

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION

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

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

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

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

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > 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.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > 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.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > 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.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > 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.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > 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.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > 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.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > 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.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > 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.

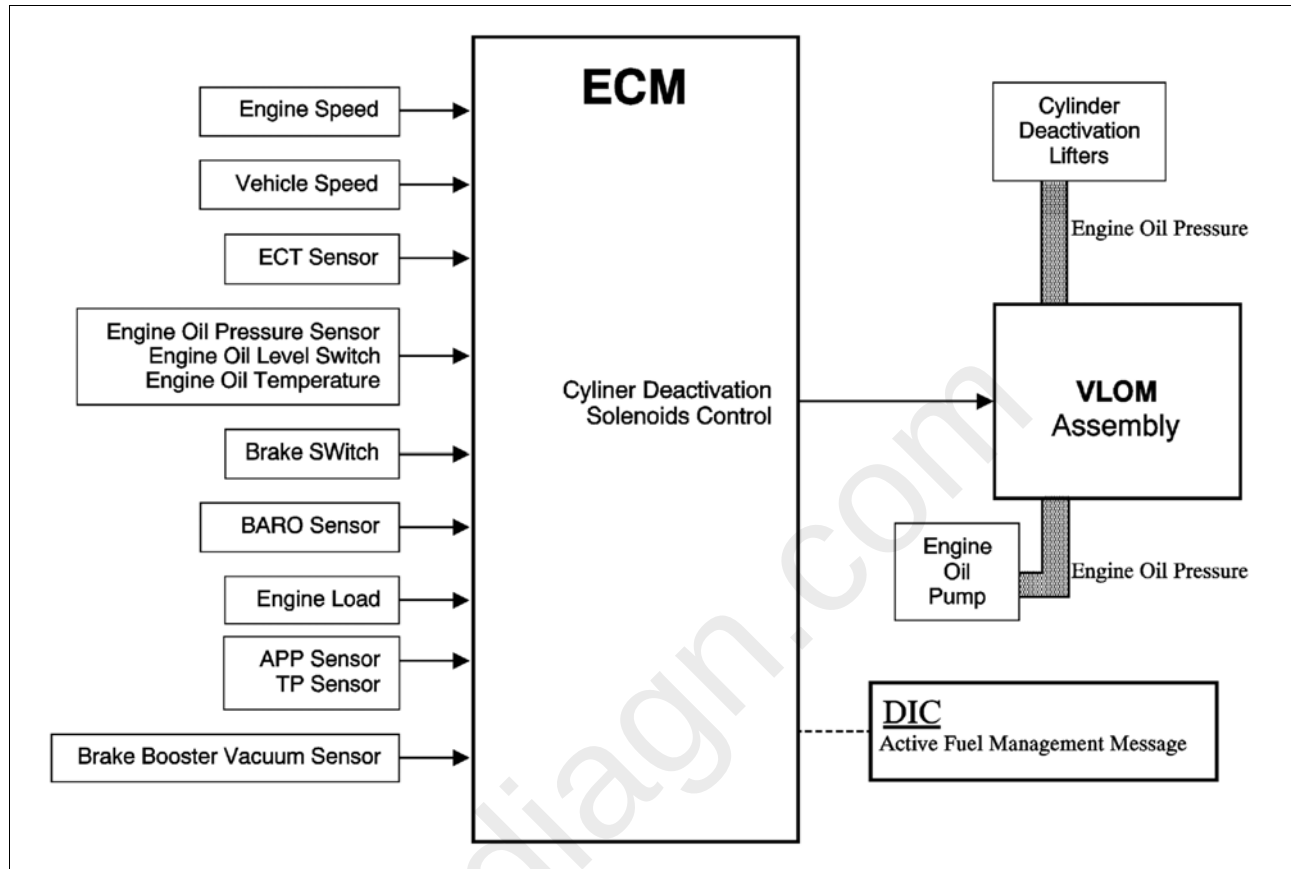
DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > EMISSIONS CONTROL INFORMATION LABEL

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).

DESCRIPTION AND OPERATION > CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DESCRIPTION

Fig 1: Cylinder Deactivation (Active Fuel Management) System Description



Courtesy of GENERAL MOTORS COMPANY

To provide maximum fuel economy under light load driving conditions, the engine control module (ECM) will command the cylinder deactivation system ON to deactivate engine cylinders 1, 7, 6, and 4, switching to a V4 mode. The engine will operate on 8 cylinders, or V8 mode, during engine starting, engine idling, and medium to heavy throttle applications.

Manifold absolute pressure (MAP) and the conditions listed below determine when cylinder deactivation is enabled.

- Engine has been running for greater than 30 s
- Engine speed is between 700 and 2800 rpm
- Engine oil pressure is between 187-455 kPa (27-66 psi)
- Engine coolant temperature is between 40-129°C (100-264°F)
- Engine oil temperature is between 16-128°C (61-263°F)
- Throttle angle is 6% or less

- Ignition voltage is greater than 11 V
- Transmission is not in first, second, or reverse gear
- Vehicle speed is greater than 25 kph (15.5 mph)
- Brake booster pressure is greater than 42.0 kPa (6 psi)
- Vehicle is not in fuel shut off mode
- Vehicle is not in heater performance mode
- Vehicle is not in tip in bump acceleration mode
- Vehicle is not in oil aeration mode
- Vehicle is not in low range (if equipped)

When cylinder deactivation is commanded, the ECM will determine what cylinder is firing and begin deactivation on the next closest deactivated cylinder in firing order sequence. For example, if cylinder number 1 is on its combustion event when cylinder deactivation is commanded ON, the next cylinder in the firing order sequence that can be deactivated is cylinder number 7. If cylinder number 5 is on its combustion event when cylinder deactivation is commanded ON, then the next cylinder in the firing order sequence that can be deactivated is cylinder number 4.

Cylinder deactivation is accomplished by not allowing the intake and exhaust valves to open on the selected cylinders by using special valve lifters. The deactivation lifters contain spring loaded locking pins that connect the internal pin housing of the lifter to the outer housing.

The pin housing contains the lifter plunger and pushrod seat which interfaces with the pushrod. The outer housing contacts the camshaft lobe through a roller. During V8 mode, when all cylinders are active, the locking pins are pushed outward by spring force, locking the pin housing and outer housing together causing the lifter to function as a normal lifter. When cylinder deactivation is commanded ON, the locking pins are pushed inward with engine oil pressure directed from the valve lifter oil manifold assembly solenoids. When the lifter pin housing is unlocked from the outer housing, the pin housing will remain stationary, while the outer housing will move with the profile of the camshaft lobe, which results in the valve remaining closed. One valve lifter oil manifold assembly solenoid controls both the intake and exhaust valves for each deactivating cylinder. There are 2 distinct oil passages going to each cylinder deactivation lifter bore, one for the hydraulic lash-adjusting feature of the lifter, and one for controlling the locking pins used for cylinder deactivation.

Although both intake and exhaust valve lifters are controlled by the same solenoid in the valve lifter oil manifold assembly, the intake and exhaust valves do not become deactivated at the same time. Cylinder deactivation is timed so that the cylinder is on an intake event. During an intake event, the intake cam lobe is pushing the valve lifter upwards to open the intake valve against the force of the valve spring. The force exerted by the valve spring is acting on the side of the lifter locking pins, preventing them from moving until the intake valve has closed. When the intake valve lifter reaches the base circle of the camshaft lobe, the valve spring force is reduced, allowing the locking pins to move, deactivating the intake valve. However, when cylinder deactivation is commanded ON, the exhaust valve for the deactivated cylinder is in the closed position, allowing the locking pins on the valve lifter to move immediately, and deactivate the exhaust valve.

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

During the transition from V8 to V4 mode, the Fuel Injectors will be turned OFF on the deactivated cylinders. To help prevent spark plug fouling, the ignition system secondary voltage or spark is still present across the spark plug electrodes on the deactivated cylinders. If all enabling conditions are met and maintained for cylinder deactivation operation, the ECM calibrations will limit cylinder deactivation to a cycle time of 10 minutes in V4 mode, then return to V8 mode for 1 minute.

Switching between V8 and V4 modes is accomplished in less than 250 milliseconds, making the transitions seamless and transparent to the vehicle operator. The 250 milliseconds includes the time for the ECM to sequence the transitions, the response time for the valve lifter oil manifold assembly solenoids to energize, and the time for the valve lifters to deactivate, all within 2 revolutions of the engine crankshaft.

DESCRIPTION AND OPERATION > CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DESCRIPTION > VALVE LIFTER OIL MANIFOLD ASSEMBLY

The cylinder deactivation system uses an electro-hydraulic actuator device called the valve lifter oil manifold assembly. The valve lifter oil manifold assembly is bolted to the top of the engine valley, below the intake manifold assembly. The valve lifter oil manifold assembly consists of 4 electrically operated normally closed solenoids. Each solenoid controls the application of engine oil pressure to the intake and exhaust valve lifters on the cylinders selected to deactivate. Engine oil pressure is routed to the valve lifter oil manifold assembly from an internal oil passage on the rear of the cylinder block.

All 4 valve lifter oil manifold assembly solenoids are connected in parallel to a fused ignition 1 voltage circuit, supplied by the powertrain relay. The ground or control circuit for each solenoid is connected to a low side driver internal to the engine control module (ECM).

