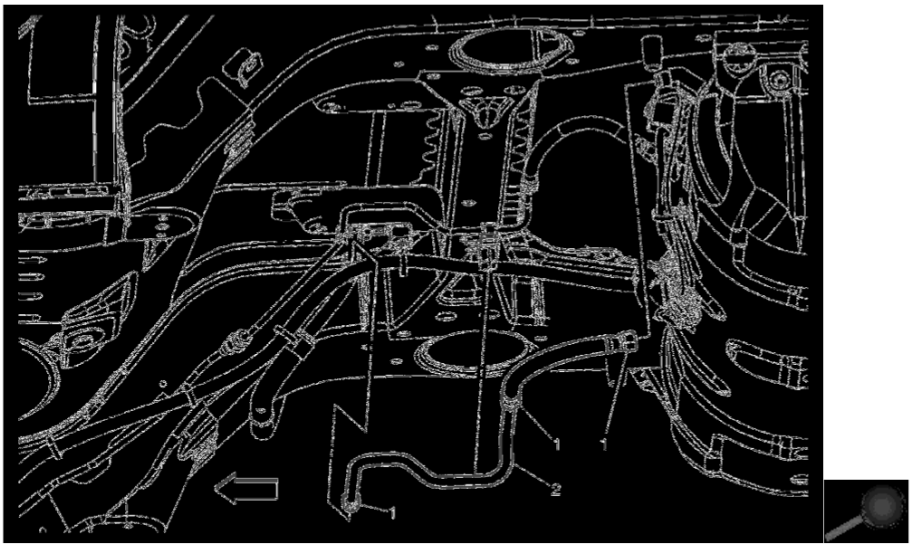
LPG Tank Filler Hose Pressure Relief

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief. 2. Remove the filler cap.
1	Non Return Valve. **Procedure** Detend the non return valve to release the pressure.

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LPG Tank Filler Hose Replacement (LWR)



LPG Tank Filler Hose Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Detend the filler valve to relive the pressure on the filler hose, filler tube, and filler hose. Refer to LPG Tank Filler Hose Pressure Relief. 2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle. 3. Lower the rear frame to gain access. Refer to Rear Frame Replacement.
1	Pipe Connection Nut (Qty: 3) **Tighten**

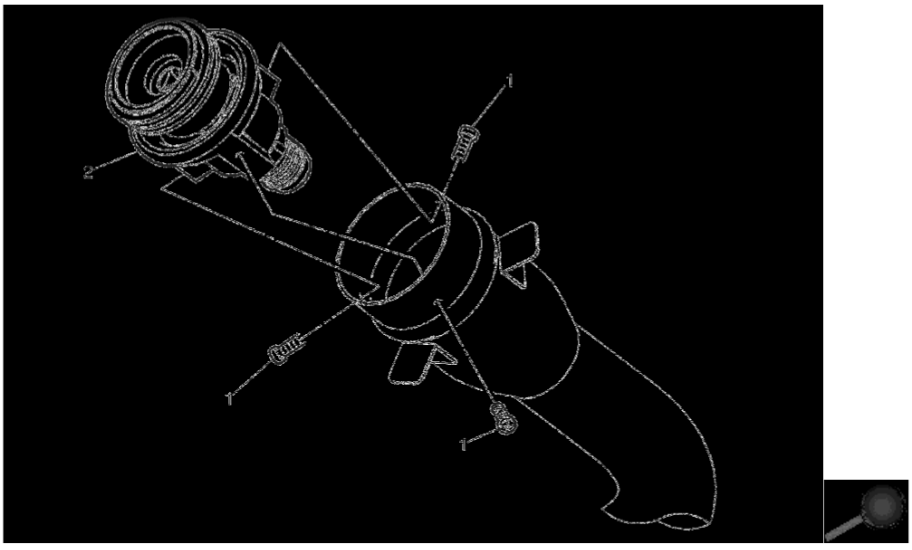
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Callout	Component Name
	62 N•m (46 lb ft)
2	LPG Tank Filler Hose **Procedure** 1. Remove LPG tank filler hose from the LPG shutoff valve and filler tube and disconnect from the retainers. 2. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.

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Fuel Tank Filler Hose Check Valve Replacement (LWR)



Fuel Tank Filler Hose Check Valve Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief. 2. Detend the filler valve to release the pressure on the filler valve, filler tube, and filler hose. Refer to LPG Tank Filler Hose Pressure Relief. 3. Remove the filler tube. Refer to Filler Tube Replacement.
1	Fuel Tank Fill Hose Check Valve Fastener (Qty: 3) **Caution:** Refer to Fastener Caution.

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Callout	Component Name
	Tighten 9 N•m (80 lb in)
2	Fuel Tank Fill Hose Check Valve

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LPG Fuel Feed Front Pipe Replacement (LWR)

Special Tools

BO-38185 Hose Clamp Pliers

For equivalent regional tools. Refer to Special Tools

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

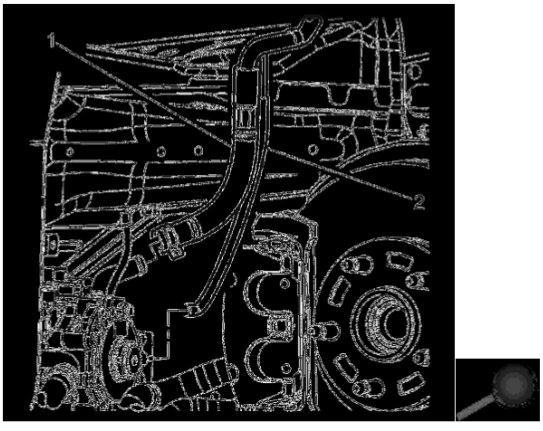
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

1. Relive the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Remove the front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement.
4. Disconnect the LPG fuel feed hose pipe to filter. Refer to LPG Fuel Feed Hose Replacement.

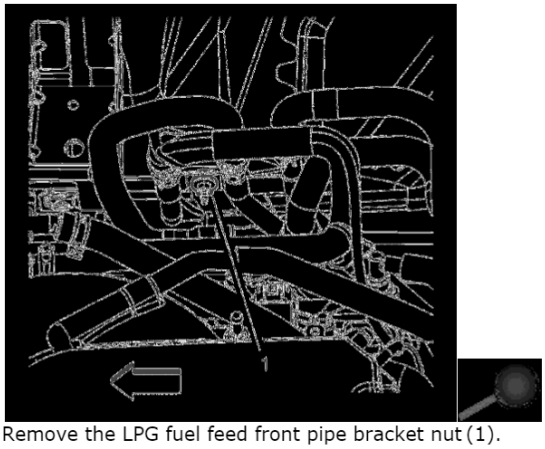


Note: Clamps are glued onto hose.

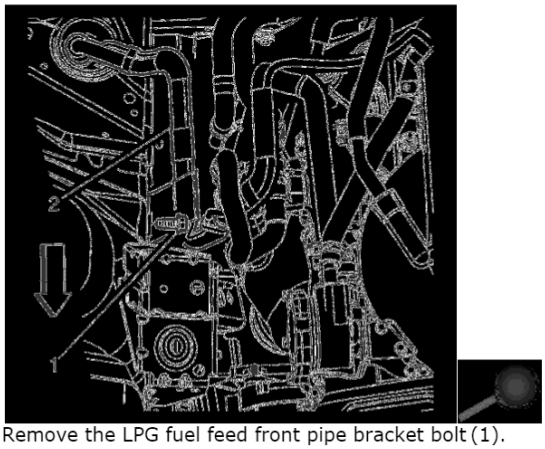
5. Disconnect the LPG fuel feed front pipe clamp assembly (1) using *BO-38185* Hose Clamp Pliers.
6. Disconnect fuel feed vacuum line (2) from the LPG vaporizer.

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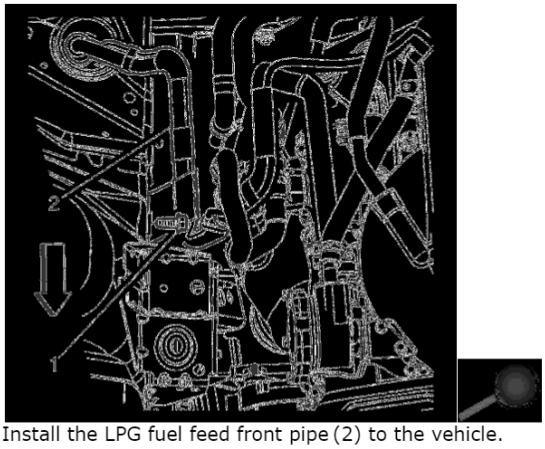


7. Remove the LPG fuel feed front pipe bracket nut (1).



8. Remove the LPG fuel feed front pipe bracket bolt (1).
9. Remove the LPG fuel feed front pipe (2) from the vehicle.

Installation Procedure

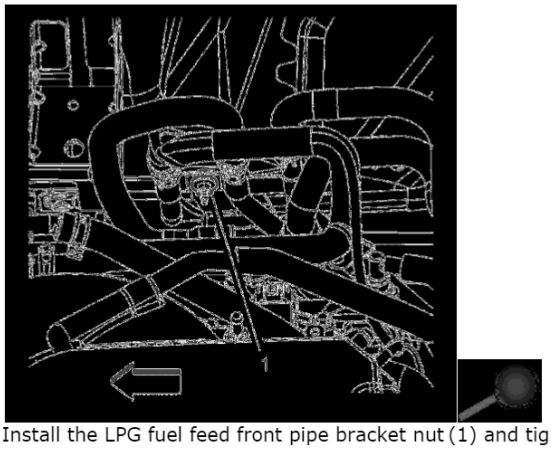


1. Install the LPG fuel feed front pipe (2) to the vehicle.

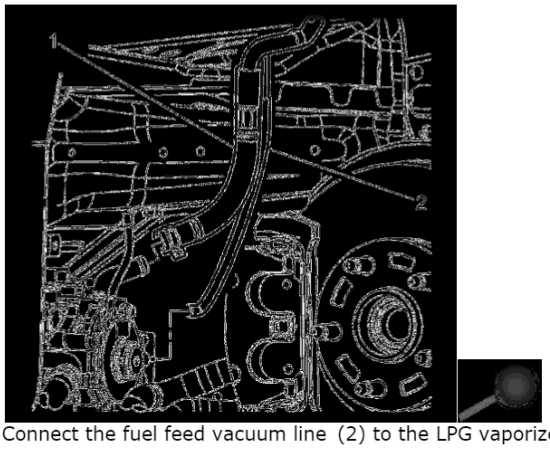
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Caution: Refer to Fastener Caution.

2. Install the LPG fuel feed front pipe bracket bolt (1) and tighten to **12 N•m (9 lb ft)**.



3. Install the LPG fuel feed front pipe bracket nut (1) and tighten to **12 N•m (9 lb ft)**.



4. Connect the fuel feed vacuum line (2) to the LPG vaporizer.
5. Connect the LPG fuel feed front pipe (1) to the LPG vaporizer using *BO-38185* Hose Clamp Pliers.
6. Connect the LPG fuel feed hose pipe to filter. Refer to LPG Fuel Feed Hose Replacement.
7. Perform leak test after final assembly. Refer to LPG Leak Testing.
8. Install the front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement.
9. Lower the vehicle

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LPG Fuel Feed Pipe Fitting Replacement (LWR)

Removal Procedure

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

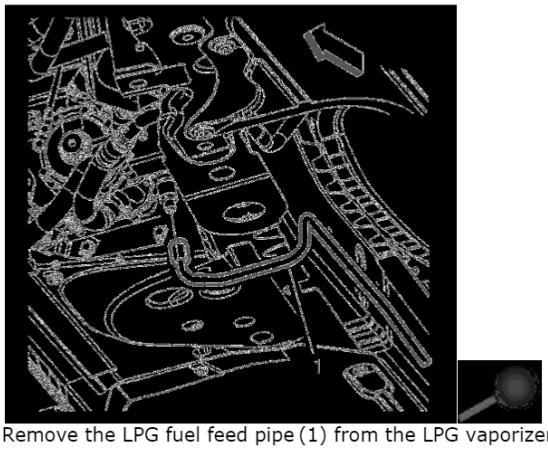
Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

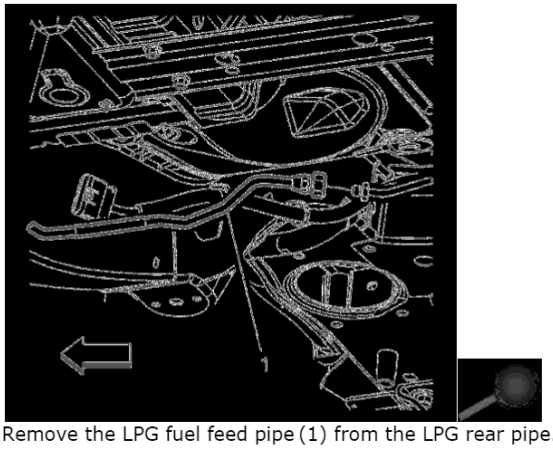
1. Revieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Remove the front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement.



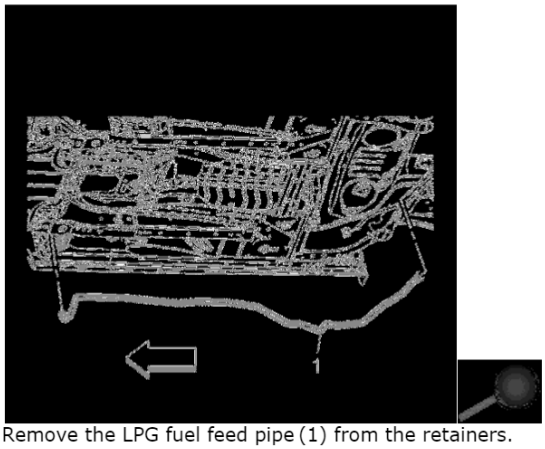
4. Remove the LPG fuel feed pipe (1) from the LPG vaporizer.

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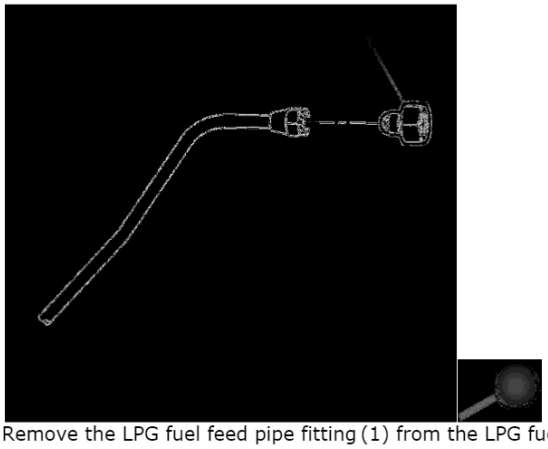
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5. Remove the LPG fuel feed pipe (1) from the LPG rear pipe.



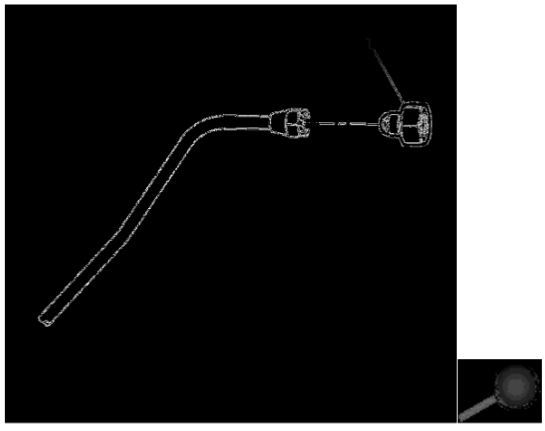
6. Remove the LPG fuel feed pipe (1) from the retainers.
7. Remove the LPG fuel feed pipe (1) from the vehicle.