When all enabling conditions are met for cylinder deactivation, the ECM will ground each solenoid control circuit in firing order sequence, allowing current to flow through the solenoid windings. With the coil windings energized, the solenoid valve opens, redirecting engine oil pressure through the valve lifter oil manifold assembly into 8 separate vertical passages in the engine lifter valley. The 8 vertical passages, 2 per cylinder, are connected to the valve lifter bores of the cylinders to be deactivated. When vehicle-operating conditions require a return to V8 mode, the ECM will turn OFF the control circuit for the solenoids, allowing the solenoid valves to close. With the solenoid valves closed, engine oil pressure in the control ports is exhausted through the body of the solenoids into the engine block lifter valley. The housing of the valve lifter oil manifold assembly incorporates several bleeds in the oil passages to purge any air trapped in the valve lifter oil manifold assembly or engine block.

To help control contamination to the hydraulic circuits, a small replaceable oil screen is located in the valve lifter oil manifold assembly oil inlet passage, below the oil pressure sensor. The oil pressure sensor is a 3-wire sensor which provides oil pressure information to the ECM.

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

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

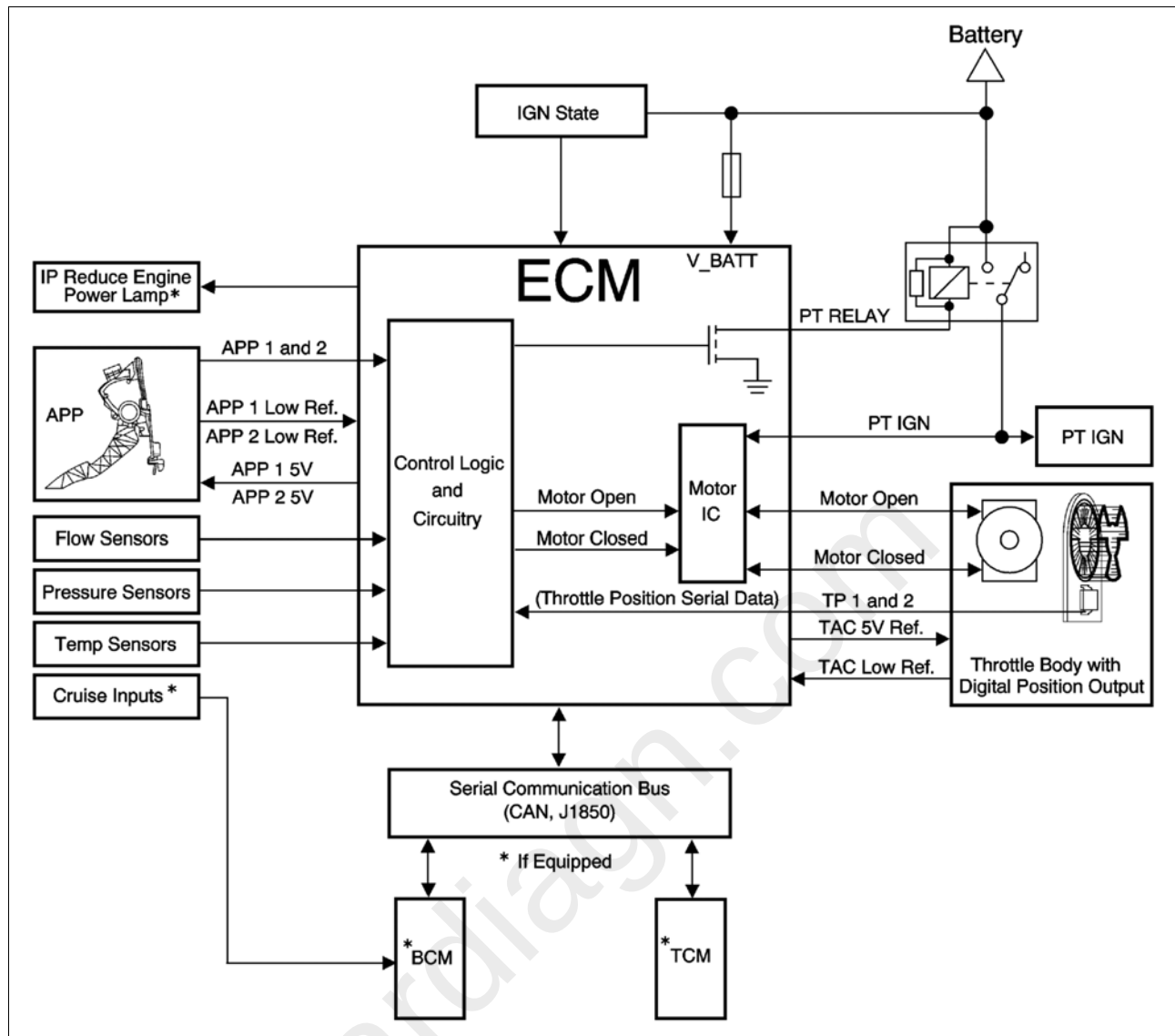
- Engine coolant temperature out of range for cylinder activation
- Engine vacuum out of range
- Brake booster vacuum out of range

- Transmission gear incorrect or shift in progress
- Accelerator pedal out of range or rate of pedal application too fast
- Engine oil pressure and temperature out of range
- Engine speed out of range
- Vehicle speed out of range
- Minimum time in V8 mode not met
- Maximum V4 mode time exceeded
- Decel fuel cutoff is active
- Reduced engine power is active
- Torque management is active
- Catalytic converter over temperature protection is active
- Piston protection is active, knock detected
- Cylinder deactivation solenoid driver circuit faults

DESCRIPTION AND OPERATION > THROTTLE ACTUATOR CONTROL (TAC) SYSTEM

DESCRIPTION

Fig 1: Throttle Actuator Control (TAC) System Description



Courtesy of GENERAL MOTORS COMPANY

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

DESCRIPTION AND OPERATION > THROTTLE ACTUATOR CONTROL (TAC) SYSTEM DESCRIPTION > MODES OF OPERATION

Normal Mode

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

- Minimum pedal value-At key-up, the ECM updates the learned minimum pedal value.
- Minimum throttle position values-At key-up, the ECM updates the learned minimum throttle position value. In order to learn the minimum throttle position value, the throttle blade is moved to the Closed position.
- Ice break mode-If the throttle blade is not able to reach a predetermined minimum throttle position, the ice break mode is entered. During the ice break mode, the ECM commands the maximum pulse width several times to the throttle actuator motor in the closing direction.
- Battery saver mode-After a predetermined time without engine speed, the ECM commands the battery saver mode. During the battery saver mode, the TAC module removes the voltage from the motor control circuits, which removes the current draw used to maintain the idle position and allows the throttle to return to the spring loaded default position.

Reduced Engine Power Mode

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

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

Throttle/Idle Learn

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.

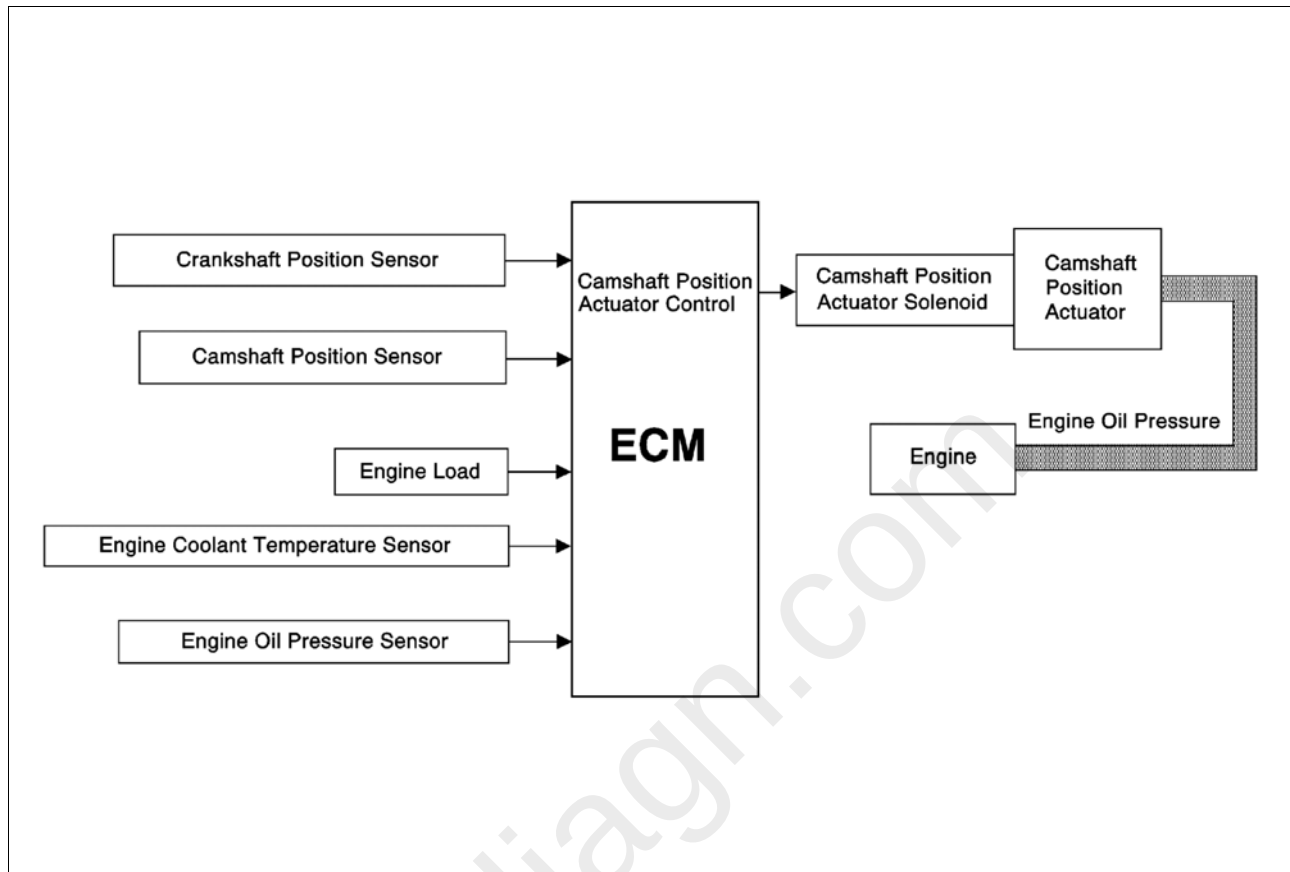
An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to unlearn the coking. To accelerate the process, the scan tool has the ability to reset all learned values back to zero. A new ECM will also have values set to zero.

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

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

DESCRIPTION AND OPERATION > CAMSHAFT ACTUATOR SYSTEM DESCRIPTION

Fig 1: Camshaft Actuator System Description



Courtesy of GENERAL MOTORS COMPANY

DESCRIPTION AND OPERATION > CAMSHAFT ACTUATOR SYSTEM DESCRIPTION > CAMSHAFT POSITION (CMP) ACTUATOR SYSTEM

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

DESCRIPTION AND OPERATION > CAMSHAFT ACTUATOR SYSTEM DESCRIPTION > CMP ACTUATOR SYSTEM OPERATION

The camshaft position (CMP) actuator system is controlled by the control module. The control module sends a pulse width modulated signal to a CMP actuator solenoid in order to control the amount of engine oil flow to a camshaft actuator passage. There are 2 different passages for oil to flow through, a

passage for CAM advance and a passage for CAM retard. The camshaft actuator is attached to the front of the camshaft, and is hydraulically operated in order to change the angle of the camshaft relative to crankshaft position (CKP). Engine oil pressure (EOP), viscosity, temperature, engine oil level, and aftermarket engine oil additives can have an adverse affect on camshaft phaser performance.

DESCRIPTION AND OPERATION > CAMSHAFT ACTUATOR SYSTEM DESCRIPTION > CMP ACTUATOR SOLENOID CIRCUIT DIAGNOSTIC

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

DESCRIPTION AND OPERATION > CAMSHAFT ACTUATOR SYSTEM DESCRIPTION > CMP ACTUATOR SYSTEM PERFORMANCE DIAGNOSTIC

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

DESCRIPTION AND OPERATION > 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 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).

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > ELECTRONIC RETURNLESS FUEL SYSTEM

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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > CHASSIS CONTROL MODULE

The chassis control module is a serviceable GMLAN module. The chassis control module receives the desired fuel pressure message from the engine control module (ECM) and controls the fuel pump located within the fuel tank to achieve the desired fuel pressure. The chassis control module sends a 25 kHz PWM signal to the fuel pump, and pump speed is changed by varying the duty cycle of this signal. Maximum current supplied to the fuel pump is 22 A.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL PRESSURE SENSOR

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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL TANK

The fuel tanks are molded from high density polyethylenes and stores the fuel supply. Each fuel tank is mounted in front of the rear wheel area by metal straps that shield the tanks from debris. The left tank is the primary tank which contains the primary fuel tank fuel pump module assembly. A transfer tube between the two tanks allow for even fuel and weight distribution. Two hoses route inside the transfer tube to supply the secondary jet pump with fuel from the bottom of the secondary tank and vapor hose that allows the vapors and pressure to equalize between the tanks. The right tank is the secondary tank which contains a secondary fuel tank module.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL FILL PIPE

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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > PRIMARY FUEL TANK FUEL PUMP MODULE

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

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

- The fuel level sensor
- The fuel pump and reservoir assembly
- The pressure relief regulator valve
- The fuel strainer
- The primary jet pump
- The secondary jet pump

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > SECONDARY FUEL TANK MODULE

The secondary fuel tank module contains a fuel level sensor, fuel tank pressure sensor, and holds the secondary jet pump transfer hose near the bottom of the tank.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL LEVEL SENSOR

Each fuel tank contains a 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 high speed CAN-bus to the body control module (BCM). The BCM then sends the fuel level percentage via low speed CAN-bus to the instrument panel cluster (IPC) in order to control the fuel gauge. The engine control module monitors the signal circuits of the fuel level sensors in order to determine the fuel level.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL PUMP

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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > PRESSURE RELIEF REGULATOR VALVE

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

pressure relief regulator valve is set higher than the pressure that is used on a mechanical returnless fuel system pressure regulator.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > PRIMARY AND SECONDARY JET PUMP

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

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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > 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.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > 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.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > HIGH PRESSURE FUEL PUMP

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 under the intake manifold and is driven by a three-lobe cam on the 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 control circuit with a 12 V pulse-width modulated (PWM) signal, which regulates fuel pressure by opening and closing 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. The high pressure fuel pump is normally closed and will not deliver an increase in fuel pressure when the control solenoid is NOT powered. 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 21.5 MPa (3,118 psi).

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > 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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL INJECTORS

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

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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL RAIL PRESSURE SENSOR

The fuel rail pressure sensor is a dual analog sensor that 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 two separate signal circuits. 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.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > 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.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > STARTING MODE

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

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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > 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.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > RUN MODE

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

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

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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > 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.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > 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.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > 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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > 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

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL TRIM

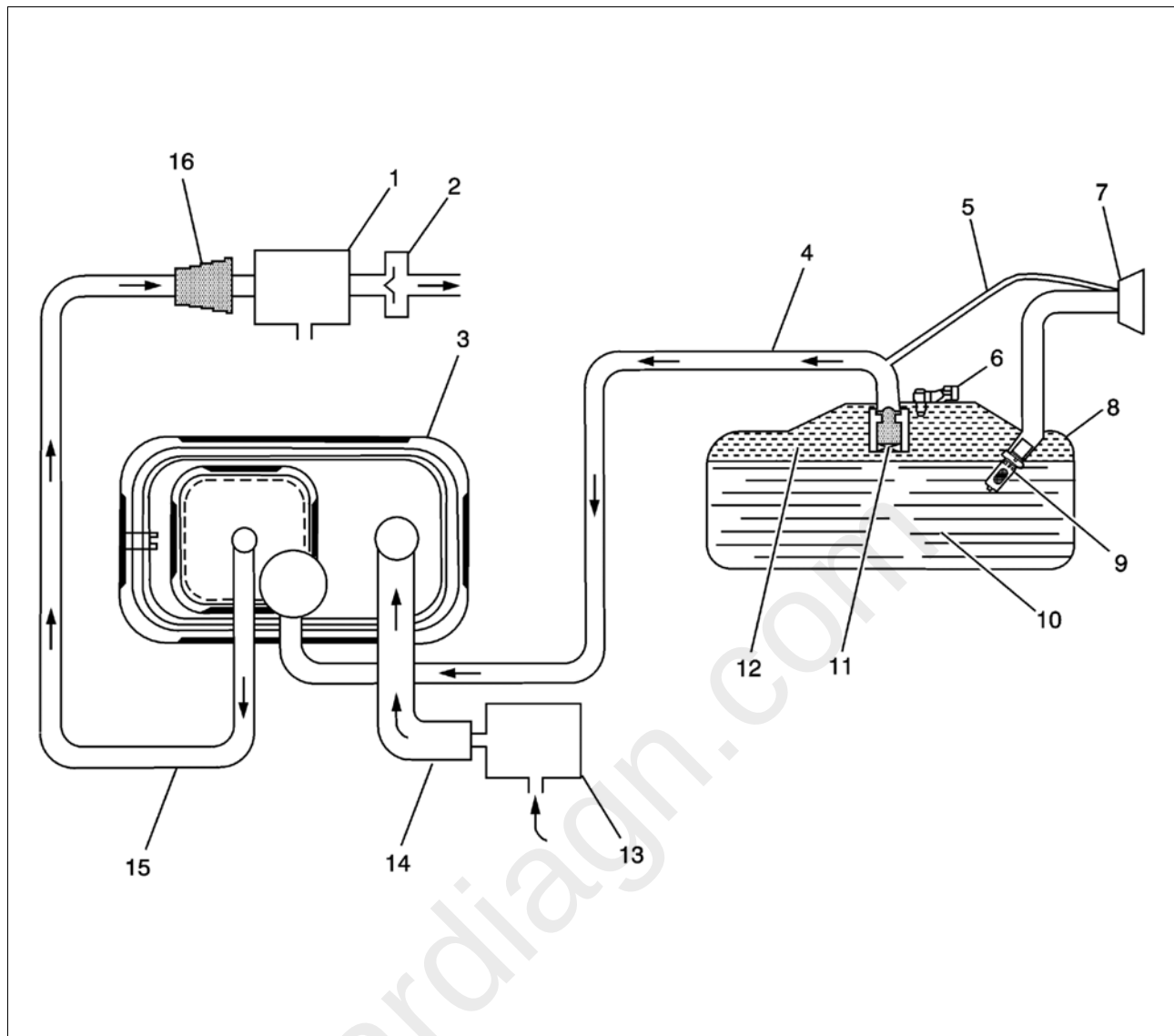
The ECM controls the air/fuel metering system in order to provide the best possible combination of driveability, fuel economy, and emission control. The ECM monitors the heated oxygen sensor (HO2S) signal voltage while in Closed Loop and regulates the fuel delivery by adjusting the pulse width of the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

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM

DESCRIPTION > TYPICAL EVAPORATIVE EMISSION (EVAP) SYSTEM HOSE

ROUTING DIAGRAM > EDIT TO ADD FLVV INFO BELOW. NECESSARY TO REORDER CALL-OUTS FROM #8 ON BECAUSE OF ART WORK CALL OUT DIRECTIONS. MUST BE IN A CLOCKWISE NUMERIC ORDER.