8. Remove the LPG fuel feed pipe fitting (1) from the LPG fuel feed pipe.

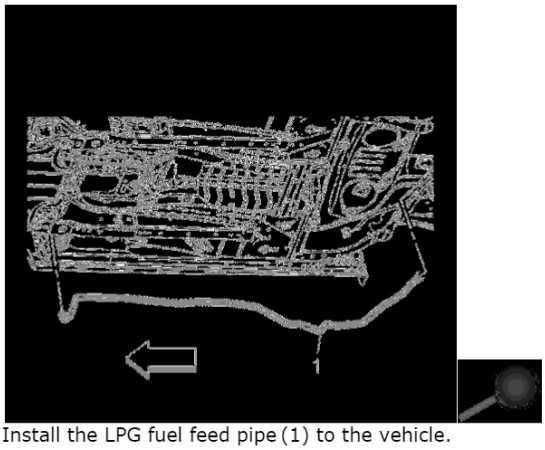
Installation Procedure

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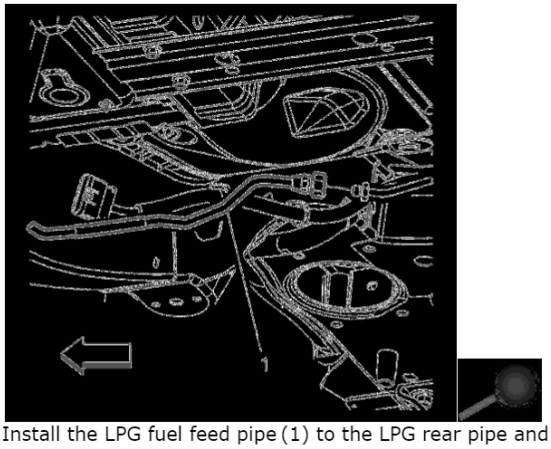
Caution: Refer to Component Fastener Tightening Caution.

1. Install the LPG fuel feed pipe fitting (1) to the LPG fuel feed pipe and torque to **19 N·m (14 lb ft)**.

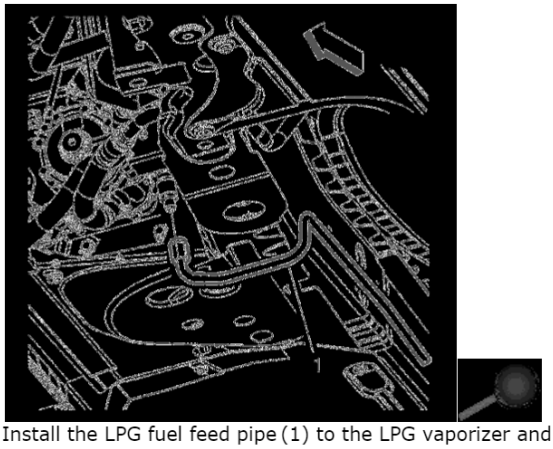


2. Install the LPG fuel feed pipe (1) to the vehicle.
3. Install the LPG fuel feed pipe (1) to the retainers.

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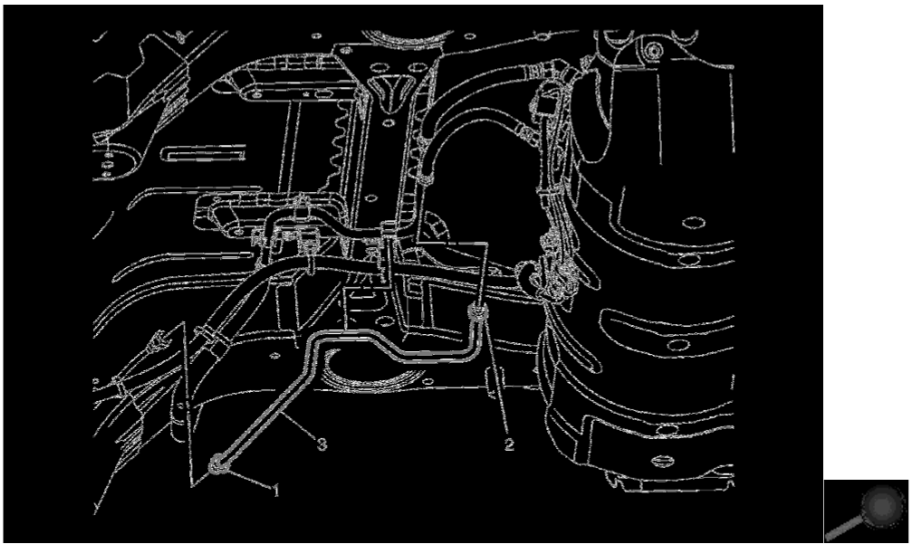
4. Install the LPG fuel feed pipe (1) to the LPG rear pipe and torque to **19 N•m (14 lb ft)**. .



5. Install the LPG fuel feed pipe (1) to the LPG vaporizer and torque to **19 N•m (14 lb ft)**..
6. Perform LPG leak test after final assemply. Refer to LPG Leak Testing
7. Install the front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement.
8. Lower the vehicle

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LPG Rear Pipe Replacement (LWR)



LPG Rear Pipe Replacement

Callout	Component Name
	Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Warning:** Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required. **Warning:** Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury. **Preliminary Procedure** 1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief. 2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle. 3. Lower the rear frame to gain access. Refer to Rear Frame Replacement
1	Pipe Connection Nut. **Caution:** Refer to Component Fastener Tightening Caution. **Tighten**

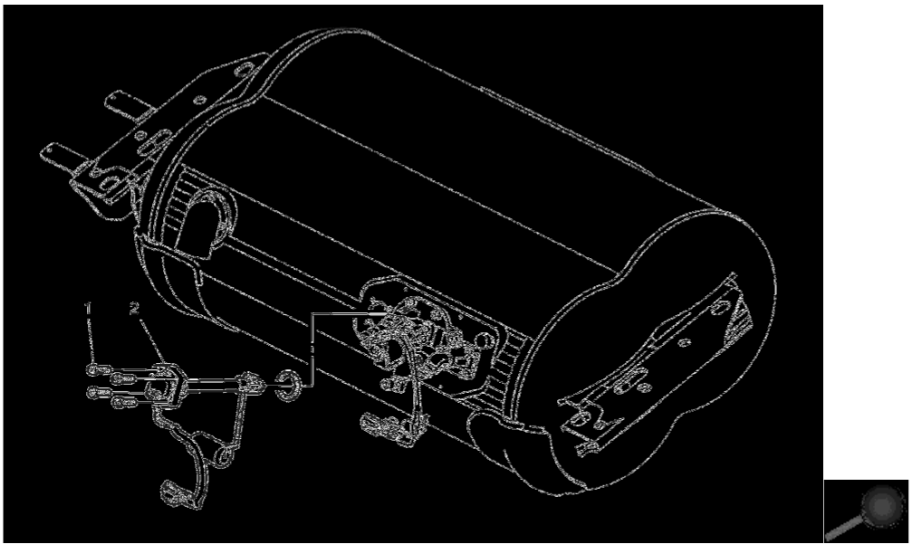
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Callout	Component Name
	20 N•m (15 lb ft)
2	Pipe Connection Nut. **Tighten** 30 N•m (22 lb ft)
3	LPG Rear Pipe. **Procedure** 1. Remove the LPG rear pipe from the LPG fuel feed pipe and fuel feed hose and disconnect from retainers. 2. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.

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Fuel Sender Assembly Replacement (LWR)



Fuel Sender Assembly Replacement

Callout	Component Name

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Preliminary Procedure

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Disconnect the electrical connectors.
4. Disconnect the LPG rear hose. Refer to LPG Fuel Feed Hose Replacement.
5. Remove the LPG fuel tank. Refer to Fuel Tank Replacement.
6. Empty the LPG fuel tank. Refer to LPG Tank Unloading.
7. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.

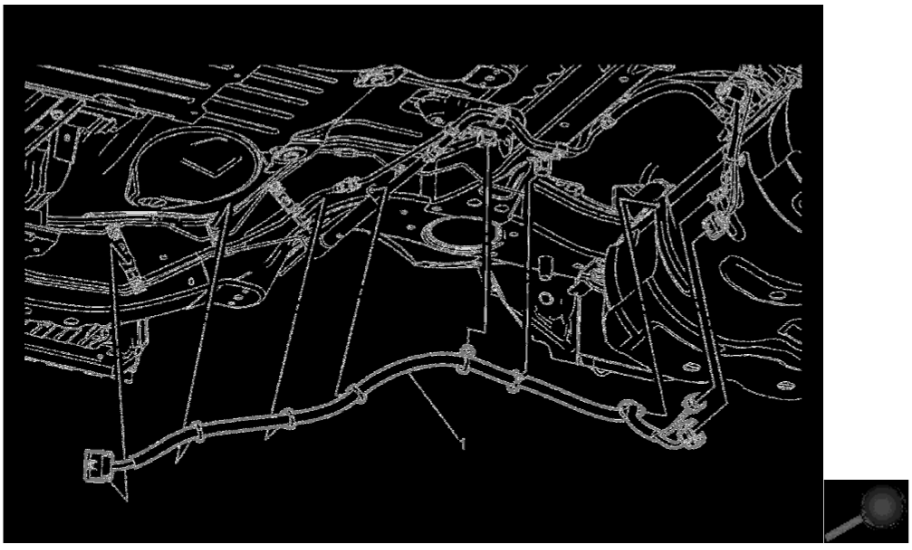
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Callout	Component Name
1	Fuel Sender Assembly Fasteners (Qty: 4). **Caution:** Refer to Fastener Caution. **Tighten** 6 N•m (53 lb in)
2	Fuel Sender Assembly. **Procedure** Remove o-ring and DISCARD, install new o-ring.

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LPG Wiring Harness Replacement (LWR)



LPG Wiring Harness Replacement

Callout	Component Name
Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425. Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet. The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder. **Preliminary Procedure** **Warning:** Refer to Battery Disconnect Warning. 1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection 2. Disconnect the LPG wiring harness electrical connector from the body harness electrical connector. 3. Disconnect the LPG wiring harness electrical connector from the LPG fuel pump and the LPG sender assembly.	
1	LPG Wiring Harness. **Procedure** Disconnect the retainers.

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LPG Tank Unloading (LWR)

Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

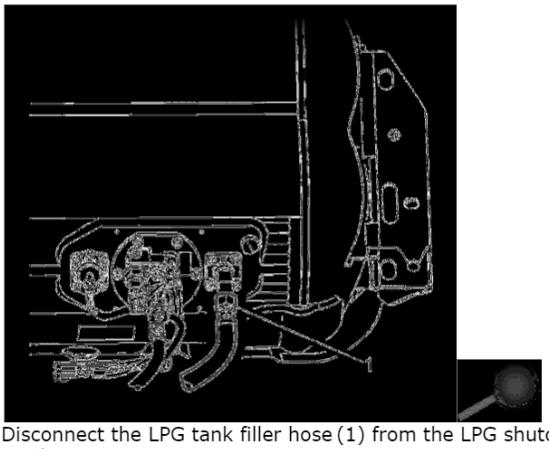
Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.

Warning: Refer to Battery Disconnect Warning.

Warning: Refer to Safety Glasses Warning.

1. Detend the filler valve to release the pressure on the filler line. Refer to LPG Tank Filler Hose Pressure Relief.
2. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
3. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.



4. Disconnect the LPG tank filler hose (1) from the LPG shutoff valve. Refer to LPG Tank Filler Hose Replacement.
5. Disconnect the LPG rear hose from the fuel PUMP. Refer to LPG Rear Pipe Replacement
6. In order to unload the LPG tank, follow Australian Standards AS/NZS 2746 appendix C and D.

   Note: Tank pump solenoid needs to be energized.
7. Perform LPG leak test after final assembly. Refer to LPG Leak Testing.

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LPG Fuel Sender Control Module Replacement (LWR)

Removal Procedure

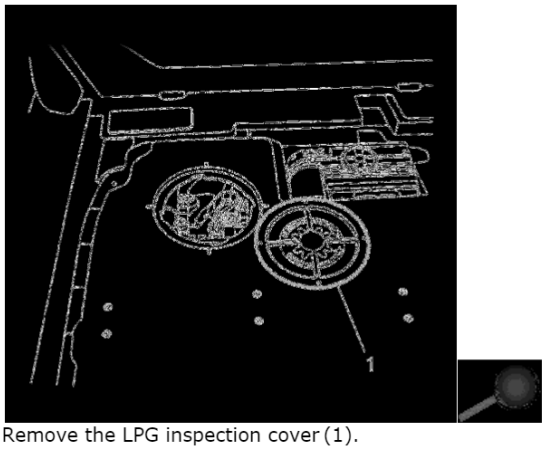
Warning: All service and repair work on LPG components must be performed by a properly trained specialist or by an authorised LPG technician and the work must be carried out to Australian Standard AS/NZS 1425.

Different States/Territories may have additional service requirements. The additional work should be carried out and noted on the service coupons found in the owner's Service/Warranty Booklet.

The LPG cylinder must be removed and pressure tested by an authorised LPG cylinder test centre once every 10 years from the original test date stamped on a plate attached to the cylinder.

Warning: Do not allow smoking or the use of open flames in the area where work on the fuel system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

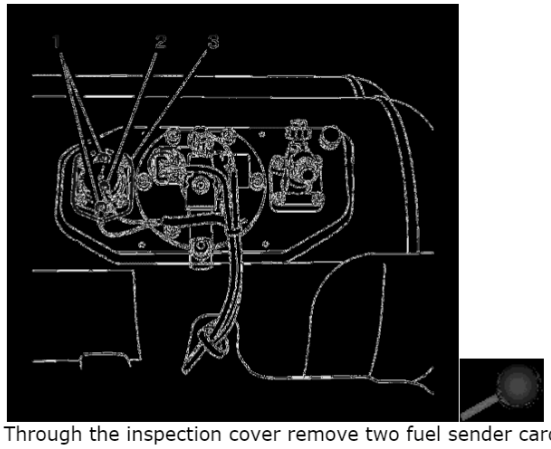
Warning: Provide proper ventilation when working with fuel in enclosed areas where fuel vapors can collect. The lack of adequate ventilation may result in personal injury.



1. Remove the LPG inspection cover (1).

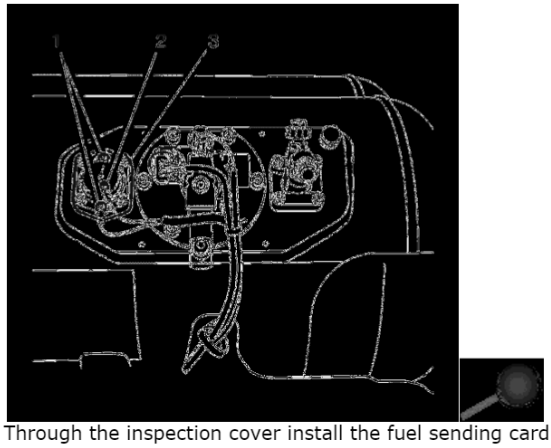
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2. Through the inspection cover remove two fuel sender card assembly screws (1).
3. Remove the wire retaining screws (2).
4. Remove the fuel sending card assembly (3).

Installation Procedure

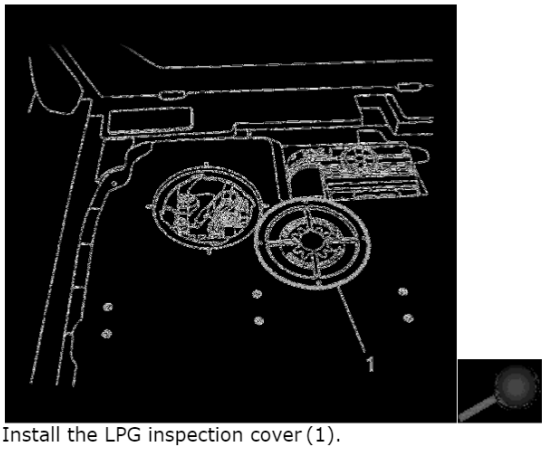


1. Through the inspection cover install the fuel sending card assembly (3).
2. Install the wire retaining screws (2).

   Caution: Refer to Fastener Caution.

   Note: The advised torque for the two fuel sender card assembly screws is **1 N•m (9 lb in)**, no further tighten is required as damage will occur to the sender card housing.
3. Install the two fuel sender card assembly screws (1) and tighten to **1 N•m (9 lb in)**.

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4. Install the LPG inspection cover (1).

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Temperature Versus Resistance - Engine Coolant Temperature Sensor

Temperature Versus Resistance - Engine Coolant Temperature Sensor

Temperature C°/F°	Resistance Ohms	Resistance Tolerance Ohms
Engine Coolant Temperature (ECT)		
−40/−40	100865	4,87
−20/−4	28582	4.00
−10/14	16120	3.60
0/32	9399	3.21
20/68	3511	2,64
25/77	2795	2.50
40/104	1465	2.36
60/140	671	2.19
80/176	334	2.04
100/212	178	2.31
120/248	100.90	2.68
140/284	60.30	2.87

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Temperature Versus Resistance - Intake Air Temperature Sensor (Hitachi Sensor)

Temperature Versus Resistance - Intake Air Temperature Sensor

Temperature C°/F°	Resistance Minimum Ohms	Resistance Maximum Ohms
Hitachi Intake Air Temperature (IAT) Sensor		
−40/−40	37,527	49,882
−20/−4	13,110	16,329
−10/14	8,145	9,851
0/32	5,205	6,122
20/68	2,298	2,570
25/77	1,900	2,100
40/104	1,073	1,226
60/140	537	639
80/176	289	356
100/212	165	210
120/248	99	129
140/284	62	83
150/302	49	67

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Altitude Versus Barometric Pressure

Altitude Versus Barometric Pressure

Altitude Measured in Meters (m)	Altitude Measured in Feet (ft)	Barometric Pressure Measured in Kilopascals (kPa)	Barometric Pressure Measured in Pounds Per Square Inch (PSI)
Determine your altitude by contacting a local weather station or by using another reference source.			
4,267	14,000	56–64	8.1–9.3
3,962	13,000	58–66	8.4–9.6
3,658	12,000	61–69	8.8–10.0
3,353	11,000	64–72	9.3–10.4
3,048	10,000	66–74	9.6–10.7
2,743	9,000	69–77	10.0–11.2
2,438	8,000	71–79	10.3–11.5
2,134	7,000	74–82	10.7–11.9
1,829	6,000	77–85	11.2–12.3
1,524	5,000	80–88	11.6–12.8
1,219	4,000	83–91	12.0–13.2
914	3,000	87–95	12.6–13.8
610	2,000	90–98	13.1–14.2
305	1,000	94–102	13.6–14.8
0	0 Sea Level	96–104	13.9–15.1
−305	−1,000	101–105	14.6–15.2

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Ignition System Specifications

Ignition System Specifications

Application	Specification
Firing Order	1–2–3–4–5–6
Spark Plug Torque	Refer to Fastener Tightening Specifications
Spark Plug Gap	Refer to Engine Mechanical Specifications
Spark Plug Type	Refer to Electronic Parts Catalog

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Fastener Tightening Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Pedal Position Sensor Screws	9 N•m	80 lb in
Air Cleaner Duct to Air Cleaner Assembly Clamp	2 N•m	18 lb in
Air Cleaner Inlet Duct to Air Cleaner Assembly Clamp	4 N•m	35 lb in
Air Cleaner Inlet Duct to Throttle Body Retaining Clamp	4 N•m	35 lb in
Air Cleaner Outlet Duct to Air Cleaner Assembly Clamp (LFW)	2 N•m	18 lb in
Air Cleaner Outlet Duct to Throttle Body Retaining Clamp (LFW)	2 N•m	18 lb in
Air Cleaner to Chassis Retaining Bolts	10 N•m	89 lb in
Camshaft Position Actuator Solenoid Valve to Engine Front Cover Retaining Bolt	9 N•m	80 lb in
Camshaft Position Sensor to Engine Front Cover Retaining Bolt	10 N•m	89 lb in
Crankshaft Position Sensor to Engine Block Retaining Bolt	10 N•m	89 lb in
Engine Coolant Temperature (ECT) Sensor	20 N•m	15 lb ft
Evaporative Emission Canister Purge Valve Solenoid to Intake Manifold Bolt (LLT)	9 N•m	80 lb in
Evaporative Emission Canister Purge Valve Solenoid to Intake Manifold Bolt (LFW)	10 N•m	89 lb in
Evaporative Emission Canister Retaining Nuts	6 N•m	53 lb in
Fill Line Fitting to LPG Tank Bolts	18 N•m	13 lb ft
Front Fuel/Brake Pipe Assembly Protection Plate to Vehicle Mounting Bolts	22 N•m	16 lb ft
Fuel Feed Intermediate Pipe (LFW)		
	16 N•m	12 lb ft

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Application	Specification	
	Metric	English
• First Pass		
• Final Pass	32 N•m	24 lb ft
Fuel Feed Pipe Bolts (LFW)	50 N•m	37 lb ft
Fuel Feed Pipe to High Pressure Fuel Pump Fitting (LFW)	28 N•m	21 lb ft
Fuel Filler Tube Hose Clamp	4 N•m	35 lb in
Fuel Filler Tube to Chassis Retaining Bolts	9 N•m	80 lb in
Fuel Rail to Lower Manifold Retaining Bolts	10 N•m	89 lb in
Fuel Pipe Shield Retaining Bolts (LFW)	10 N•m	89 lb in
Fuel Pressure Sensor to Fuel Rail (LFW)	33 N•m	24 lb ft
Fuel Pump Flow Control Module Retaining Nut (LFW)	9 N•m	80 lb in
Fuel Tank Assembly Strap to Chassis Retaining Bolts	30 N•m	22 lb ft
Heated Oxygen Sensor - Bank 1 Sensor 1	42 N•m	31 lb ft
Heated Oxygen Sensor - Bank 1 Sensor 2	42 N•m	31 lb ft
Heated Oxygen Sensor - Bank 2 Sensor 1	42 N•m	31 lb ft
Heated Oxygen Sensor - Bank 2 Sensor 2	42 N•m	31 lb ft
High Pressure Fuel Pump Retaining Bolts (LFW)	15 N•m	11 lb ft
Ignition Coil to Camshaft Cover Retaining Bolts	10 N•m	89 lb in
Injector Fuel Rail Bolts Bank 1 and Bank 2 (LFW)		
• First Pass	12 N•m	106 lb in
• Final Pass	23 N•m	17 lb ft
Intake Manifold Runner Control Solenoid to Manifold Retaining Bolts (LY7)	10 N•m	89 lb in
Knock Sensor to Engine Block Retaining Bolt	23 N•m	17 lb ft

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Application	Specification	
	Metric	English
LPG Control Module to LPG Control Module Bracket Retaining Nuts	5 N•m	44 lb in
LPG Convertor to Body Retaining Bolts	5 N•m	44 lb in
LPG Fill Line to Body Clamp Screw	3 N•m	27 lb in
LPG Fill Line to LPG Fill Valve	18 N•m	13 lb ft
LPG Fill Line to LPG Tank Fitting	62 Y	46 lb ft
LPG Fill Valve to Body Retaining Nut	62 Y	46 lb ft
LPG Filler Tube to Chassis Retaining Bolts	9 N•m	80 lb in
LPG Filler Tube to Fuel Tank	5 N•m	44 lb in
LPG Fuel Injector to Fuel Rail Retaining Nuts	5 N•m	44 lb in
LPG Shutoff Filter to LPG Shutoff Valve Retaining Bolt	4 N•m	35 lb in
LPG Tank Gauge to LPG Tank Retaining Screws	3 N•m	27 lb in
LPG Tank to Body Retaining Nuts and Bolts	30 N•m	22 lb ft
LPG Wiring Harness Earth Cable to Air Conditioning Compressor Retaining Bolt	22 N•m	16 lb ft
LPG Wiring Harness Power Cable Retaining Nut	10 N•m	89 lb in
Mass Airflow Sensor to Air Box Retaining Screws	4 N•m	35 lb in
Mass Airflow Sensor to Air Cleaner Assembly Screws (LFW)	1 N•m	9 lb in
Rear Frame to Chassis Retaining Bolts		
• First Pass	65 N•m	48 lb ft
• Final Pass	125 degrees	
Rear Fuel/Brake Pipe Assembly Stone Guard Retaining Nuts (LY7)	4 N•m	35 lb in
Rear Stone Guard to Chassis Retaining Nuts (LFW)	4 N•m	35 lb in
Service Line Fitting to LPG Convertor		13 lb ft

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Application	Specification	
	Metric	English
	18 N•m	
Service Line Fitting to LPG Manual Service Valve and Bolts		
• First Pass	10 Y	89 lb in
• Final Pass	60 degrees	
Service Line Fitting to LPG Shutoff Valve	18 N•m	13 lb ft
Spark Plug	20 N•m	15 lb ft
Throttle Body to Intake Manifold Retaining Bolts	10 N•m	89 lb in

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Adhesives, Fluids, Lubricants, and Sealers

Adhesives, Fluids, Lubricants, and Sealers

Application	Type of Material	GM Part Number	
		United States	Canada
Anti-Seize Compound	Anti-seize	88862477	88862478
Camshaft Prelube	Lubricant	88862586	88862827
Coolant and Oil Plug Threads	Sealant	12346004	10953480
Crankshaft Prelube	5W-30	19293000	19286321
Engine Oil	5W-30	19293000	19286321
GM Fuel System Treatment Plus	Cleaner	88861011	88861012
Oil Pan, Engine Front Cover, Crankshaft Rear Oil Seal Housing, Expansion Plugs	Sealant	12378521 (150g cartridge)	88901148
		88861417 (75 gram squeeze tube)	88861418

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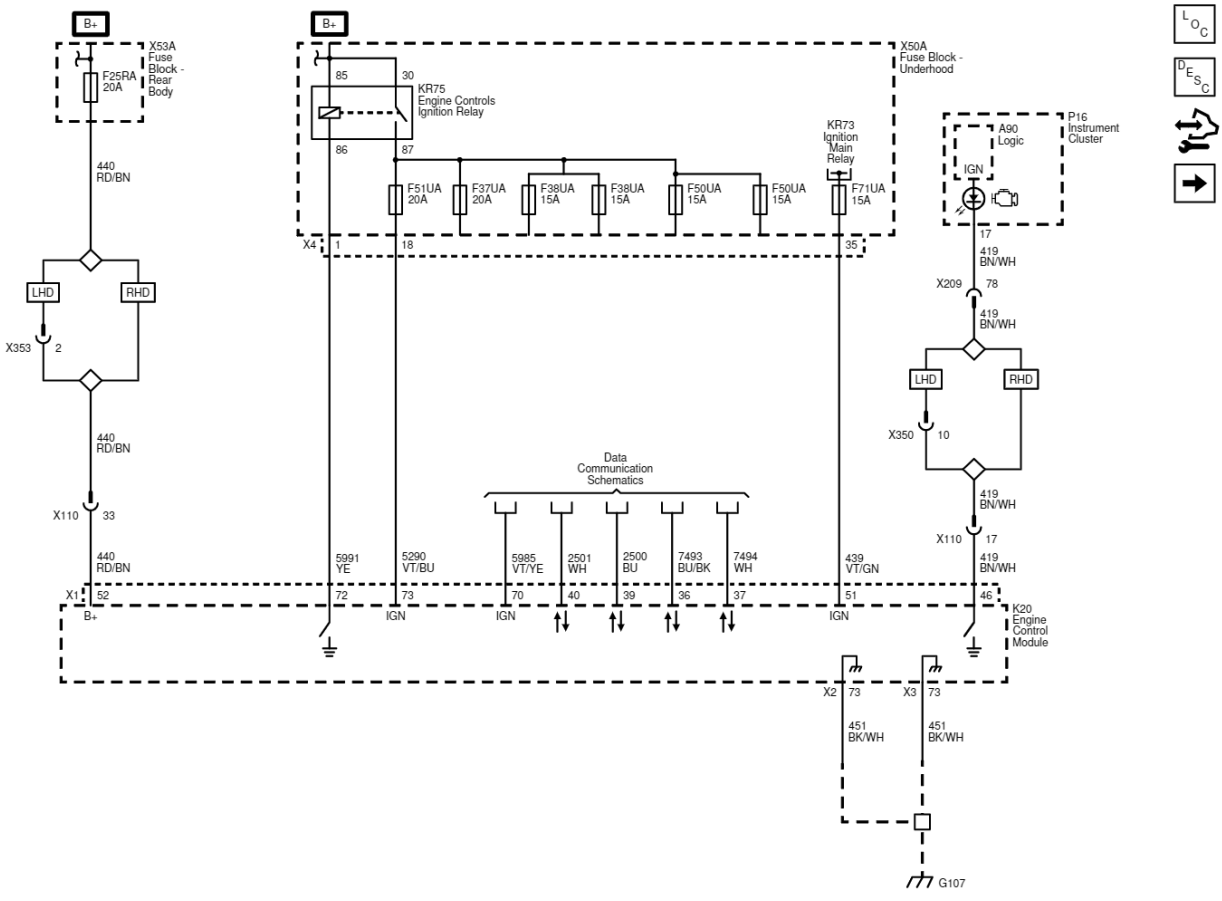
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Engine Controls Schematics (LFW/LFX)

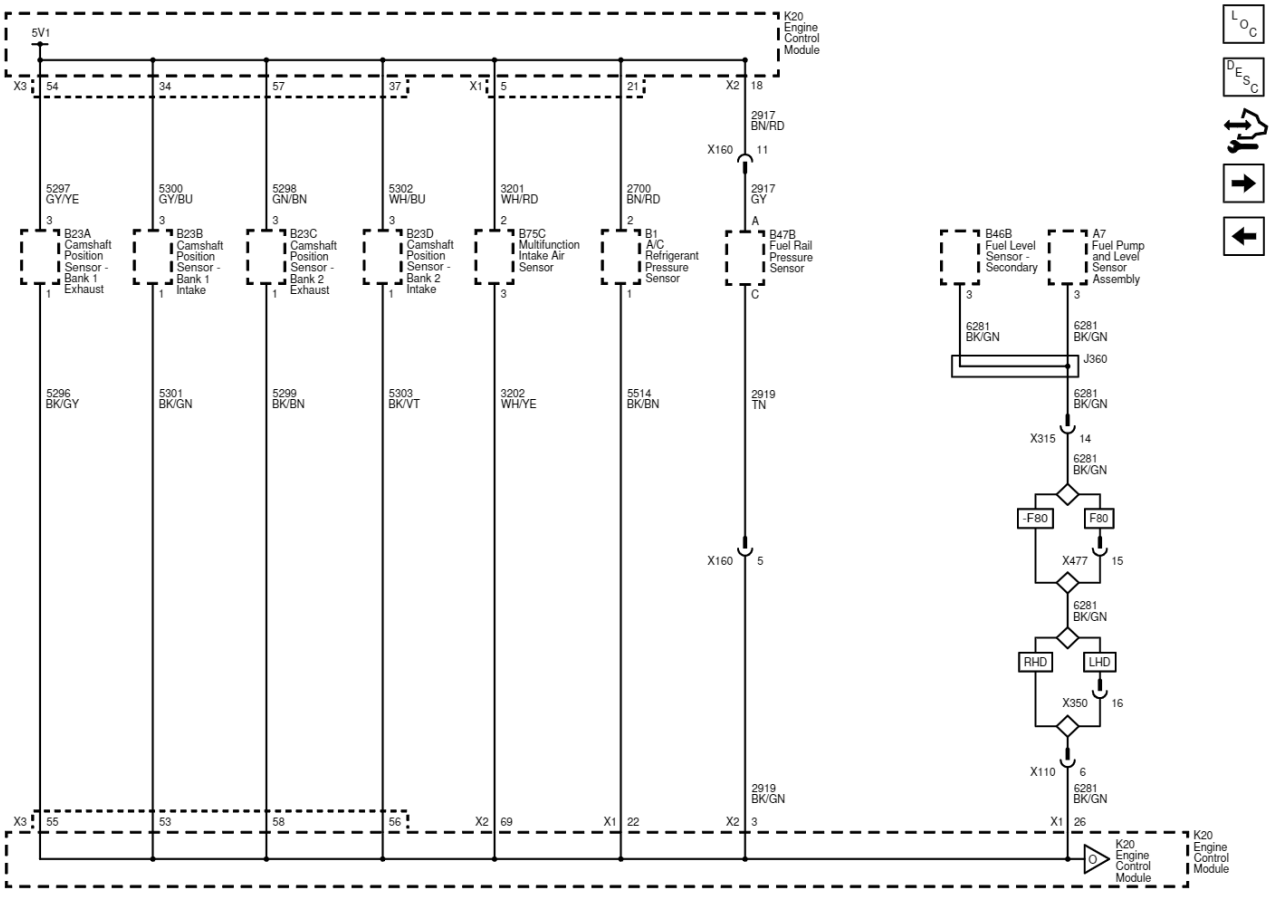
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Figure 8: Ignition Controls - Camshaft Actuators, Camshaft, Crankshaft, and Knock Sensors
Figure 9: Fuel Controls - Fuel Injectors, Fuel Pressure Sensor and High Pressure Fuel Pump
Figure 10: Fuel Controls - Fuel Pump Flow Control
Figure 11: Fuel Controls - Fuel Pump and Fuel Pressure Sensor
Figure 12: Fuel Controls - Fuel Composition Sensor and Evaporative Emission
Figure 13: Controlled/Monitored Subsystem References