Fig 1: Typical Evaporative Emission (EVAP) System Hose Routing Diagram



Courtesy of GENERAL MOTORS COMPANY

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

10	Liquid Fuel
11	Fill Limit Vent Valve (FLVV)
12	Fuel Vapor
13	EVAP Canister Vent Solenoid Valve
14	Vent hose
15	EVAP Purge Tube
16	EVAP Canister Purge Tube Connector

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM

DESCRIPTION > EVAP SYSTEM OPERATION

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

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM

DESCRIPTION > PURGE SOLENOID VALVE LEAK TEST

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

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM

DESCRIPTION > LARGE LEAK TEST

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

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM

DESCRIPTION > CANISTER VENT RESTRICTION TEST

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

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM

DESCRIPTION > SMALL LEAK TEST

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

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

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

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM

DESCRIPTION > EVAP SYSTEM COMPONENTS

The EVAP system consists of the following components:

EVAP Purge Solenoid Valve

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

Purge Tube Check Valve



NOTE:

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

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

EVAP Canister

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

Vapor Recirculation Tube

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

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

Fuel Tank Pressure Sensor

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

Fuel Fill Pipe Check Valve

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

EVAP Vent Solenoid Valve

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

Fuel Fill Cap

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

Capless Fuel Fill

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

Fill Limit Vent Valve

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

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

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > ELECTRONIC IGNITION SYSTEM OPERATION

The electronic ignition system produces and controls the high energy secondary spark. This spark ignites the compressed air/fuel mixture at precisely the correct time, providing optimal performance, fuel economy, and control of exhaust emissions. The engine control module (ECM) primarily collects information from the crankshaft position and camshaft position sensors to control the sequence, dwell, and timing of the spark.

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > CRANKSHAFT POSITION SENSOR

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 the reluctor wheel on the crankshaft. The reluctor wheel is spaced at 60-tooth spacing, with two missing teeth for the reference gap. The reference gap is used to identify the crankshaft position at each start-up. The crankshaft position sensor produces an ON/OFF DC voltage of varying frequency, with 58 output pulses per crankshaft revolution. The crankshaft position sensor sends a digital signal to the ECM as each tooth on the reluctor wheel rotates past the crankshaft position sensor. The ECM uses each crankshaft position signal pulse to determine crankshaft speed 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.

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.

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > CAMSHAFT POSITION SENSOR

The camshaft position sensor detects magnetic flux changes between the four narrow and wide tooth slots on the reluctor wheel. The camshaft position sensor provides a digital ON/OFF DC voltage of varying frequency per each camshaft revolution. The ECM will recognize the narrow and wide tooth patterns to identify camshaft position, or which cylinder is in compression and which is in exhaust. The information is then used to determine the correct time and sequence for fuel injection and ignition spark

events.

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.

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > KNOCK SENSOR

The knock sensor system enables the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation, also known as spark knock. The knock sensor system uses one or two 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 are dependant upon the level of knock that the knock sensor detects. The ECM receives the knock sensor signal through two isolated signal circuits for each knock sensor.

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

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

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > IGNITION COILS

Each ignition coil has an ignition 1 voltage feed and a ground circuit. The engine control module (ECM) supplies a low reference and an ignition control circuit. Each ignition coil contains a solid state driver module. The ECM will command the ignition control circuit ON, which allows the current to flow through the primary coil windings. When the ECM commands the ignition control circuit OFF, this will interrupt current flow through the primary coil windings. The magnetic field created by the primary coil windings will collapse across the secondary coil windings, which induces a high voltage across the spark plug electrodes.

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > ENGINE MISFIRE DETECTION

The crankshaft position sensor is used to determine when an engine misfire is occurring. The camshaft position sensor is used to determine which cylinder is misfiring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM is able to detect individual misfire events. 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 a predetermined threshold, this information is sent to the ECM. The ECM uses the rough road information when calculating engine misfire. Under certain driving conditions, a misfire rate can be high enough to cause the 3-way catalytic converter to overheat damaging the converter. The malfunction indicator lamp (MIL) will flash ON and OFF when converter overheating, damaging conditions are present.

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DIAGNOSTIC INFORMATION AND PROCEDURES > 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > MALFUNCTION INDICATOR

LAMP (MIL) DIAGNOSIS > 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 INFORMATION AND PROCEDURES > MALFUNCTION INDICATOR

LAMP (MIL) DIAGNOSIS > 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > MALFUNCTION INDICATOR

LAMP (MIL) DIAGNOSIS > REFERENCE INFORMATION

Schematic Reference

- Engine Controls Schematics
- Instrument Cluster Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- Circuit Testing
- Connector Repairs

- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References for scan tool information

DIAGNOSTIC INFORMATION AND PROCEDURES > MALFUNCTION INDICATOR LAMP (MIL) DIAGNOSIS > 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.
 1. The MIL Control Circuit Low Voltage Test Status
 2. The MIL Control Circuit Open Test Status
 3. The MIL Control Circuit High Voltage Test Status
 1. **If Malfunction is displayed**
Refer to Circuit/System Testing
 1. **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.
 1. The MIL Control Circuit Low Voltage Test Status
 2. The MIL Control Circuit Open Test Status
 3. The MIL Control Circuit High Voltage Test Status
 1. **If Malfunction is displayed**
Refer to Circuit/System Testing
 1. **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.
 1. **If the malfunction indicator lamp does not turn ON and OFF**

Refer to Circuit/System Testing

1. If the malfunction indicator lamp turns ON and OFF

6. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > MALFUNCTION INDICATOR LAMP (MIL) DIAGNOSIS > 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.

1. If the malfunction indicator lamp illuminates

1. Test for infinite resistance between the control circuit terminal X1 46 and ground.

1. If less than infinite resistance, repair the short to ground in the circuit.

2. If infinite resistance, replace the P16 Instrument Cluster.

1. 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.

1. If the malfunction indicator lamp illuminates

Replace the K20 Engine Control Module.

2. If the malfunction indicator lamp does not illuminate

1. Test for less than 1 V between the control circuit terminal X1 46 and ground.

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

1. If less than 1 V

2. Ignition OFF.

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

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

1. 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 8 and ground.

1. If the test lamp does not illuminate and the circuit fuse is open

1. Ignition OFF.
2. Test for infinite resistance between the ignition voltage circuit and ground.
 1. If less than infinite resistance, repair the short to ground on the circuit.

1. If the test lamp does not illuminate and the circuit fuse is good

1. Ignition OFF.
2. Test for less than 2 Ω in the ignition voltage circuit end to end.
 1. If 2 Ω or greater, repair the open/high resistance in the circuit.

1. If the test lamp illuminates

8. Replace the P16 Instrument Cluster.

DIAGNOSTIC INFORMATION AND PROCEDURES > MALFUNCTION INDICATOR LAMP (MIL) DIAGNOSIS > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

- Instrument Cluster Replacement
- Control Module References for control module replacement, programming, and setup

DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE CRANKS BUT DOES NOT RUN > DIAGNOSTIC INSTRUCTIONS

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

DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE CRANKS BUT DOES NOT RUN > CIRCUIT/SYSTEM DESCRIPTION

This Engine Cranks but Does Not Run diagnostic is an organized approach to identify a condition which causes the engine to crank but does not continue to run. This diagnostic directs the service technician to the appropriate system diagnosis.

DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE CRANKS BUT DOES NOT RUN > DIAGNOSTIC AIDS

Inspect for any of the conditions listed below:

- Insufficient fuel. Thoroughly inspect the fuel delivery system for sufficient fuel volume to the fuel injectors. Inspect the fuel supply components for partial blockage or restrictions.
- A stuck camshaft position actuator solenoid valve, which may cause retarded valve timing and low fuel pressure. The engine may sound like it is cranking too fast. A compression test may show low compression and exhaust flow out of the tailpipe may be noticeably less when compared to a known good vehicle. DTC P00C6 may also set. Use the scan tool to cycle the camshaft actuator solenoid valve several times and then try to start the engine. Examine the valve for contamination and clean, if necessary. Perform a dynamic test on the valve to verify correct operation, if necessary-Refer to DTC P0011 for instructions.
- Fuel injector ON time inadequate. When this condition is present, there may be fuel spray at the fuel injectors and the indicated fuel pressure may be correct, yet there may not be enough fuel to start the engine. If the engine control module (ECM) receives incorrect inputs from the various information sensors, the fuel delivered by the fuel injectors may be inadequate to start the engine. Check all the engine data parameters with a scan tool and compare the values indicated with the expected values or the values from a known good vehicle.
- An unstable engine reference signal. Observe the Engine Speed parameter while cranking the engine. The scan tool should indicate a steady 200-300 RPM while cranking. If erratic values such as sudden spikes in the engine speed are displayed, the engine reference signal is not stable enough for the engine to start and run correctly.
- Loose, unsecured engine electrical grounds. Inspect the engine for good secure electrical grounds.
- Water or foreign material in the fuel, which can cause either a no start or a engine will not stay running condition. During freezing weather water can freeze inside the fuel system. The engine may start after 30 min in a heated repair shop. The malfunction may not recur until parked overnight in freezing temperatures. Extreme weather conditions can cause contaminated fuel to prevent the vehicle from starting.
- An ignition system that is susceptible to moisture. If the engine starts and runs after being brought into a warm, dry repair shop, the ignition system may be susceptible to moisture. Spray water on the ignition system components and wiring while cranking the engine in order to check for an engine starting or will not stay running concern.
- If the engine almost starts and then stalls, check for an open in the ground circuits of the crankshaft position sensor and the camshaft position sensor.

DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE CRANKS BUT DOES NOT RUN > REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

- COMPONENT CONNECTOR END VIEWS - INDEX
- Electrical Center Identification 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 26792 HEI Spark Tester

DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE CRANKS BUT DOES NOT RUN > CIRCUIT/SYSTEM VERIFICATION



NOTE:

This diagnostic assumes the following:

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

1. Crank the engine for up to 15 seconds.

2. Verify DTC P0117, P0118, P0122, P0123, P0201-P0208, P0222, P0223, P0300-P0308, P0335, P0336, P0351-P0358, P0562, P0563, P0601-P0604, P0606, P0607, P062F, P0633, P0685, P0690, P1631, P1682, or P2610 is not set.

1. If any of the DTCs are set

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

1. If none of the DTCs are set

3. Ignition ON.

4. Verify the security indicator on the instrument cluster illuminates momentarily.

1. If the indicator stays illuminated or is flashing

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

1. If the indicator does not stay illuminated and is not flashing

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

1. If 0 RPM

Refer to DTC P0335 or P0336 for further diagnosis.

1. If greater than 0 RPM

6. Connect the **EL 26792** HEI Spark Tester between the boot of a spark plug wire and ground.



NOTE:

- 1. Perform the spark test on at least one cylinder for each cylinder bank.*
- 2. An erratic or weak spark is considered a no spark condition.*

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

1. If the spark tester does not spark

Refer to Electronic Ignition System Diagnosis .

1. If the spark tester sparks

8. Ignition ON.



NOTE:

- 1. If the engine is too hot, high fuel pressure readings may result due to hot soak fuel boiling. Allow the engine coolant temperature to cool down to below 60° C (150°F) before attempting to verify fuel pressure.*
- 2. The scan tool Fuel Pump Enable may need to be commanded On a few times in order to obtain the highest possible fuel pressure.*

9. Command the Fuel Pump Enable On several times with a scan tool.

10. Verify the scan tool Fuel Pressure Sensor parameter is between 320-608 kPa (46-88 psi) with the fuel pump running.

1. If not within the specified range

Refer to Fuel System Diagnosis .

1. If within the specified range

 NOTE:

The fuel pressure may vary slightly when the fuel pump stops running. After the fuel pump stops running, the fuel pressure should stabilize and remain constant.

11. Verify the fuel pressure, after the fuel pump has turned OFF, decreases to 468-544 kPa (68-79 psi) and does not decrease greater than 34 kPa (5 psi) in 1 minute.

1. If not within the specified range

Refer to Fuel System Diagnosis .

1. If within the specified range

12. Verify the conditions listed below do not exist:

1. A stuck camshaft position actuator solenoid valve. It may be necessary to perform a dynamic test on the valve to verify correct operation. Refer to DTC P0011 for instructions.
2. Collapsed air intake duct to the throttle body
3. Restricted air filter element
4. Spark plugs for being fouled
5. A skewed manifold absolute pressure (MAP) sensor-Refer to DTC P0106 .
6. A skewed engine coolant temperature (ECT) sensor-Refer to DTC P0116 .
7. Exhaust system restricted-Refer to Restricted Exhaust .
8. Fuel contamination-Refer to Alcohol/Contaminants-in-Fuel Diagnosis .
9. Engine mechanical condition, such as worn timing chain and gears or low compression-Refer to Symptoms - Engine Mechanical , or Engine Compression Test .

1. If a condition exists

Repair as necessary.

1. If no conditions exist

13. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > ENGINE CRANKS BUT DOES NOT RUN > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

DIAGNOSTIC INFORMATION AND PROCEDURES > POOR FUEL FILL QUALITY

Problem	Causes
DEFINITION: During the fueling process a continual, occasional, or no-fuel nozzle shut-off condition has occurred.	
Difficult to fill	• Fuel fill limiter vent valve stuck closed • Evaporative emission (EVAP) canister restricted • EVAP vent valve stuck closed • Hose between canister and canister vent solenoid twisted or kinked if applicable • High fuel temperature • Fuel filler hose is kinked • Faulty dispensing nozzle • Ignition switch ON, vent valve closed
Over fill	• Fill limiter vent valve stuck open or leaking • Fuel inlet check valve stuck open
Pre-mature shut-off of the fuel dispensing nozzle occurs immediately after engaging dispensing nozzle, tank empty	• Restricted vapor lines or fuel fill pipe • High fuel temperature • Inlet check valve at tank stuck closed, fill pipe full of fuel • Fuel tank full, gauge not accurate
Pre-mature shut-off of the fuel dispensing nozzle, more than 1/8 of tank capacity dispensed	• Kinked, pinched or plugged lines in fuel tank vent system • EVAP vent valve stuck closed or restricted • EVAP canister restricted • Fuel limiting vent valve stuck closed or obstruction at top of fuel tank
Fuel Spitback	• Restricted EVAP canister • High fuel temperature • Ignition switch ON, EVAP vent valve closed

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR 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 INFORMATION AND PROCEDURES > FUEL INJECTOR DIAGNOSIS > 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 ECM initially opens each fuel injector with 65 V. This high voltage 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. The ECM varies the amount of time each fuel injector is open to provide proper combustion under all engine load conditions.

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.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR DIAGNOSIS > REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Electrical Information Reference

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

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR DIAGNOSIS > 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 1.06 Ω +/- 10% @ 20°C (68°F) between the high voltage supply circuit terminal 2 and the high voltage control circuit terminal 1 at the Q17 Fuel Injector.

1. If not within the specified range

Replace the Q17 Fuel Injector.

1. If within the specified range

2. Test for infinite resistance between each terminal at the Q17 Fuel Injector and the Q17 Fuel Injector housing/case.

1. If not infinite resistance

Replace the Q17 Fuel Injector.

1. If infinite resistance

3. All OK, perform the Fuel Injector Balance Test .

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR DIAGNOSIS > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

Fuel Injector Replacement

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL SYSTEM DIAGNOSIS > DIAGNOSTIC INSTRUCTIONS

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

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL SYSTEM DIAGNOSIS > CIRCUIT/SYSTEM DESCRIPTION

The engine control module (ECM) supplies voltage to the chassis control module when the ECM detects that the ignition is ON. The voltage from the ECM to the chassis control module remains active for 2 s, unless the engine is in Crank or Run. While this voltage is being received, the chassis control module closes the ground switch of the fuel tank fuel pump module and also supplies a varying voltage to the fuel

tank fuel pump module in order to maintain the desired fuel line pressure.

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

An electric turbine style fuel pump attaches to the fuel tank 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 ECM.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL SYSTEM DIAGNOSIS > DIAGNOSTIC AIDS

Observe the scan tool Cylinder 1 - 8 Misfire Counters or perform the Fuel Injector Balance Test to help identify a leaking fuel injector. Refer to Fuel Injector Balance Test .

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL SYSTEM DIAGNOSIS > 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

J 37287 Fuel Line Shut-Off Adapter

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

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL SYSTEM DIAGNOSIS > CIRCUIT/SYSTEM VERIFICATION



NOTE:

- *Repair all fuel system related DTCs before performing this diagnostic.*
- *Inspect the fuel system for damage or external leaks before proceeding.*
- *Verify that adequate fuel is in the fuel tank before proceeding.*
- *The scan tool Fuel Pump Enable control function may need to be commanded ON a few times in order to obtain the highest possible fuel pressure.*
- *DO NOT perform the Fuel System Diagnosis if the engine coolant temperature is above 60°C (150°F). High fuel pressure readings may result due to hot soak fuel boiling. With the engine OFF, the fuel pressure may increase beyond the pressure relief regulator valve's setting point of 690 kPa (100 PSI) ± 5 %.*

1. Ignition ON, engine OFF.
2. Verify the scan tool Fuel Pressure Sensor parameter is between 320-608 kPa (46-88 PSI) while commanding the Fuel Pump Enable On several times with a scan tool.

1. **If less than 320 kPa (46 PSI)**

Refer to Circuit/System Testing - Fuel Pressure Low.

1. **If greater than 690 kPa (100 PSI)**

Replace the G12 Fuel Pump.

1. **If between 320-608 kPa (46-88 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.

3. Verify the fuel pressure decreases to 468-544 kPa (68-79 PSI) after the fuel pump is turned Off.

1. **If the fuel pressure does not decrease to 468-544 kPa (68-79 PSI)**

Replace the G12 Fuel Pump.

1. **If the fuel pressure decreases to 468-544 kPa (68-79 PSI)**

4. Verify the fuel pressure does not decrease greater than 34 kPa (5 PSI) in 1 min.

1. **If the fuel pressure decreases greater than 34 kPa (5 PSI)**

Refer to Circuit/System Testing - Fuel Pressure Leaks Down.

1. **If the fuel pressure does not decrease greater than 34 kPa (5 PSI)**

5. Relieve the fuel pressure to 69 kPa (10 PSI), refer to Fuel Pressure Relief .
6. Verify the fuel pressure does not decrease greater than 14 kPa (2 PSI) in 5 min.

1. **If the fuel pressure decreases greater than 14 kPa (2 PSI)**

Replace the G12 Fuel Pump.

1. **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.

7. Operate the vehicle within the conditions of the customer's concern while monitoring the scan tool Fuel Pressure Sensor parameter.
8. Verify the fuel pressure does not drop off during acceleration, cruise or hard cornering.
 1. **If the fuel pressure drops off**

Refer to Circuit/System Testing - Fuel Pressure Drops OFF.
 1. **If the fuel pressure does not drop off**
9. If the fuel system components test normal, refer to Symptoms - Engine Controls , Fuel Injector Diagnosis , and Fuel Injector Balance Test for further diagnosis.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL SYSTEM DIAGNOSIS > CIRCUIT/SYSTEM TESTING

Fuel Pressure Low

1. Verify none of the conditions listed below exist:
 1. Restricted fuel feed pipe
 2. Restricted or plugged strainer
 3. Poor connections at the fuel pump harness connector and the ground circuits
1. **If a condition exist**

Repair as necessary.
1. **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 **J 37287** Fuel Line Shut-Off Adapters between the fuel feed pipe and the fuel rail.
3. Open the valve on the **J 37287** Fuel Line Shut-Off Adapters.
4. Ignition ON, command the Fuel Pump Enable On with a scan tool.
5. Close the valve on the **J 37287** Fuel Line Shut-Off Adapters.
6. Verify the scan tool Fuel Pressure Sensor parameter does not decrease greater than 34 kPa (5 PSI) in 1 min.