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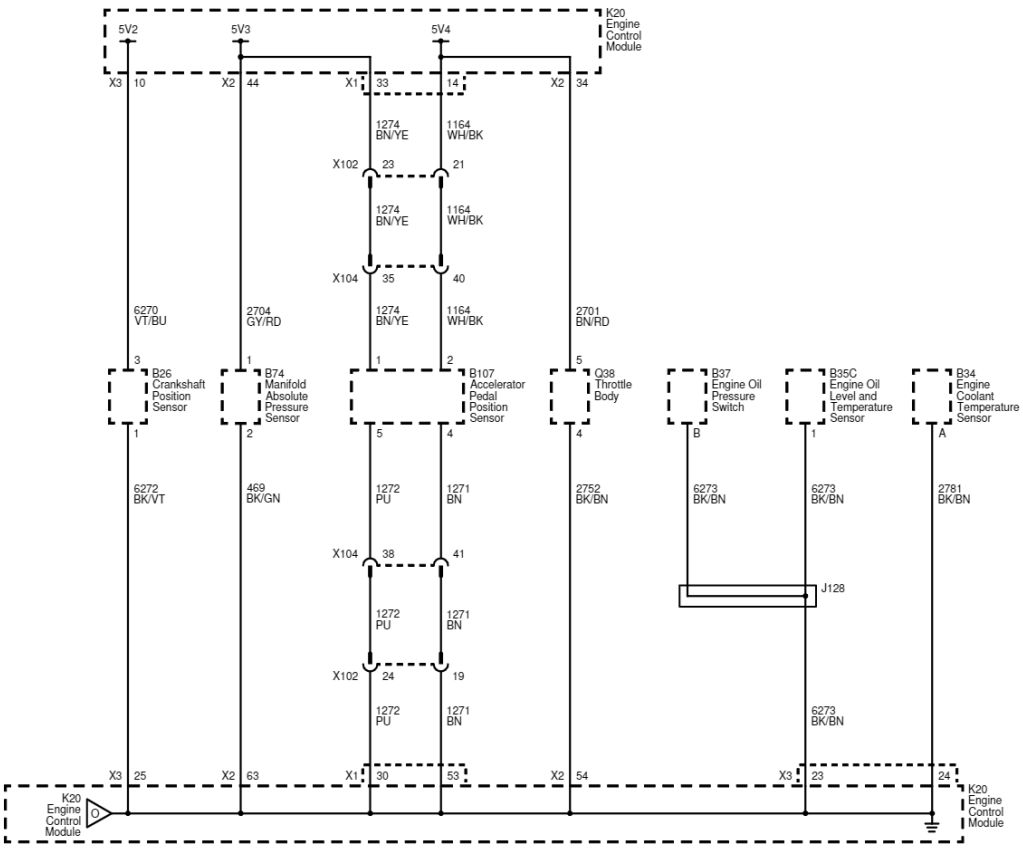
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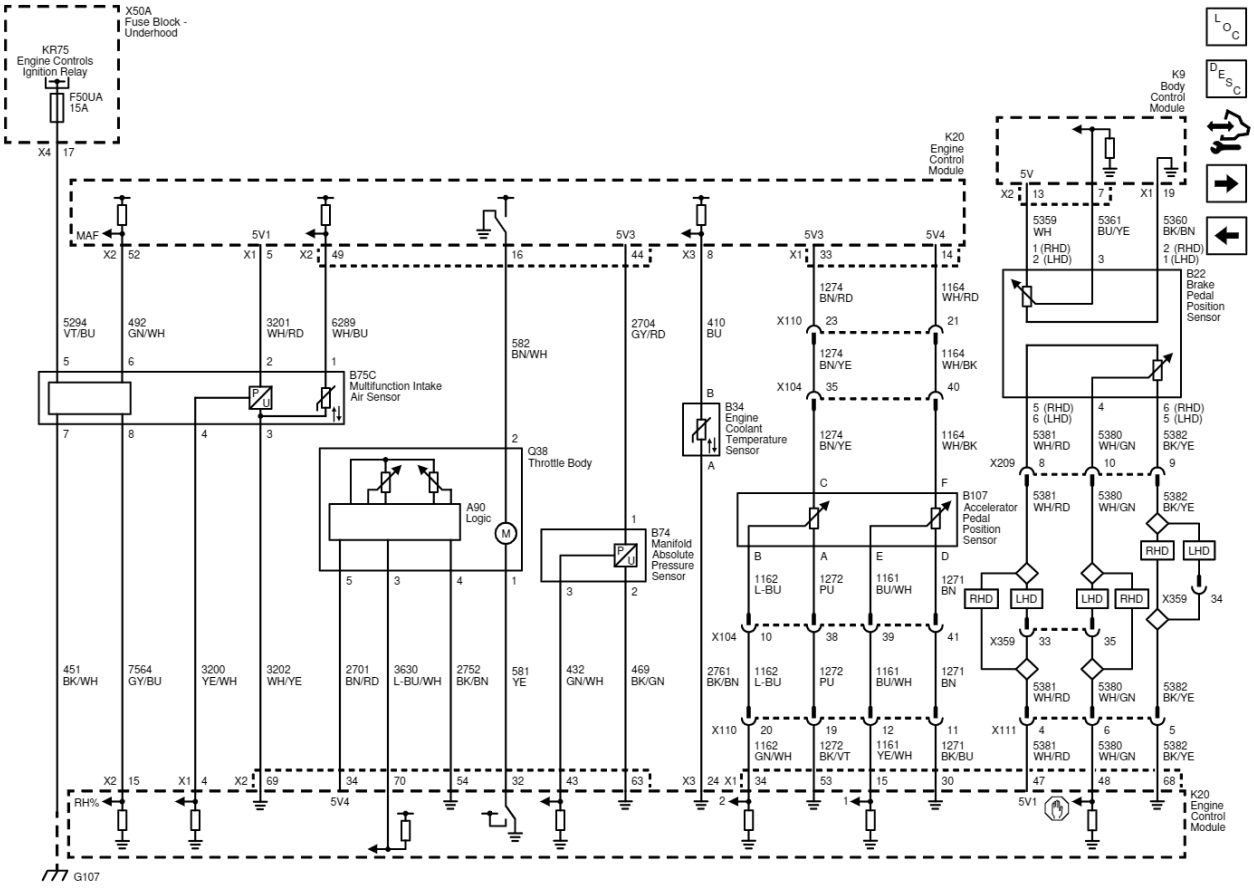
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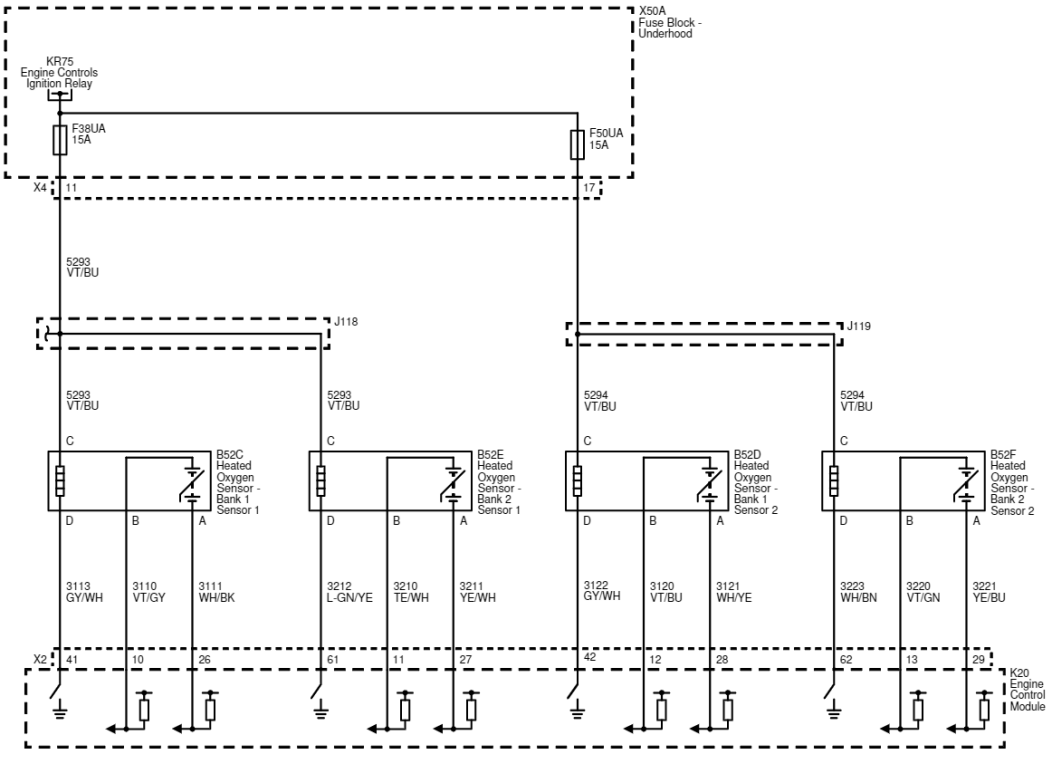
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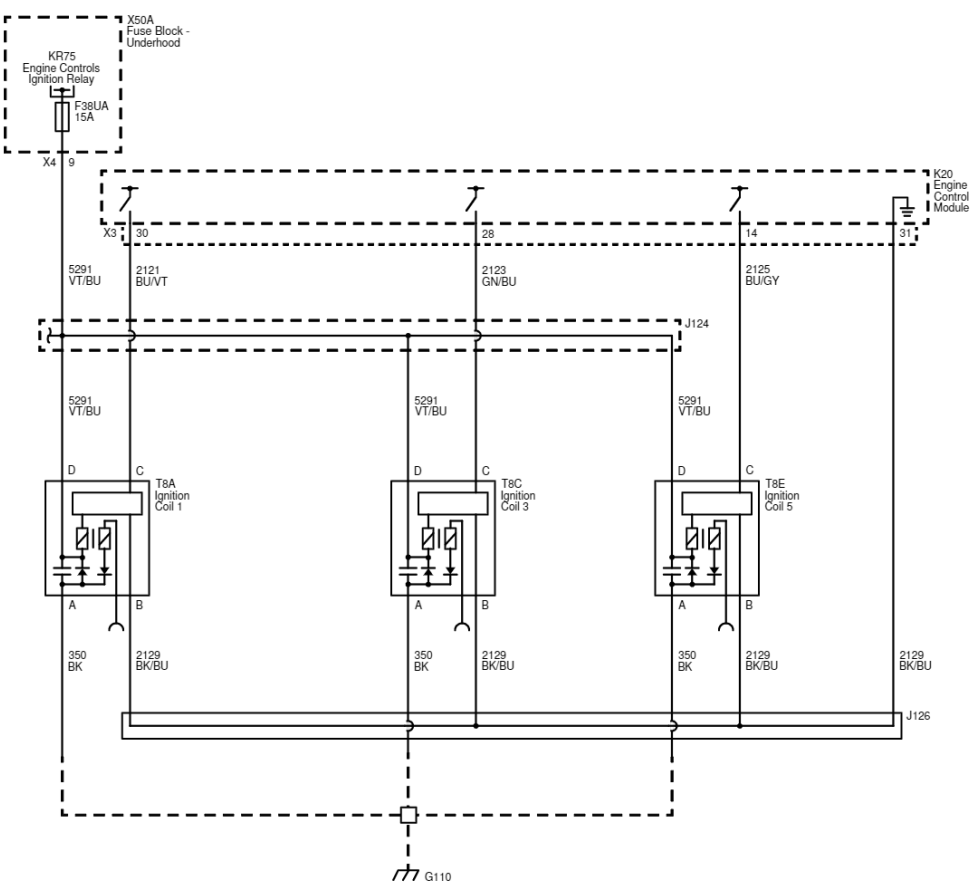
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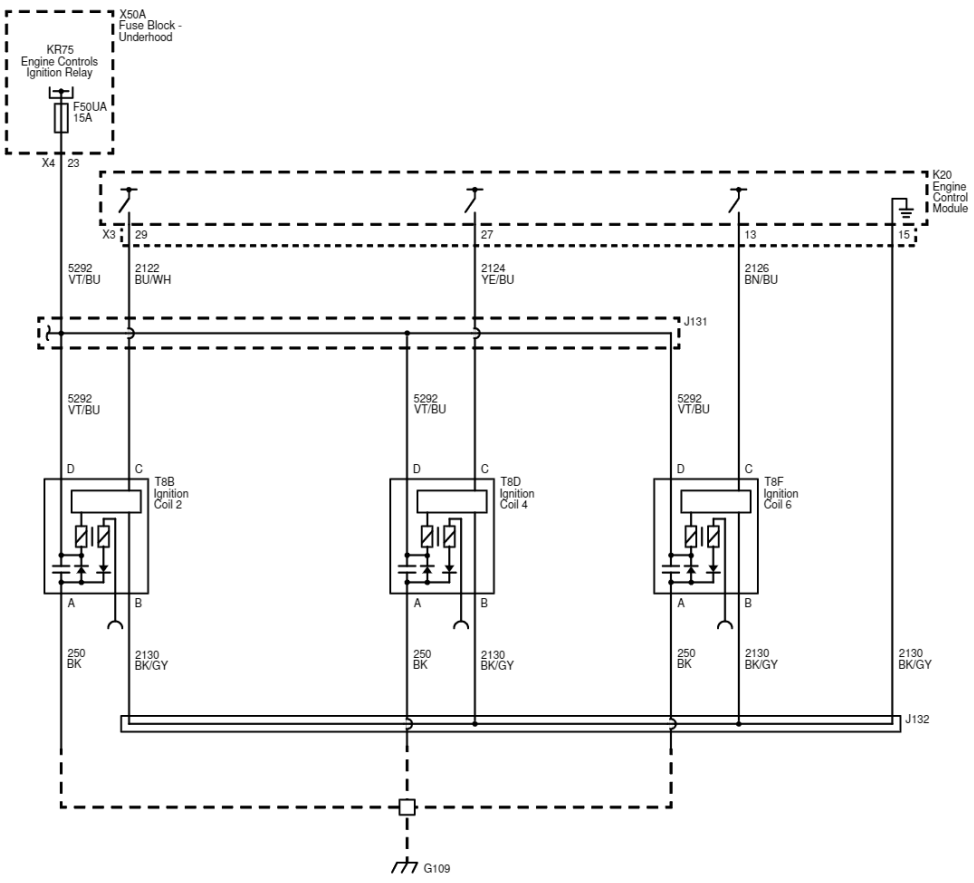
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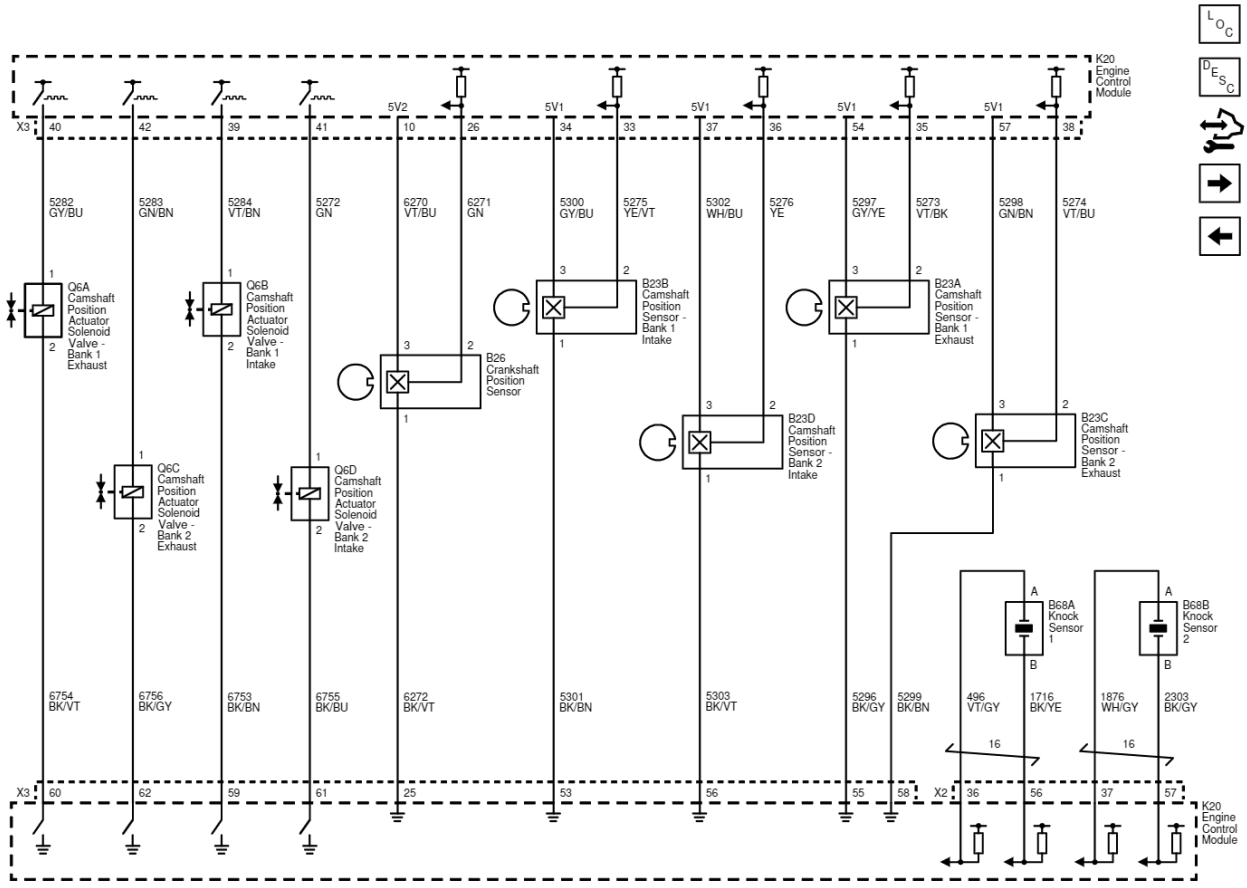
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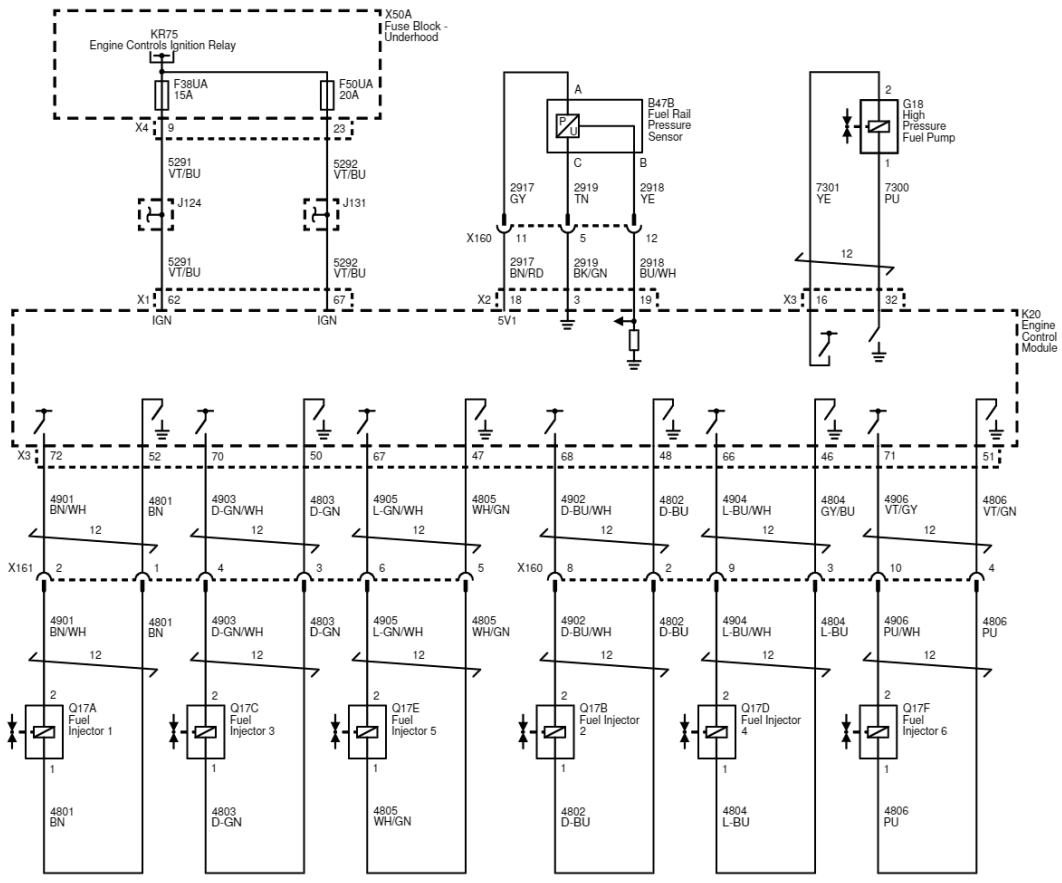
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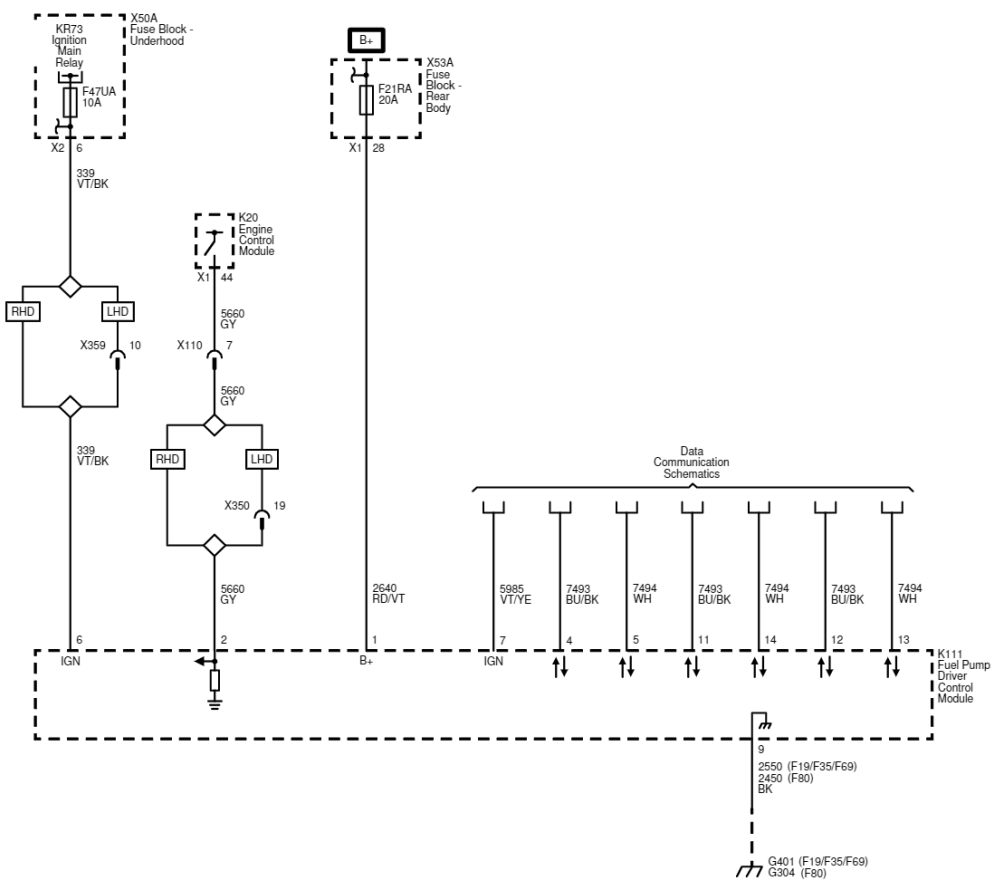
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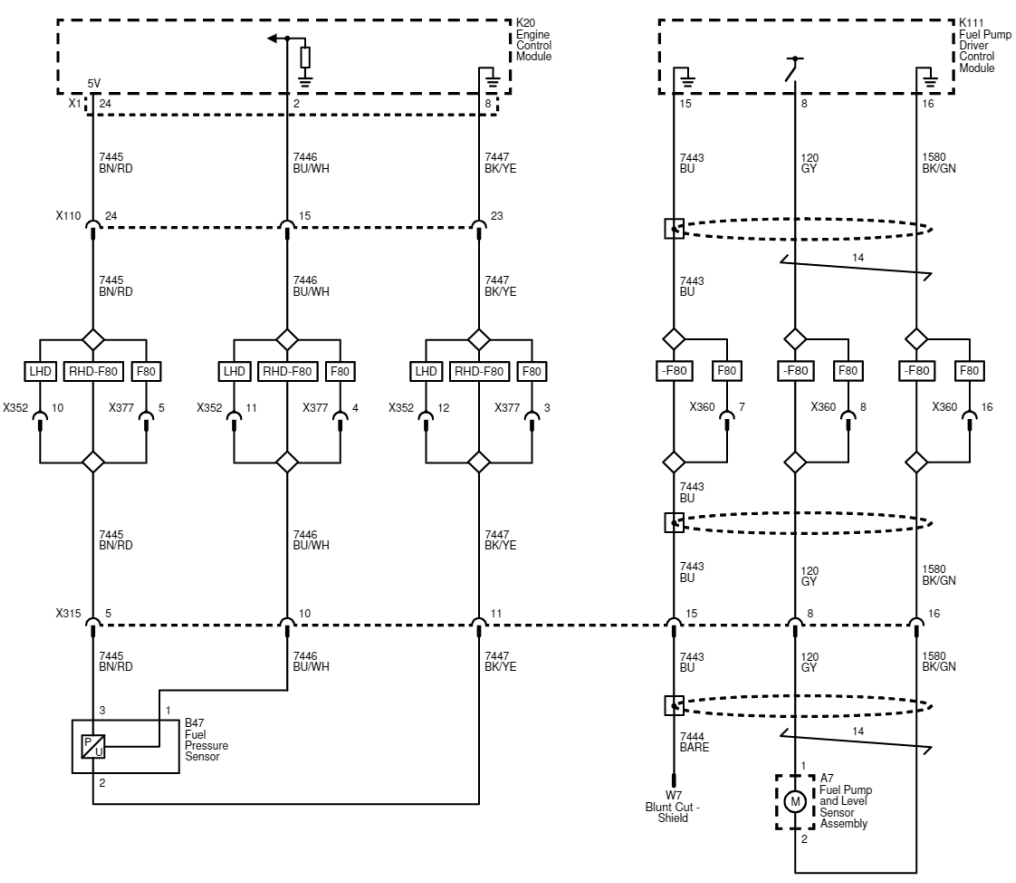
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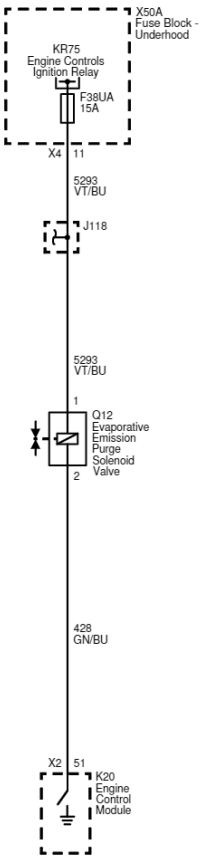
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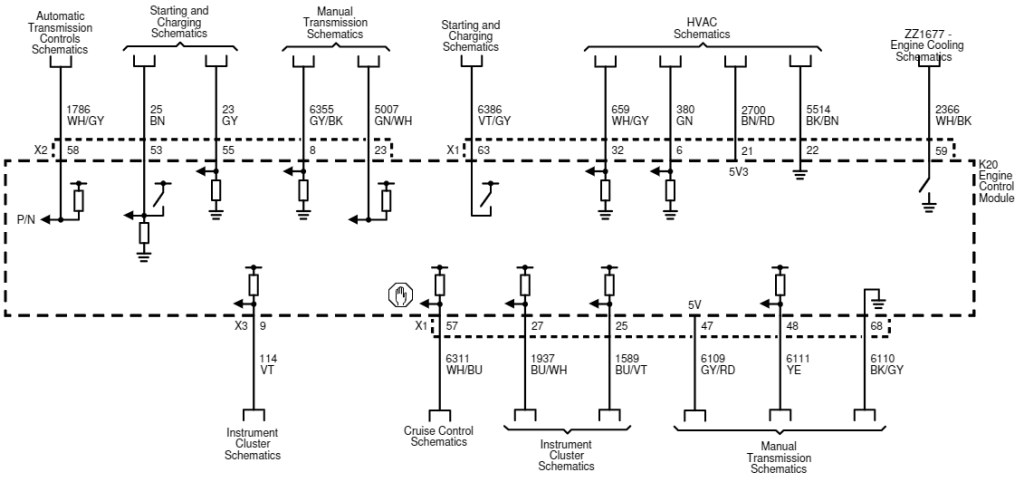
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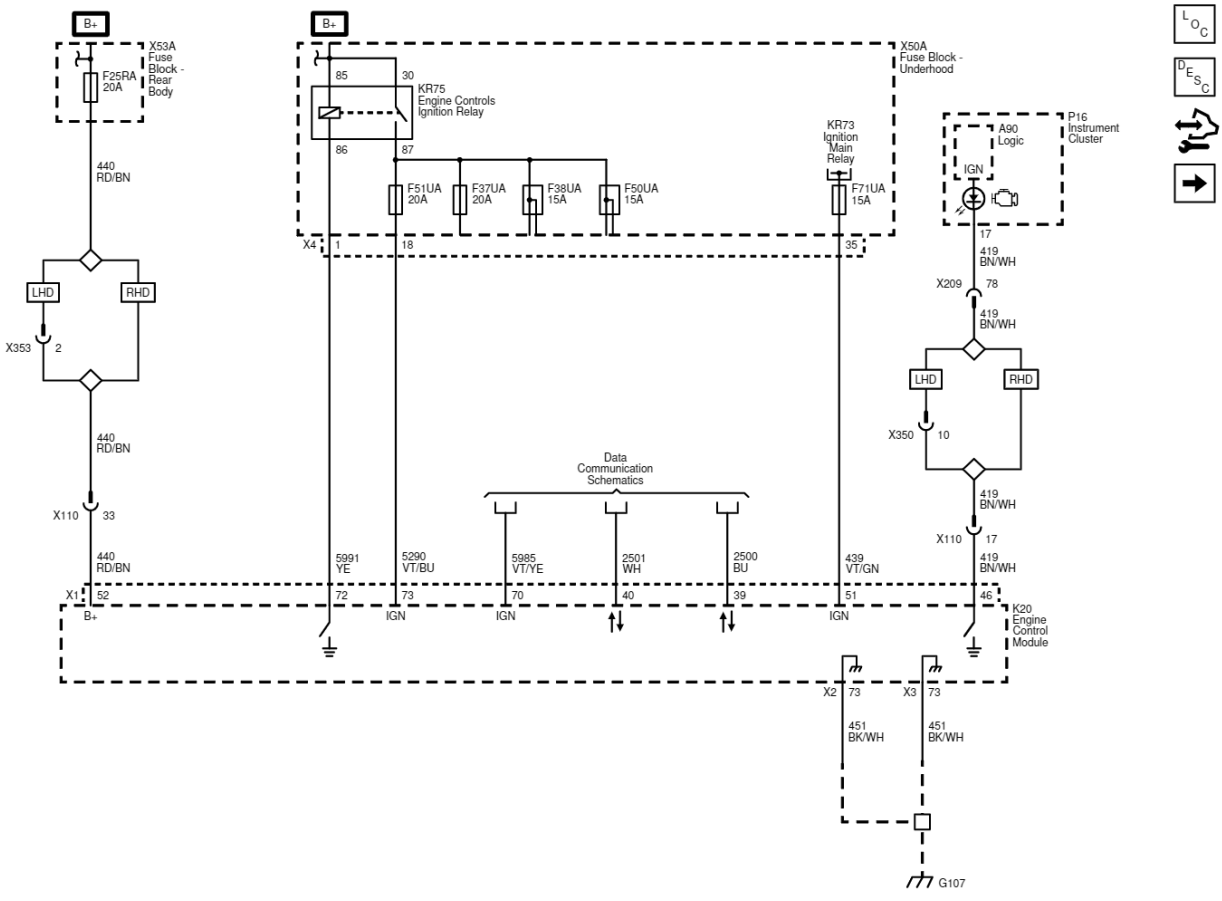
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Engine Controls Schematics (LWR)

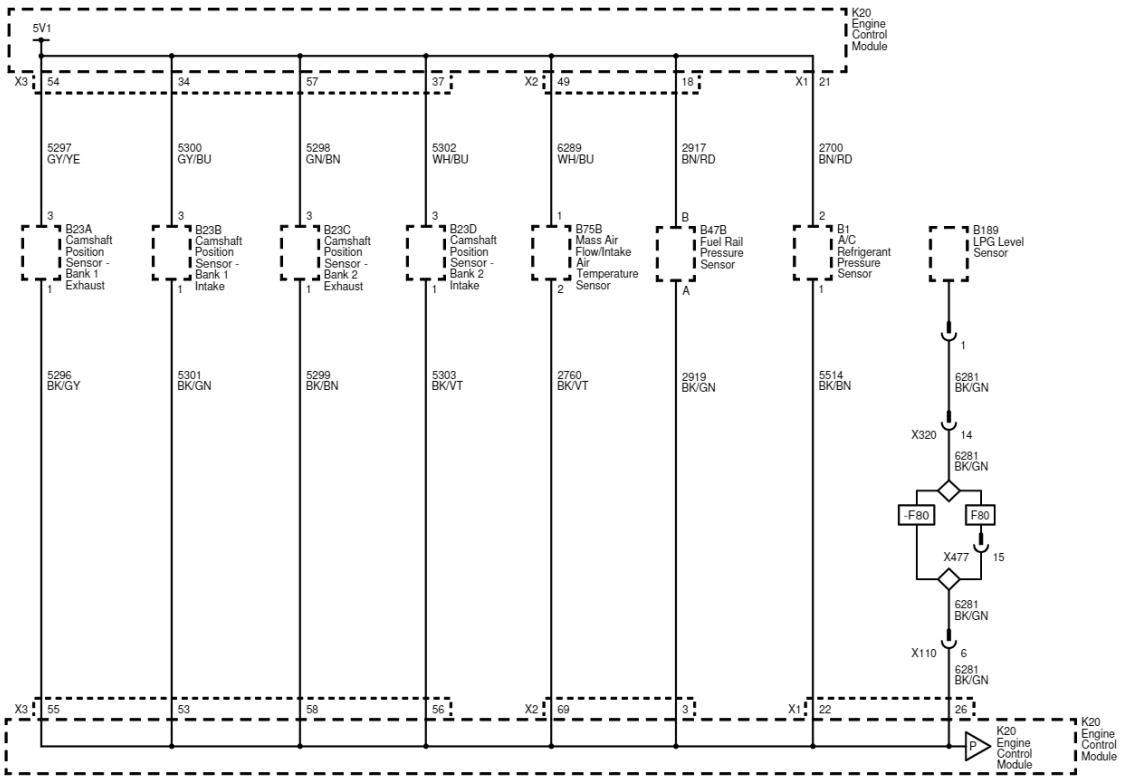
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Figure 12: Fuel Controls - Fuel Injector Control and LPG Vaporizer
Figure 13: Fuel Controls - LPG Cut-Off Solenoid Valves < February 2014
Figure 14: Fuel Controls - LPG Cut-Off Solenoid Valves > February 2014
Figure 15: Controlled/Monitored Subsystem References