1. If the fuel pressure drops

Test or replace the G12 Fuel Pump.

1. If the fuel pressure does not drop

7. Locate and replace the leaking Q17 Fuel Injector.

Fuel Pressure Drops OFF

1. Verify none of the conditions listed below exist:

1. Restricted fuel feed pipe
2. Restricted or plugged strainer
3. Poor connections at the Fuel Pump harness connector and the ground circuit

1. If a condition exist

Repair as necessary.

1. If a condition does not exist

2. Test or replace the G12 Fuel Pump.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL SYSTEM DIAGNOSIS > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Feed Intermediate Pipe Replacement - Position 1
- Fuel Feed Intermediate Pipe Replacement - Position 2
- Fuel Feed Pipe Replacement
- Fuel Injector Replacement
- Fuel Tank Fuel Pump Module Replacement for G12 Fuel Pump replacement

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR BALANCE TEST

> DIAGNOSTIC INSTRUCTIONS

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

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR BALANCE TEST

> CIRCUIT/SYSTEM DESCRIPTION

Two methods of testing fuel injector balance are available, the Active Fuel Injector Tester (AFIT) or a scan tool. The Active Fuel Injector Tester and SIDI adaptor connects to the engine control module harness connectors to test the high pressure fuel pump performance, fuel injector wiring, and fuel injector operation. The AFIT displays step by step instructions to precisely determine pressure drop of each fuel injector. The scan tool fuel injector balance test is performed while the engine is running at idle. The scan tool pressurizes the fuel rail to a predetermined pressure before each fuel injector is pulsed for a precise amount of time allowing a measured amount of the fuel to be injected. This causes a drop in the system fuel pressure that is recorded and used to compare each fuel injector.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR BALANCE TEST

> DIAGNOSTIC AIDS

- Monitoring the scan tool scan tool Cylinder 1 - 8 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR BALANCE TEST

> REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **CH-47976** Active Fuel Injector Tester
- **CH-47976-500** Active Fuel Injection Tester (AFIT) SIDI Adapter Kit

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

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR BALANCE TEST > CIRCUIT/SYSTEM VERIFICATION

1. Ignition ON.
2. Verify the scan tool Fuel Remaining parameter is greater than 10%.
 1. **If the Fuel Remaining parameter is less than 10%** , add fuel to the fuel tank.
 1. **If the Fuel Remaining parameter is 10% or greater**
3. Verify the scan tool ECT Sensor parameter is less than 60°C (140°F).
 1. **If the ECT Sensor parameter is greater than 60°C (140°F)** , allow the engine temperature to cool.
 1. **If the ECT Sensor parameter is 60°C (140°F) or less**
4. Verify the battery is fully charged and all accessories are Off.
 1. **If the battery is not fully charged** , charge or repair battery as necessary.
 1. **If the battery is fully charged**
5. Perform the appropriate Fuel Injector Balance Test in Circuit System Testing.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR BALANCE TEST > CIRCUIT SYSTEM TESTING

Fuel Injector Balance Test with Active Fuel Injector Tester

1. Ignition OFF, all vehicle systems OFF. Install the **CH-47976** Active Fuel Injector Tester and the **CH-47976-500** Active Fuel Injection Tester (AFIT) SIDI Adapter Kit, refer to the Active Fuel Injector Tester User Guide. It may take up to 2 minutes for all vehicle systems to power down.
2. Turn ON the Active Fuel Injector Tester and select the vehicle.
3. Ignition ON, perform the Injector Test with the Active Fuel Injector Tester.
 1. **If the Active Fuel Injector Tester aborts testing due to fuel pressure or fuel leak down**

Refer to Fuel System Diagnosis .
 1. **If the Active Fuel Injector Tester does not abort testing**

4. Compare the test results with the appropriate recommended tolerance.

1. If any fuel injector exceeds the recommended tolerance

Replace the appropriate Q17 Fuel Injector(s).

1. If all fuel injectors are within the recommended tolerance

5. Perform Fuel Injector Circuit Diagnosis .

Fuel Injector Balance Test with Scan Tool

1. Ignition ON.

2. Command the Fuel Pump Enable ON with a scan tool.

3. Verify the fuel pressure is between 320-580 kPa (46-84 PSI) with the fuel pump running.

1. If not within 320-580 kPa (46-84 PSI)

Refer to Fuel System Diagnosis .

1. If within 320-580 kPa (46-84 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.

4. Verify the fuel pressure does not decrease greater than 34 kPa (5 PSI) within 1 minute.

1. If greater than the specified value

Refer to Fuel System Diagnosis .

1. If less than the specified value

5. Engine idling.

6. Verify the scan tool Fuel Rail Pressure Sensor 1 parameter is between 1.9-5.0 MPa (276-725 PSI).

1. If not between 1.9-5.0 MPa (276-725 PSI)

Refer to Fuel System Diagnosis .

1. If between 1.9-5.0 MPa (276-725 PSI)

 **NOTE:**

The engine speed must be between 600-1, 000 RPM to perform this test.

7. Select the Fuel Injector Balance function within the Control Functions menu of a scan tool.

8. Select and test a Q17 Fuel Injector. Repeat for each Q17 Fuel Injector.
9. Obtain and record a pressure drop value for each Q17 Fuel Injector.
10. Add all of the individual pressure drop values except for the fuel injector suspected of being faulty. This is the total pressure drop.
11. Divide the total pressure drop by the number of fuel injectors that were added together. This is the average pressure drop.
12. Multiply the average pressure drop by 0.20. This is the acceptable variance from the average pressure drop, 20%.
13. Verify the difference between any individual pressure drop and the average pressure drop is not greater than the acceptable variance.

1. If greater than the acceptable variance

Replace the Q17 Fuel Injector.

1. If within the acceptable variance

14. Perform Fuel Injector Circuit Diagnosis .

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR BALANCE TEST > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

Fuel Injector Replacement

DIAGNOSTIC INFORMATION AND PROCEDURES > 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 INFORMATION AND PROCEDURES > FUEL INJECTOR CIRCUIT DIAGNOSIS > 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
Fuel Injector 7 Control +	P217B	P0207	P217C	P124E
Fuel Injector 7 Control -	P0279	P0207	P0280	P124E
Fuel Injector 8 Control +	P217E	P0208	P217F	P124F
Fuel Injector 8 Control -	P0282	P0208	P0283	P124F

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR CIRCUIT

DIAGNOSIS > 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 INFORMATION AND PROCEDURES > FUEL INJECTOR CIRCUIT

DIAGNOSIS > DIAGNOSTIC AIDS

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to Fuel Injector Diagnosis .
- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Injector Control Circuit Status parameters. An Injector Control Circuit Status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR CIRCUIT

DIAGNOSIS > REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR CIRCUIT DIAGNOSIS > 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 1-8 Current Misfire Counter parameters do not increment.
 1. **If the Cylinder 1-8 Current Misfire Counters increment**
Refer to Circuit/System Testing.
 1. **If the Cylinder 1-8 Current Misfire Counters do not increment**
3. Verify the scan tool Cylinder 1-8 Injector Control Circuit Status parameters display OK.
 1. **If the Cylinder 1-8 Injector Control Circuit Status parameters do not display OK**
Refer to Circuit/System Testing.
 1. **If the Cylinder 1-8 Injector Control Circuit Status parameters display OK**
4. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR CIRCUIT

DIAGNOSIS > 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.

1. If less than infinite resistance

1. Disconnect the harness connector of the Q17 Fuel Injector.
2. Test for infinite resistance between the Q17 Fuel Injector control + circuit and ground.
 1. If infinite resistance
3. Test for infinite resistance between the Q17 Fuel Injector control - circuit and ground.
 1. If less than infinite, repair the short to ground in the circuit.
 2. If infinite, replace the Q17 Fuel Injector.

1. If infinite resistance

3. Ignition ON.
4. Test for less than 1 V between the Q17 Fuel Injector control + circuit and ground.

1. If 1 V or greater

1. Disconnect the harness connector of the Q17 Fuel Injector, ignition ON.
2. Test for less than 1 V between the Q17 Fuel Injector control + circuit and ground.
 1. If 1 V or greater, repair the short to voltage on the circuit.
 2. If less than 1 V, repair the short to voltage on the control - circuit.

1. 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.

1. If 3 Ω or greater

1. Disconnect the harness connector of the Q17 Fuel Injector.
2. Test for less than 2 Ω on the control + circuit end to end.
 1. If 2 Ω or greater, repair the open/high resistance in the circuit.
 1. If less than 2 Ω
3. Test for less than 2 Ω on the control - circuit end to end.