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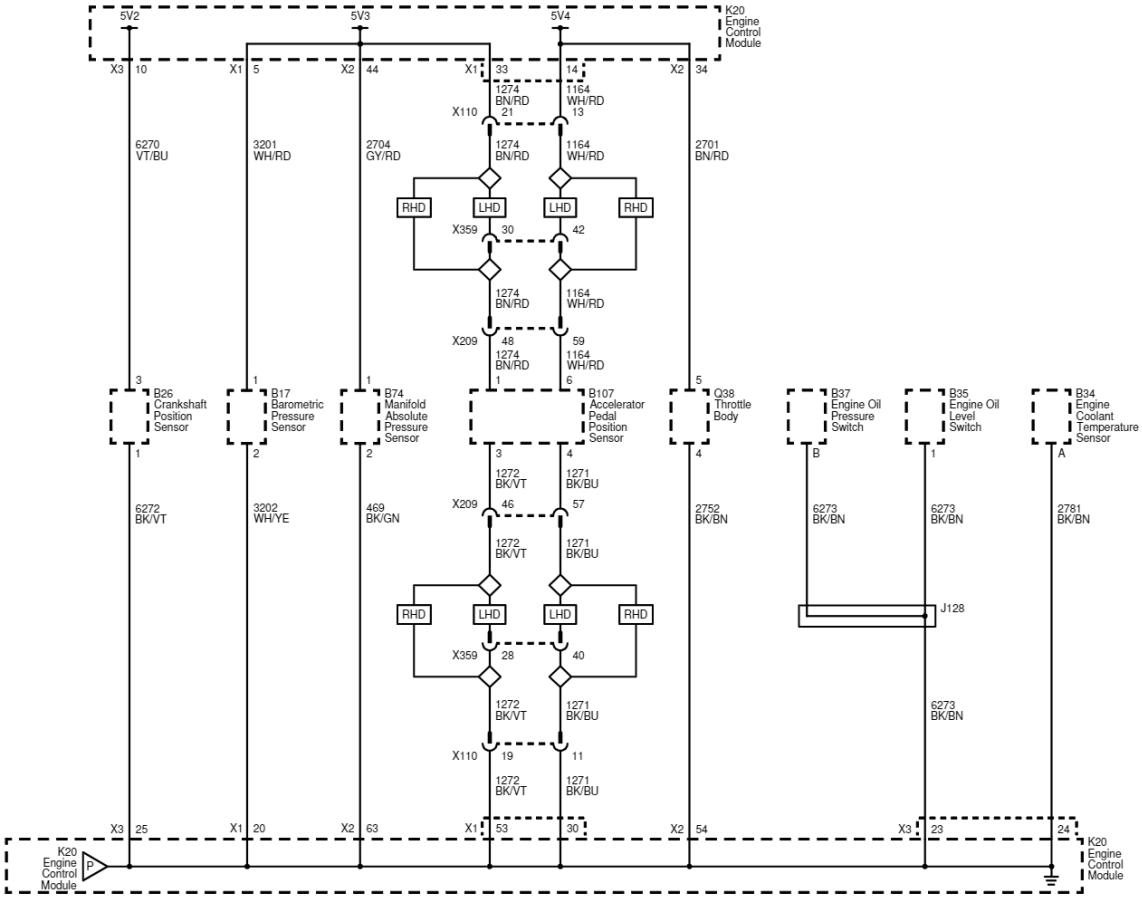
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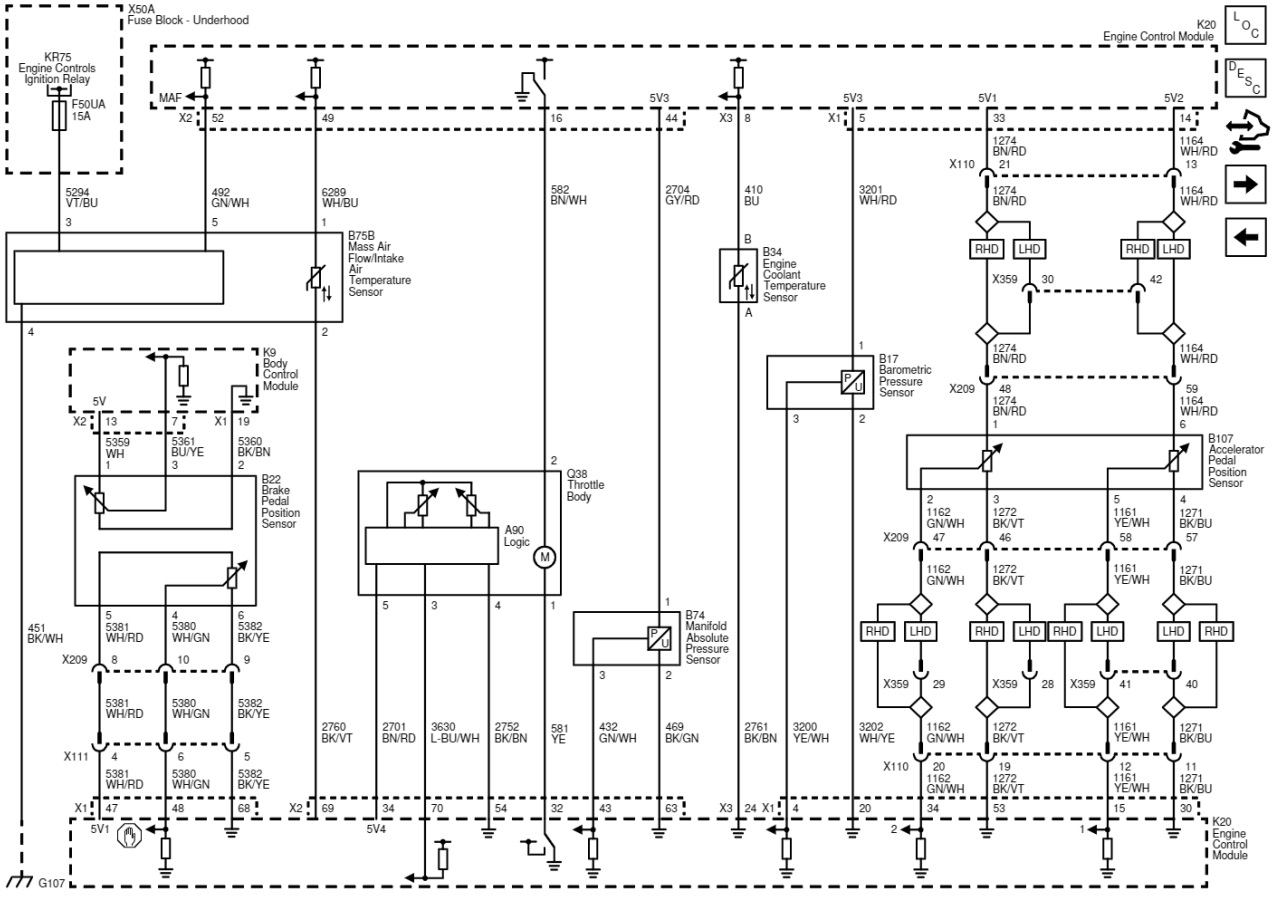
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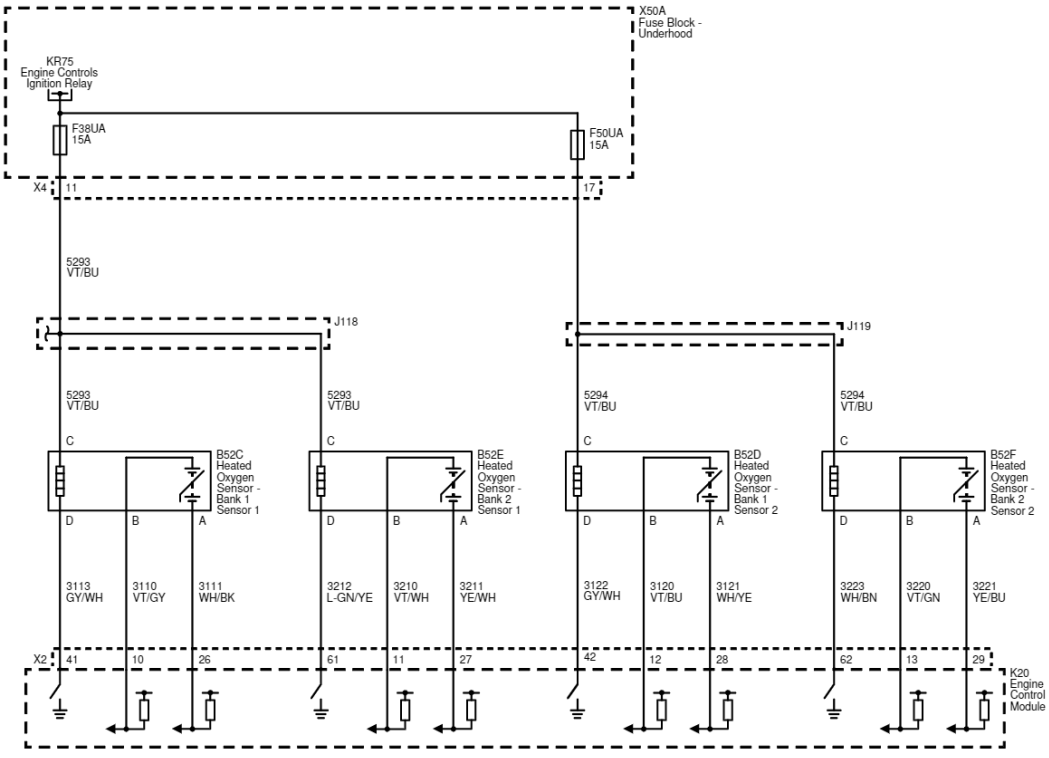
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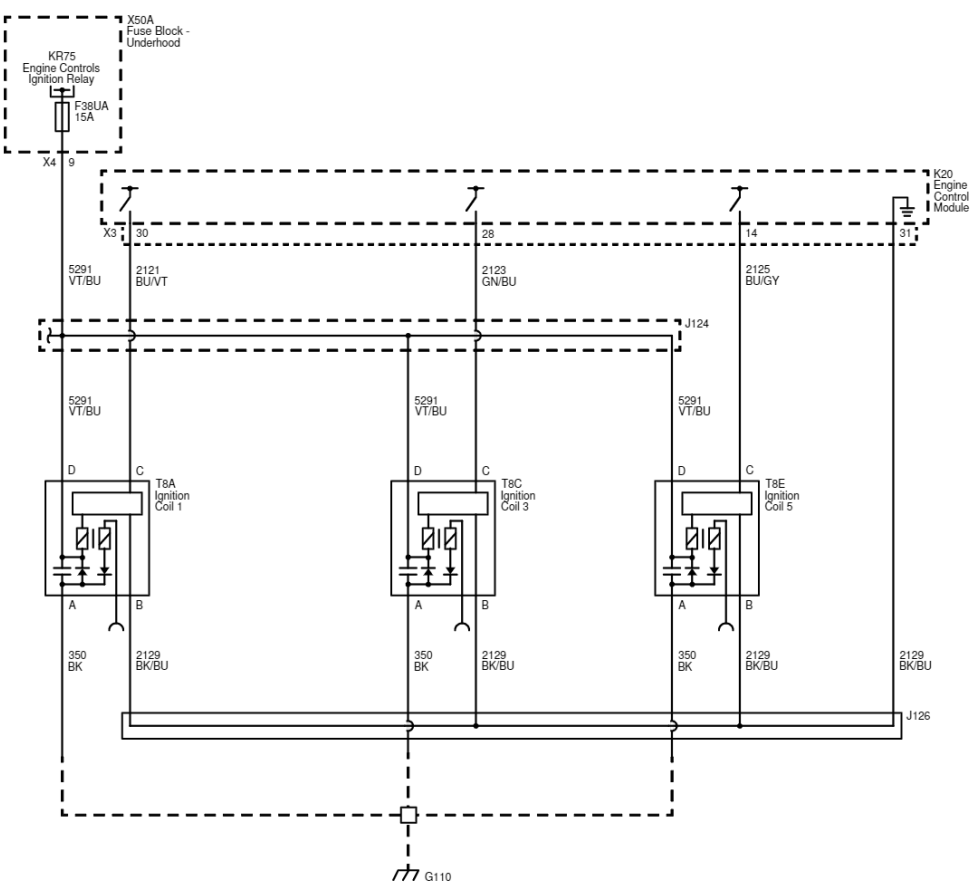
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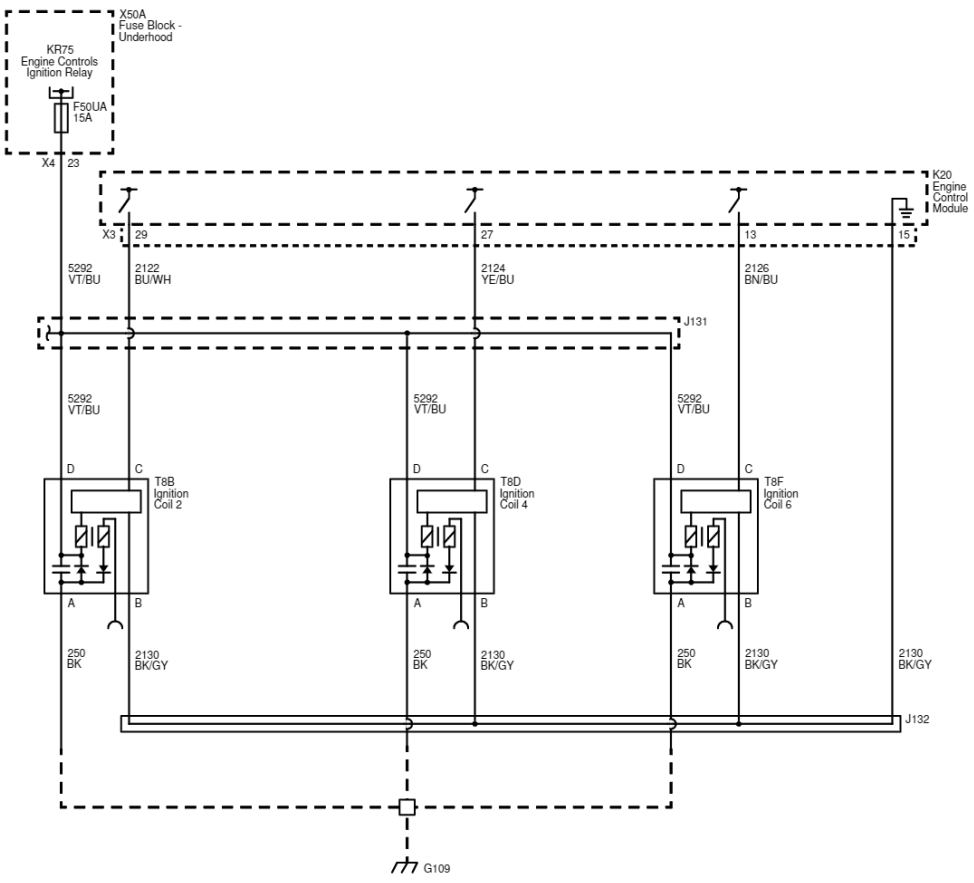
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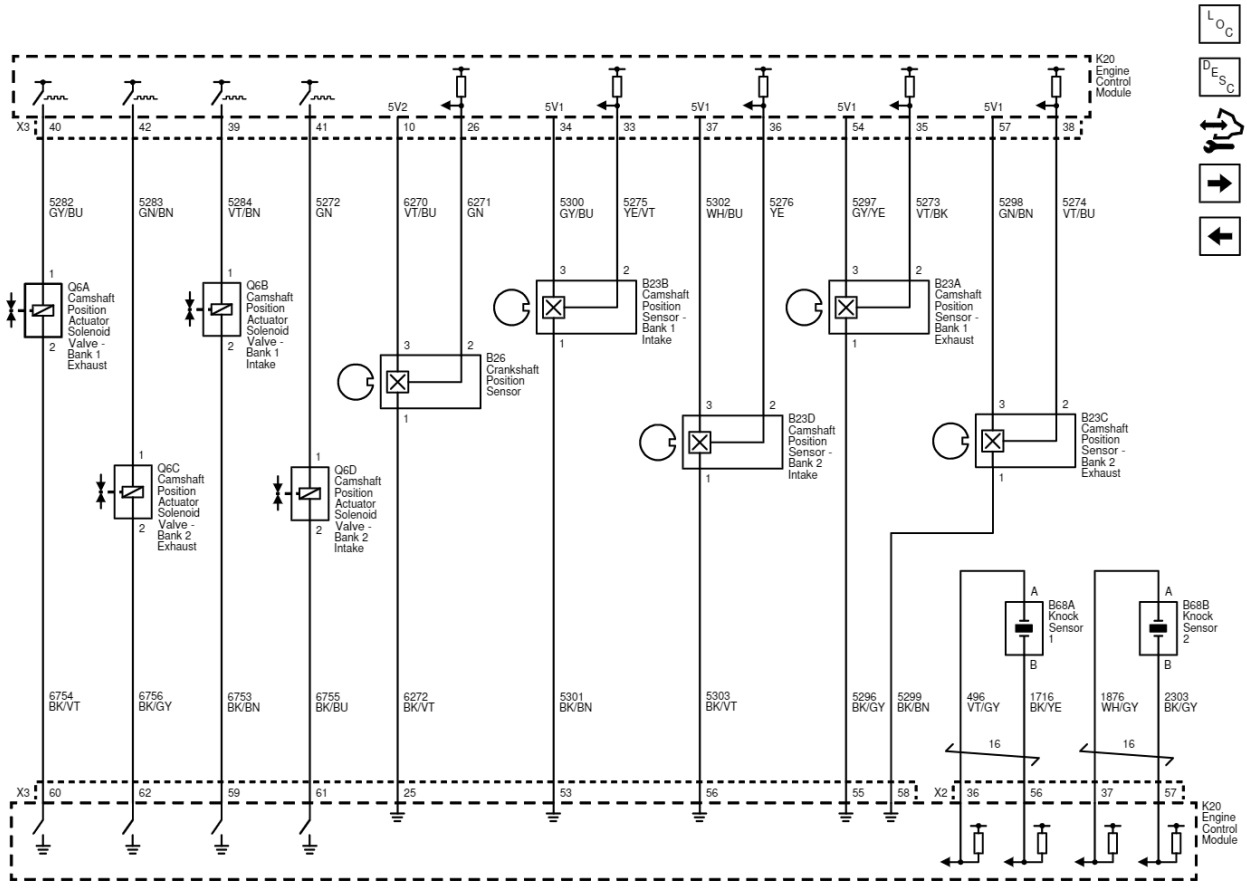
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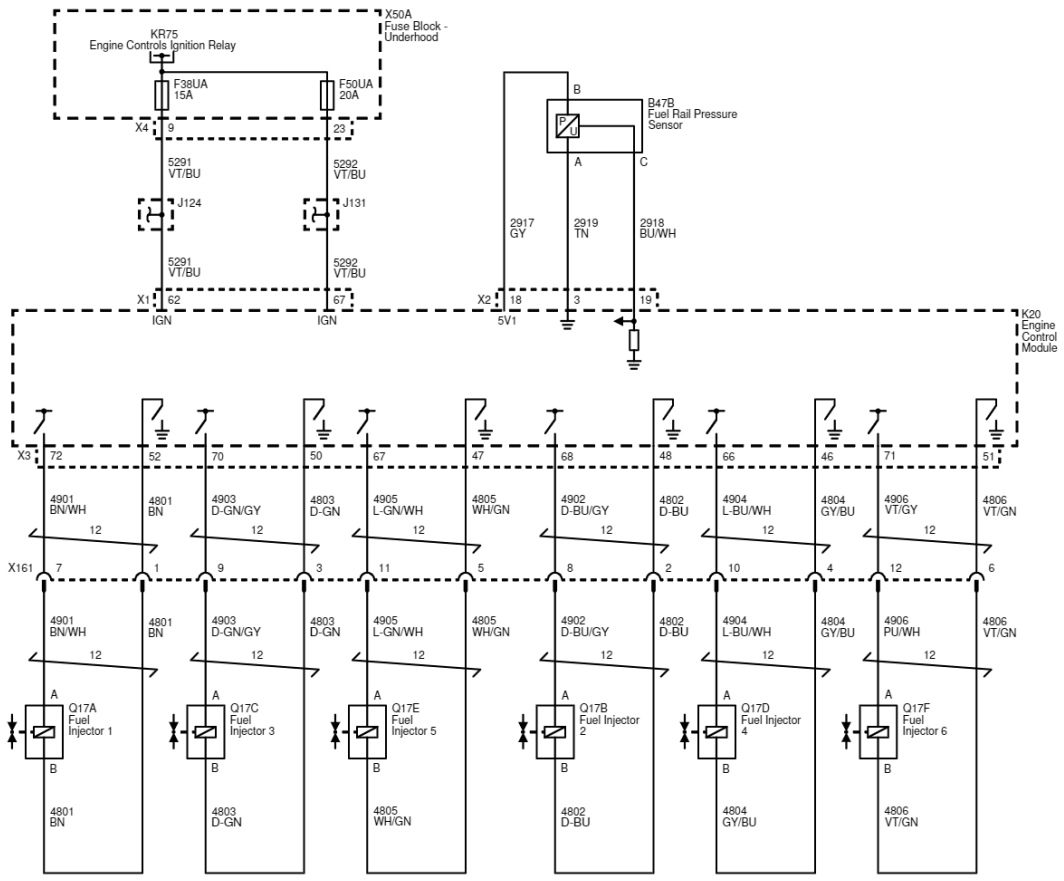