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

2. If less than 2 Ω , replace the Q17 Fuel Injector.

1. If less than 3 Ω

7. Replace the K20 Engine Control Module.

DIAGNOSTIC INFORMATION AND PROCEDURES > FUEL INJECTOR CIRCUIT DIAGNOSIS > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Injector Replacement
- Control Module References for K20 Engine Control Module replacement, programming, and setup

DIAGNOSTIC INFORMATION AND PROCEDURES > 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > ALCOHOL/CONTAMINANTS- IN-FUEL DIAGNOSIS > 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > ALCOHOL/CONTAMINANTS- IN-FUEL DIAGNOSIS > REFERENCE INFORMATION

Special Tools

CH 44175-A Alcohol Tester Kit, if available

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

DIAGNOSTIC INFORMATION AND PROCEDURES > ALCOHOL/CONTAMINANTS- IN-FUEL DIAGNOSIS > 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 min.
3. Verify the sample is clear and bright in color.

- 1. 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.

- 2. If alcohol contamination is suspected**

Refer to Circuit/System Testing - Alcohol in Fuel Testing.

- 1. If the sample remains clear and bright**

4. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > ALCOHOL/CONTAMINANTS- IN-FUEL DIAGNOSIS > CIRCUIT/SYSTEM TESTING

Alcohol in Fuel Testing with Special Tool, If Available

1. Test the fuel composition using **CH 44175-A** Alcohol Tester Kit and Instruction Manual.
2. Verify no water appears in the fuel sample.

- 1. If water appears in the fuel sample**

Clean the fuel system.

- 1. If no water appears in the fuel sample**

3. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.
4. Verify the non-blended gasoline fuel sample does not measure greater than 15% or an E85 blended gasoline fuel sample measures greater than 91% ethanol.

- 1. If greater than the specified value**

1. Add fresh regular gasoline to the vehicle's fuel tank.
2. Remove a new sample of fuel from the tank.
3. Test the fuel composition using **CH 44175-A** Alcohol Tester Kit and Instruction Manual.

4. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.
5. Verify the non-blended gasoline fuel sample does not measure greater than 15% or an E85 blended gasoline fuel sample measures greater than 91% ethanol.
 1. 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 .
 2. 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.

1. 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 s.
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 s.
6. Put the cylinder on a level surface for approximately 5 min in order to allow adequate liquid separation. If alcohol is present in the fuel, the volume of the lower layer, which would now contain both alcohol and water, will be more than 10 ml (0.34 oz). For example, if the volume of the lower layer is increased to 15 ml (0.51 oz), this indicates at least 5% 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%.
 - 1. If greater than the specified value**
 1. Add fresh regular gasoline to the vehicle's fuel tank.
 2. Remove a new sample of fuel from the tank.
 3. Test the fuel composition of the new sample.

4. Verify the non-blended gasoline fuel sample does not measure greater than 15%.

1. If greater than the specified value, drain and replace the vehicle's fuel. Refer to Fuel Tank Draining .

2. If the specified value or less, all OK.

1. If the specified value or less

8. All OK.

Particulate Contaminants in Fuel

1. Using an approved fuel container, draw approximately 0.5 liter (0.53 qt) of fuel from the bottom of the fuel tank.

2. Place the container on a level surface for approximately 5 min in order to allow settling of the particulate contamination. Particulate contamination will show up in various shapes and colors. Sand will typically be identified by a white or light brown crystals. Rubber will appear as black and irregular particles.

3. Verify there are no physical contaminants or water present in the fuel sample.

1. If any physical contaminants or water are present

Clean the fuel system.

1. If no physical contaminants or water are present

4. All OK.

**DIAGNOSTIC INFORMATION AND PROCEDURES > ALCOHOL/CONTAMINANTS-
IN-FUEL DIAGNOSIS > REPAIR INSTRUCTIONS**

Perform the Diagnostic Repair Verification after completing the repair.

Fuel System Cleaning

**DIAGNOSTIC INFORMATION AND PROCEDURES > 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.

**DIAGNOSTIC INFORMATION AND PROCEDURES > ELECTRONIC IGNITION SYSTEM
DIAGNOSIS > 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 INFORMATION AND PROCEDURES > ELECTRONIC IGNITION SYSTEM DIAGNOSIS > 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.

DIAGNOSTIC INFORMATION AND PROCEDURES > ELECTRONIC IGNITION SYSTEM DIAGNOSIS > REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

Scan Tool Reference

Control Module References

Special Tools

EL 26792 HEI Spark Tester

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

DIAGNOSTIC INFORMATION AND PROCEDURES > ELECTRONIC IGNITION SYSTEM DIAGNOSIS > CIRCUIT/SYSTEM VERIFICATION

Verify the following conditions. Refer to Spark Plug Wire Inspection , and Ignition System Specifications

- The ignition coils and spark plug wires are correctly connected
- The spark plug wire resistance is within specifications
- The correct spark plug type
- The correct spark plug gap
- The correct spark plug torque
- **If a condition was found**
Repair or replace as necessary.
- **If a condition was not found**
Refer to Circuit/System Testing.

DIAGNOSTIC INFORMATION AND PROCEDURES > ELECTRONIC IGNITION SYSTEM DIAGNOSIS > CIRCUIT/SYSTEM TESTING



NOTE:

Do not perform this diagnostic procedure unless you were sent here from a misfire DTC or the Engine Cranks But Does Not Run diagnostic.

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate T8 Ignition Coil. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 5 Ω between the ground circuit terminal 1 and ground.
 1. **If 5 Ω or greater**
 1. Ignition OFF.
 2. Test for less than 2 Ω in the ground circuit end to end.
 1. If 2 Ω or greater, repair the open/high resistance in the circuit.
 2. If less than 2 Ω , repair the open/high resistance in the ground connection.
 1. **If less than 5 Ω**
3. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.
 1. **If 5 Ω or greater**

1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the low reference circuit end to end.
 1. If 2 Ω or greater, repair the open/high resistance in the circuit.
 2. If less than 2 Ω , replace the K20 Engine Control Module.

1. If less than 5 Ω

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

1. If the test lamp does not illuminate

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

1. 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 1-8 Current Misfire Counter does not increment for the same cylinder that the suspect T8 Ignition Coil was removed from.

1. If increments

Replace the K20 Engine Control Module.

1. If does not increment

9. Test or replace the T8 Ignition Coil.

DIAGNOSTIC INFORMATION AND PROCEDURES > ELECTRONIC IGNITION SYSTEM DIAGNOSIS > 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, engine Running.

2. Verify the spark output of the T8 Ignition Coil.

1. If no output or the output is weak

Replace the T8 Ignition Coil

1. If the output is good

3. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > ELECTRONIC IGNITION SYSTEM DIAGNOSIS > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

- Ignition Coil Replacement (Bank 1) Ignition Coil Replacement (Bank 2)
- Spark Plug Replacement
- Spark Plug Wire Replacement
- Control Module References for engine control module replacement, programming, and setup.

DIAGNOSTIC INFORMATION AND PROCEDURES > EVAPORATIVE EMISSION SYSTEM DIAGNOSIS

Special Tools

EN 41413-VLV EVAP Service Port Vent Fitting

DIAGNOSTIC INFORMATION AND PROCEDURES > EVAPORATIVE EMISSION SYSTEM DIAGNOSIS > OPERATING INSTRUCTIONS FOR THE EVAPORATIVE EMISSION SYSTEM TESTER

Vehicle Setup



WARNING:

Refer to Fuel and Evaporative Emission Pipe Warning .



CAUTION:

Refer to Clean, Dry, Low Pressure Gas Source Caution .

 NOTE:

When servicing the evaporative emission (EVAP) system, test pressure must not exceed 13 in H₂O (0.5 PSI) as pressure in excess of this could cause system components to perform inaccurately.

 NOTE:

A large difference between the vehicle temperature and shop temperature will seriously affect the accuracy of the tests. Always allow at least 15 min for the vehicle temperature to adjust to the shop temperature. Refer to Temperature Variation Instructions for more information about vehicle versus shop temperatures.

1. Engine OFF, open the hood. Position a large fan to blow air under the vehicle onto the fuel tank area.
2. Connect the red battery clip from the tester to the positive battery terminal.

 NOTE:

The vehicle battery must be fully charged for optimum tester performance.

3. Connect the black battery clip from the tester to chassis ground.

DIAGNOSTIC INFORMATION AND PROCEDURES > EVAPORATIVE EMISSION SYSTEM DIAGNOSIS > FLOW METER TEST - LEAK DETECTION

 CAUTION:

Refer to Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Caution .

1. Open the Nitrogen tank valve and turn the NITROGEN / SMOKE valve on the front control panel to NITROGEN.
2. Connect the hose to the correct test orifice on the bottom front of the tester. For orifice size, refer to the vehicle specific information found in service procedures for DTCs that relate to EVAP system leaks.
3. Press and release the remote switch to activate the tester.

 NOTE:

The tester will time out after about 15 min. You may press the remote switch to reactivate the tester as desired.

4. Position the sliding red flag on the flow meter to align with the floating indicator. When the red flag is set, press and release the remote switch to deactivate the tester.
5. Remove the hose from the test orifice and install the hose onto the vehicle. For proper connection location, and the special tool numbers for any adapters that may be required, refer to the service procedures for DTCs that relate to EVAP system leaks.
6. Ignition ON, seal the EVAP system per instructions in the service procedures for DTCs that relate to EVAP system leaks. Most systems can be sealed using a scan tool output control for the EVAP Vent Solenoid Valve, other systems require that the vent system be plugged.



NOTE:

- 1. Larger volume fuel tanks, and/or those with lower fuel levels, may require several minutes to fill with nitrogen.*
- 2. Static buildup may cause the float indicator to stick. It may be necessary to tap on the flow meter to free up the float.*
- 3. If fuel level is 90% or greater it will take longer to fill the system with smoke because the fuel fill tube check valve will be closed and force any smoke to pass through the on-board refueling vapor recovery pipe and orifice.*

7. Press and release the remote switch to activate the nitrogen flow and fill the system.
8. Verify the stable floating indicator position to the red flag.