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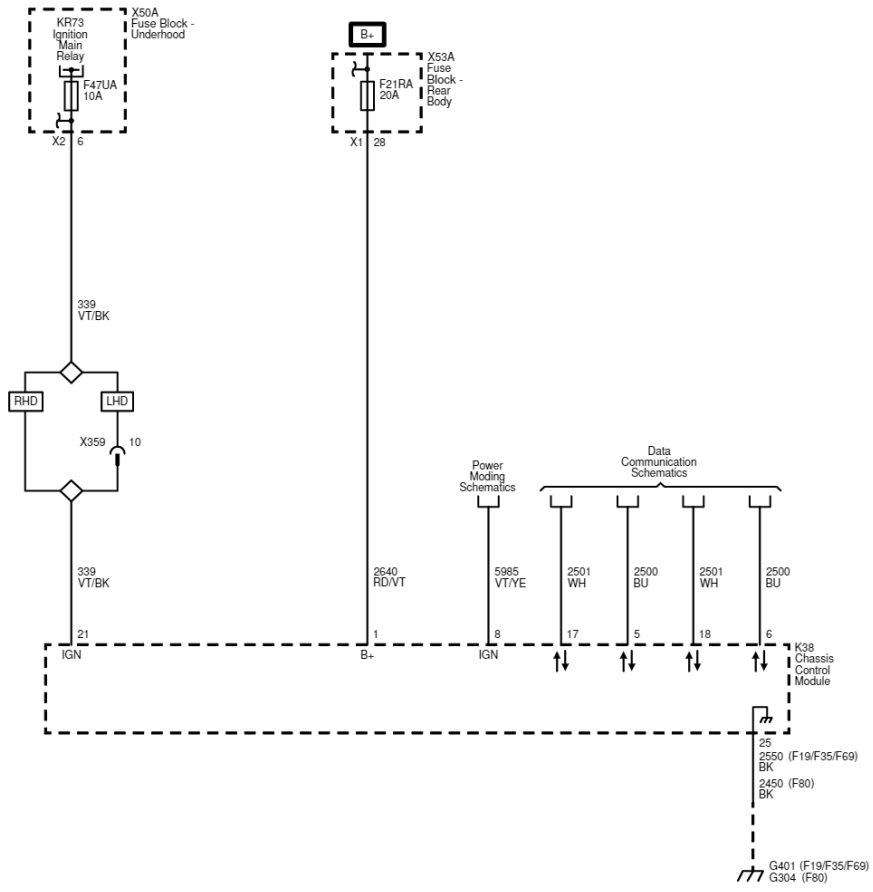
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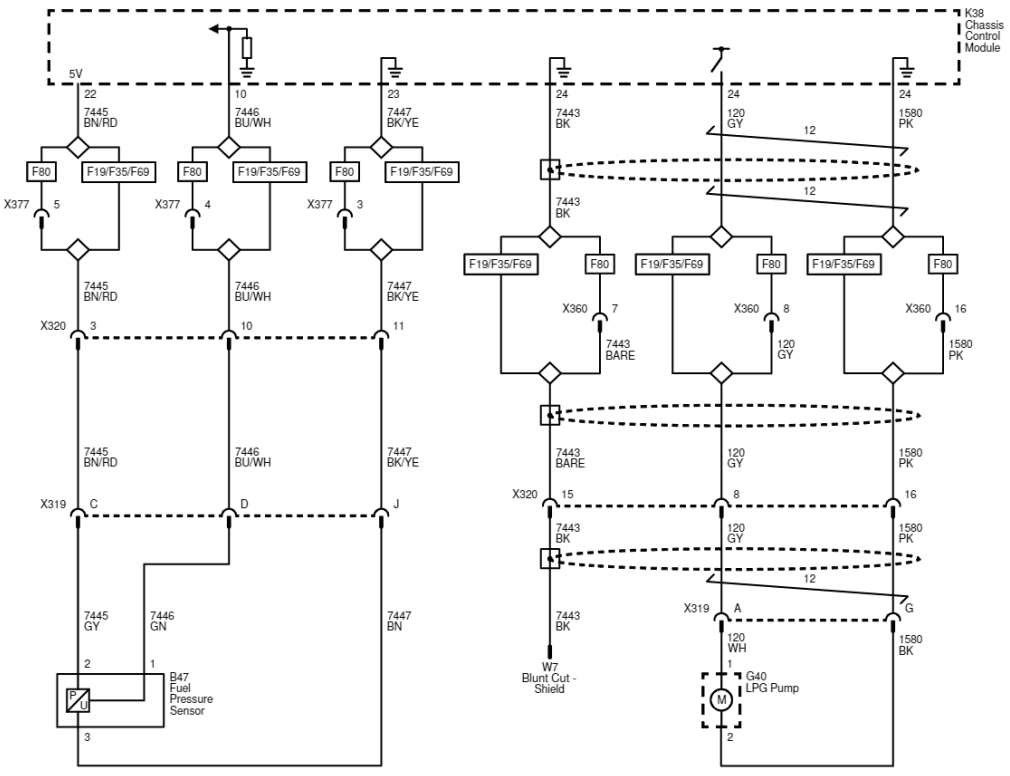
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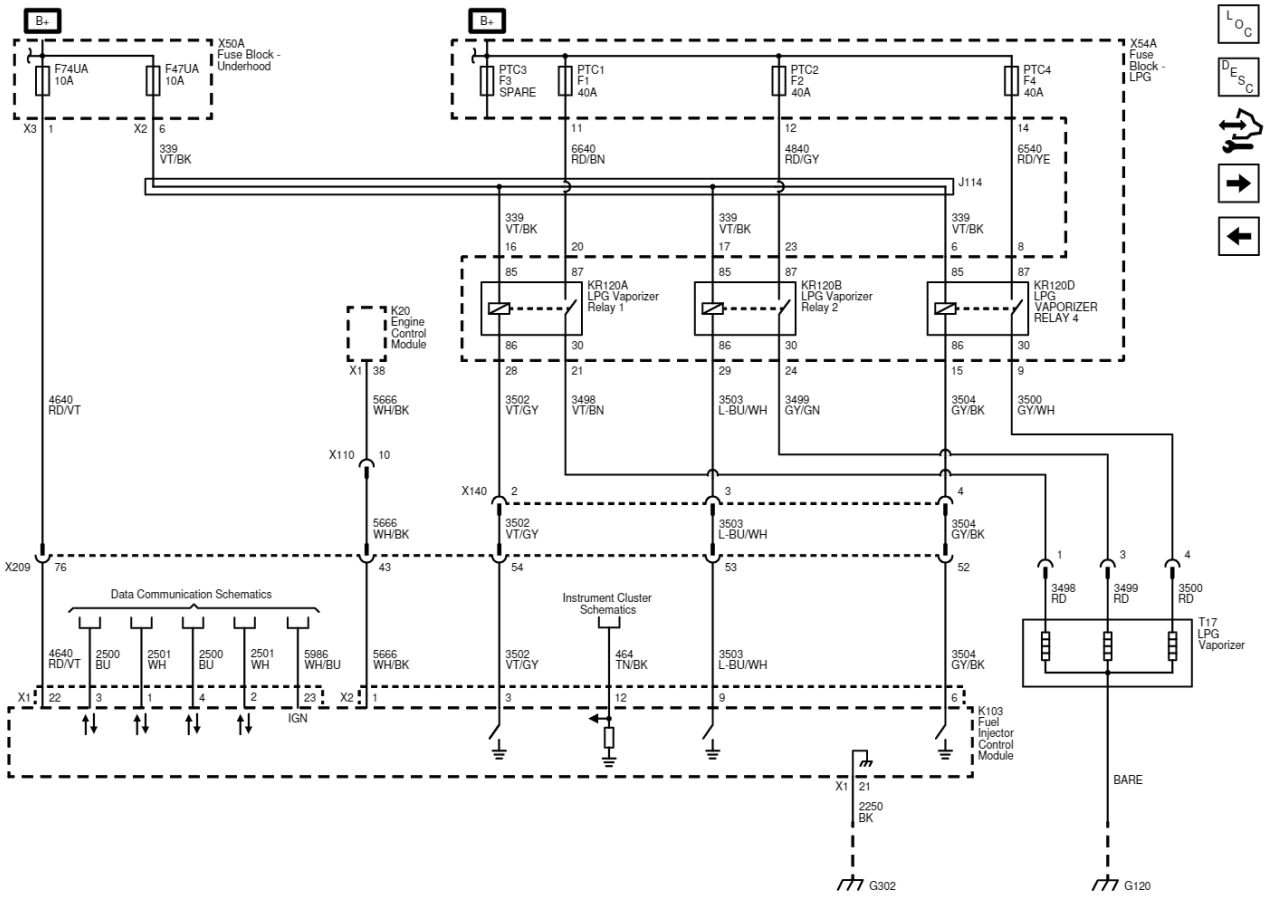
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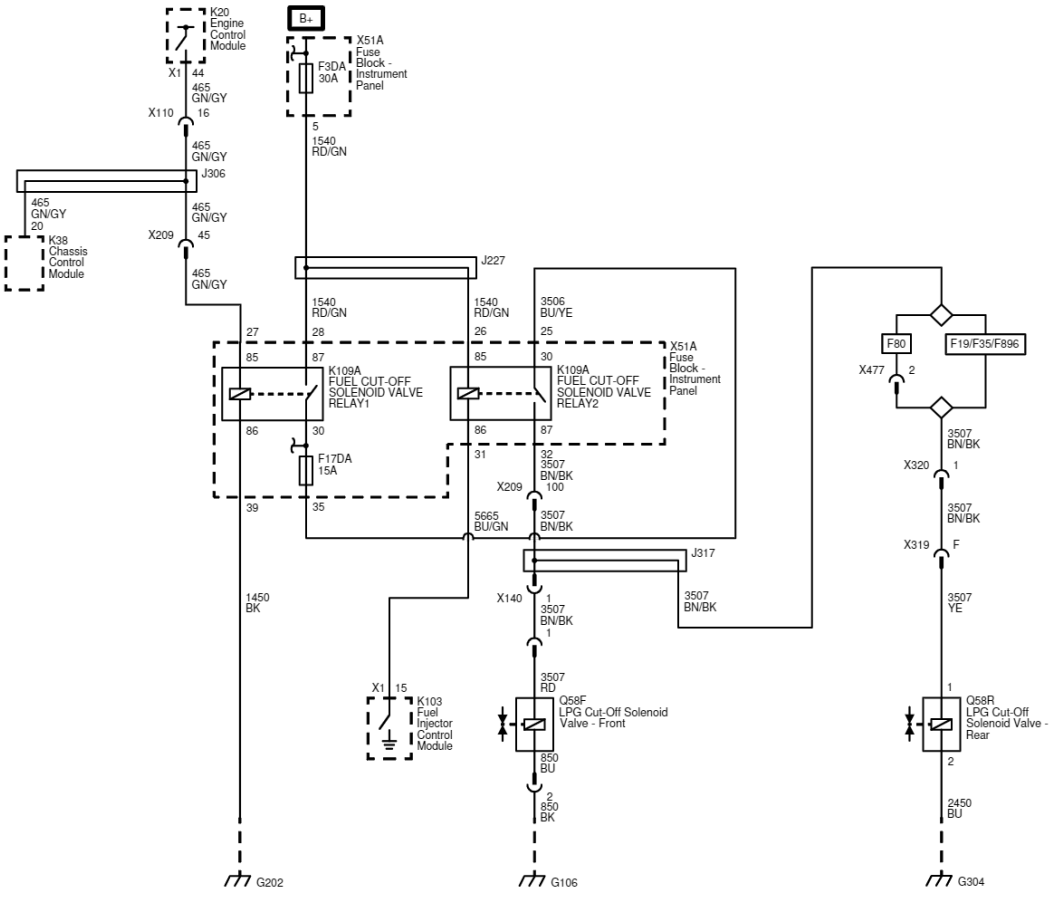
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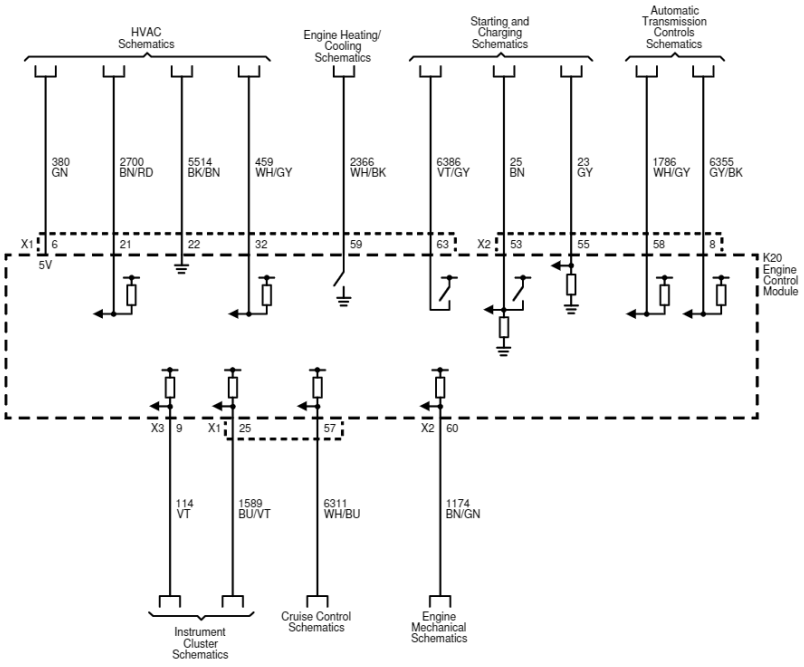
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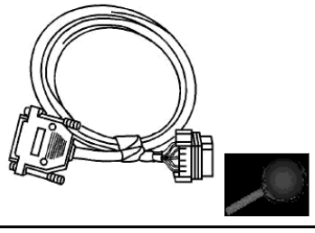
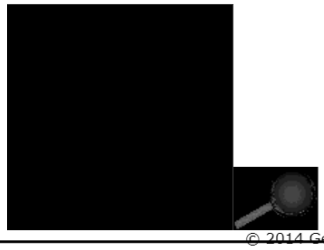


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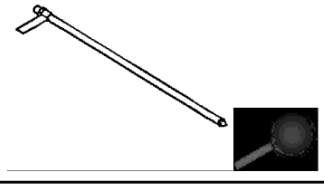
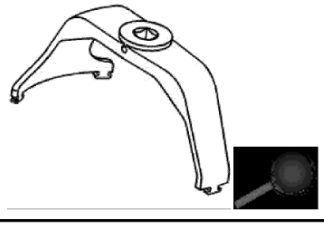
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Special Tools (Diagnostic Tools)

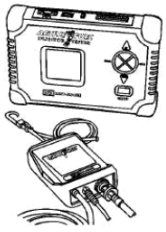
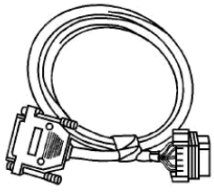
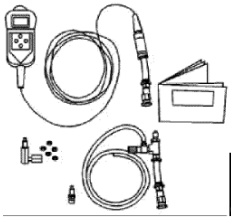
Illustration	Tool Number/Description
	CH-34730-2C J-34730-2C Injector Test Lamp
	CH-38641-B J-38641-B Diesel Fuel Quality Tester
	CH-39021-301 J-39021-301 Fuel Injector Harness Adapter
	CH-39021-460 J-39021-460 Fuel Injector Test Adapter
	CH-41415-30 GE-41415-30 J-41415-30 Fuel Tank Cap Adapter

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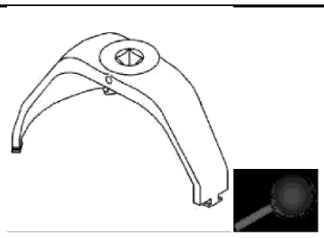
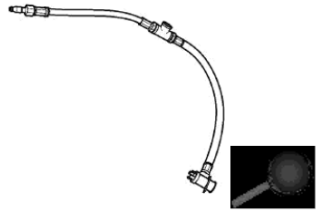
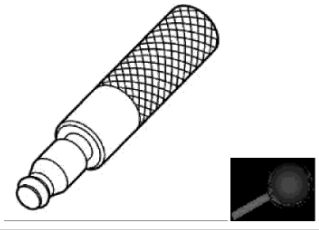
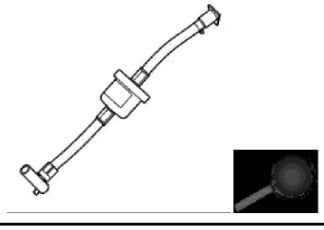
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Illustration	Tool Number/Description
	CH-42960-2 J-42960-2 Fuel Flapper Door Holder
	CH-42982 J-42982 Fuel Pressure Gauge Adapter
	CH-44175-A J-44175-A Fuel Composition Tester
	CH-45004 J-45004 Fuel Tank Drain Hose
	CH-45722 J-45722 Fuel Sender Lock Ring Wrench
	CH-45873 J-45873 Fuel Return Volume Test Kit

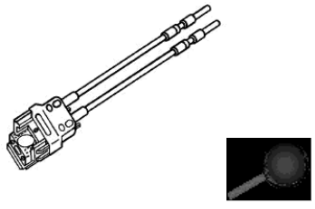
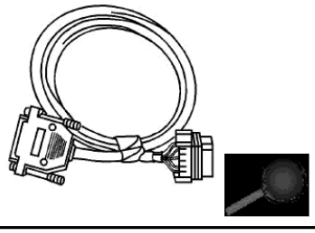
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Illustration	Tool Number/Description
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	CH-47976 Active Fuel Injector Tester (AFIT)
	CH-47976-75 Fuel Injector Harness Adapter
	CH-48027 Fuel Pressure Gauge
	CH-48096 EVAP Service Access Port Tool
	CH–48482 Fuel Sender Lock Ring Wrench

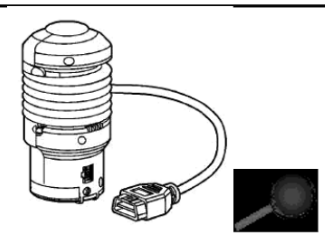
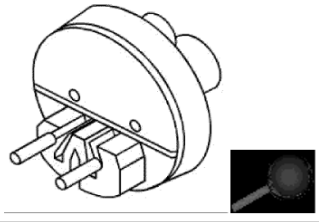
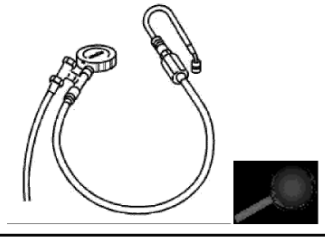
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Illustration	Tool Number/Description
	
	CH-50375 Diesel Injector Return Line Pressure Adapter
	CH-50377-A Injector Return Line Cap
	CH-50378 Injector Return Leakage Test Adapter
	EL-26792 J-26792 HEI Spark Tester
	EL-34730-405 J-34730-405 Injector Test Lamp

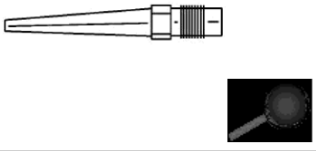
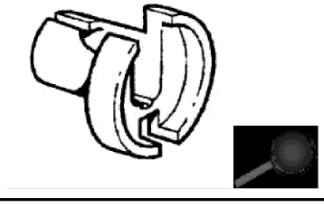
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Illustration	Tool Number/Description
	
	EL-36169-HD Heavy Duty Fused Jumper
	EL-38522-A J-38522-A Variable Signal Generator
	EL-39021 J-39021 Fuel Injector Coil Balance Tester
	EL-39021-460 J-39021-460 Fuel Injector Test Adapter
	EL-42598-B J-42598-B Vehicle Data Recorder

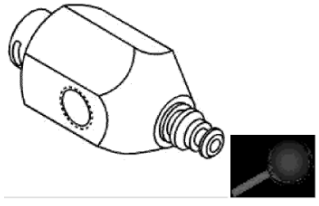
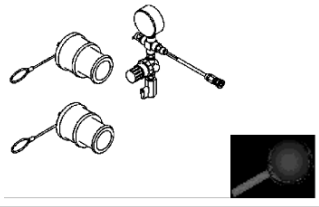
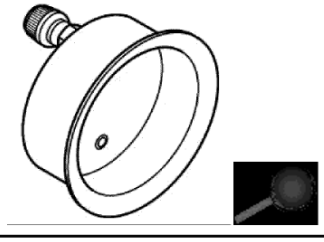
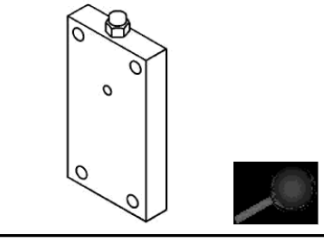
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Illustration	Tool Number/Description
	
[redacted]	EL-43244 J-43244 Relay Puller Pliers
	EL-44603 J-44603 Injector Test Lamp
	EN-34730-91 J-34730-91 KM-J-34730-91 Pressure Tester
[redacted]	EN-36012-A J-36012-A Ignition System Diagnosis Harness
	EN-37287 J-37287 Fuel Line Shut-off Adapters

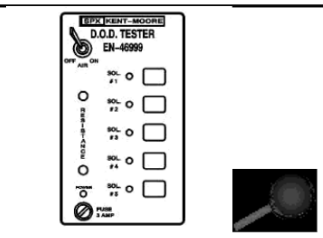
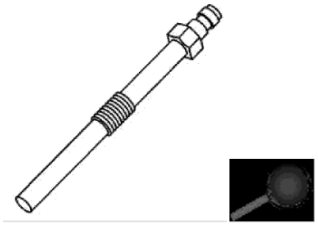
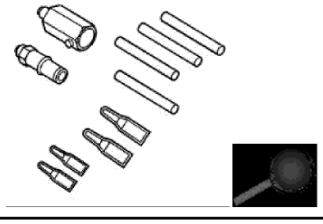
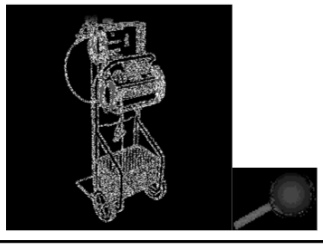
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Illustration	Tool Number/Description
	
	EN-39021-210 J-39021-210 Injector Tester Adapter Box
	EN-41413-311 J-41413-311 EVAP Plug
	EN-41413-VLV J-41413-VLV EVAP Service Port Vent Fitting
	EN–41769 J-41769 KM-41769 Fuel Line Quick Connect Separator
	EN-44602 J-44602 Injector Test Adapter

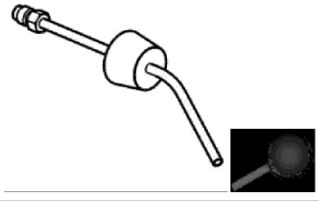
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Illustration	Tool Number/Description
	
	EN-45873-30 J-45873-30 Injector Flow Test Adapter
	EN-46091 J-46091 Charge Air Cooler Tester
	EN-46091-15A J-46091-15A Diesel Engine Pressure Test Adapter
	EN-46091-5 J-46091-5 Charge Air Cooler Tester Adapter
	EN-46999 Displacement On Demand Electric Tool

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Illustration	Tool Number/Description
	
	EN-47603 Compression Gauge Adapter
	GE-23738-A J-23738-A Vacuum Pump
	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

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Illustration	Tool Number/Description
	
	GE-41415-50 J-41415-50 Fuel Tank Cap Adapter
	GE-41415-60 Engine Induction System Leak Test Adapter/Capless Fuel Fill Adapter
	J-25070 Heat Gun 260–399°C (500–750°F)
	J-34730-375 Injector Test Lamp
	J–44581 Fuel Line Disconnect Tool

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Illustration	Tool Number/Description
	

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