1. Above the red flag, result is unacceptable - fail

Go to the Smoke Procedure

1. Below the red flag - pass. Test complete

9. Press and release the remote switch to deactivate the tester.

DIAGNOSTIC INFORMATION AND PROCEDURES > EVAPORATIVE EMISSION SYSTEM DIAGNOSIS > SMOKE PROCEDURE - LOCATE THE LEAK



NOTE:

It is not recommended to use the tester in an outside repair bay area because wind and sunlight may affect temperature and your ability to see the smoke.

1. Turn OFF any fans that may cause air movement around or near the vehicle.

 NOTE:

Completely unwind the nitrogen/smoke hose from the bracket to optimize the tester's performance.

2. Connect the nitrogen/smoke hose to the vehicle as directed in the service procedures. Some vehicles require that the nitrogen/smoke hose be connected at the front of the EVAP system at the EVAP service port. An adapter may be necessary. Other vehicles require the connection be made at the rear of the system using an adapter at the fuel fill cap or capless fuel fill. Consult the service procedures for DTCs that relate to EVAP system leaks for vehicle specific instructions regarding connection location and adapters.
3. Open the Nitrogen tank valve and turn the nitrogen/smoke valve on the control panel to smoke.

 NOTE:

The remote switch operates on a push ON, push OFF fashion.

4. Press and release the remote switch to activate the tester and inject smoke into the EVAP system.
5. Verify smoke has filled the EVAP system by opening the system opposite the end where smoke is injected.

 NOTE:

1. *When injecting smoke at the service port, remove the fuel fill cap until smoke is observed. Then close the system and continue testing.*
2. *If using a special tool fuel fill cap adapter at the filler neck, vent the system at the service port, with special tool EN 41413-VLV until smoke is observed then remove the vent fitting tool and close the system to continue with the test.*
3. *Inject smoke in less than 2 min cycles for optimum tester performance.*

6. Press and release the remote switch to deactivate the tester.

 NOTE:

For optimum visual smoke performance, deactivate the smoke flow and allow the system pressure to drop. Allowing the smoke to exit small holes at a low flow rate greatly enhances visibility.

7. Introduce smoke into the system for an additional 60 s. Continue introducing smoke at 15 s intervals, as necessary until leak source is identified.

8. Using a high-intensity white light, inspect the entire EVAP system path, and look for the source of the leak indicated by the exiting smoke.

1. **Smoke seen leaking**

- Repair or replace the affected component.

1. **No smoke seen leaking**

9. All OK

DIAGNOSTIC INFORMATION AND PROCEDURES > EVAPORATIVE EMISSION SYSTEM DIAGNOSIS > TEMPERATURE VARIATION INSTRUCTIONS

The Concern

Ideal circumstances for conducting the EVAP flow meter test require equal temperatures between the Nitrogen gas and the vehicle EVAP system. Significant differences in temperature between them can result in a flow or pressure change during testing, causing misleading results. Typically, the evaporative emission system tester is stored indoors, approximately 21°C (70°F). Vehicles brought in for diagnosis may have an EVAP system at significantly different temperatures.

For Example



NOTE:

With no temperature difference between the Nitrogen gas and EVAP system, the resulting vehicle EVAP system pressure will remain stable at 13 in. H₂O (0.5 PSI) once pressurized, providing no leaks are present.

When the EVAP flow meter tests are performed with significant differences in temperature between the Nitrogen gas and the vehicle EVAP system, the following results can occur:

- An increase in flow during the flow meter test can be caused by a vehicle's warm EVAP system cooling down.
- A decrease in flow during the flow meter test can be caused by a vehicle's cool EVAP system warming up.

The Solution

When working on a vehicle with significant temperature differences between the vehicle EVAP system and the Nitrogen gas, allow the vehicle EVAP system temperature to stabilize as close as possible to the temperature of the Nitrogen gas before conducting the flow meter test.

DIAGNOSTIC INFORMATION AND PROCEDURES > CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS > DIAGNOSTIC INSTRUCTIONS

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

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

DIAGNOSTIC INFORMATION AND PROCEDURES > CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS > CIRCUIT DESCRIPTION

To provide maximum fuel economy under light load driving conditions, the engine control module (ECM) will command the valve lifter oil manifold assembly solenoids ON, to deactivate engine cylinders 1 and 7 on the left bank, and cylinders 4 and 6 on the right bank. The valve lifter oil manifold assembly consists of 4 electrically operated normally closed solenoids, which directs pressurized engine oil to 8 deactivating valve lifters. All 4 valve lifter oil manifold assembly solenoids are connected in parallel to a fused ignition circuit supplied by the powertrain relay. The control circuit for each solenoid is connected to an individual low side driver internal to the ECM. When enabling conditions for V4 mode are met, the ECM will command each low side driver to turn ON, in engine firing order sequence.

DIAGNOSTIC INFORMATION AND PROCEDURES > CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS > DIAGNOSTIC AIDS

- Observe the scan tool Cylinder Deactivation Inhibit reasons to assist in determining the cause of the concern.
- Review scan tool Cylinder Deactivation Disable History to determine reason for disabling cylinder deactivation.
- A restricted valve lifter oil filter may cause a cylinder deactivation system concern. Inspect the valve lifter oil filter for a restriction or blockage. Refer to Valve Lifter Oil Filter Replacement .

DIAGNOSTIC INFORMATION AND PROCEDURES > CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS > REFERENCE INFORMATION

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cylinder Deactivation (Active Fuel Management) System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs

- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EN-46999 Active Fuel Management Tester

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

DIAGNOSTIC INFORMATION AND PROCEDURES > CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS > CIRCUIT/SYSTEM VERIFICATION

1. Verify the engine oil level is within the specified level.
 1. **If not within the specified level**
Repair as necessary.
 1. **If within the specified level**
2. Verify the engine oil pressure is within the specified range, refer to Oil Pressure Diagnosis and Testing .
 1. **If not within the specified range**
Repair as necessary.
 1. **If within the specified range**
3. Verify no other DTCs are set, except P0300 - P0308.
 1. **If other DTCs are set**
Refer to Diagnostic Trouble Code (DTC) List - Vehicle for further diagnosis.
 1. **If no other DTCs are not set**
4. Engine idling at the normal operating temperature.
5. Verify there is no abnormal engine noise.
 1. **If there is an abnormal engine noise**
Refer to Symptoms - Engine Mechanical for further diagnosis.
 1. **If no abnormal engine noise**
6. Verify the Cylinder Deactivation (Active Fuel Management) System Compression Test passes the compression test.

1. If compression test failed

Test the Q43 Valve Lifter Oil Manifold Assembly, refer to Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing .

1. If compression test passes

7. Refer to Circuit/System Testing.

DIAGNOSTIC INFORMATION AND PROCEDURES > CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS > CIRCUIT/SYSTEM TESTING

1. Ignition OFF, all vehicle systems OFF, remove fuse F15UA from the underhood fuse block. It may take up to 2 min for all vehicle systems to power down.



NOTE:

Probe each terminal at the underhood fuse block with a test lamp connected to ground to determine what terminal to connect the DMM. The test lamp should not illuminate on the circuit that needs to be tested.

2. Connect a DMM between the output terminal at fuse F15UA and the K20 Engine Control Module housing.

3. Ignition ON.

4. Verify the resistance of each solenoid is between 11-18 Ω while commanding the Cylinder 1, 4, 6, and 7 Deactivation Solenoid Valve Command On and Off with a scan tool.

1. If not between 11-18 Ω for all cylinder deactivation solenoids , test the ignition circuit for an open/high resistance.

1. Ignition OFF.

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

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

2. If less than 2 Ω , refer to Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing .

1. If not between 11-18 Ω for one or more but not all cylinder deactivation solenoids

1. Ignition OFF.

2. Test for less than 2 Ω on the appropriate control circuit end to end.

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

1. If less than 2 Ω

3. Test for 11-18 Ω between the ignition circuit and the appropriate control circuit at the

Q43 Valve Lifter Oil Manifold Assembly.

1. If not within the specified value, test or replace the Q43 Valve Lifter Oil Manifold Assembly.
2. If within the specified value, test or replace the K20 Engine Control Module.

1. If between 11-18 Ω



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. Operate the vehicle within the conditions of the customer's concern while monitoring the Cylinder Deactivation Inhibit parameters.
6. Verify all Cylinder Deactivation Inhibit parameters display NO.

1. If any parameter displays YES

Refer to the appropriate vehicle system to determine the cause for cylinder deactivation inhibit.

1. Symptoms - Engine Controls
2. Symptoms - Engine Cooling
3. Symptoms - Engine Electrical
4. Symptoms - Engine Mechanical

1. If none of the parameters display YES

7. Refer to Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing .

DIAGNOSTIC INFORMATION AND PROCEDURES > CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS > REPAIR INSTRUCTIONS

Perform the Diagnostic Repair Verification after completing the repair.

- Valve Lifter Oil Manifold Replacement
- Control Module References for K20 Engine Control Module replacement, programming and setup

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE SYSTEM CHECK > DIAGNOSTIC INSTRUCTIONS

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

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE SYSTEM CHECK > DESCRIPTION

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

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE SYSTEM CHECK > CONDITIONS FOR UPDATING THE I/M SYSTEM STATUS



NOTE:

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

Each system monitor requires at least one, and sometimes several diagnostic tests. The result of each test is reported by a DTC. A system monitor is complete when either all of the DTCs composing the monitor have Run and Passed, or when any one of the DTCs comprising the monitor has illuminated the malfunction indicator lamp (MIL). Once the system monitor is complete, the I/M System Status display will indicate YES in the Completed column.

For example, when the HO2S Heater Status indicates YES, either all of the oxygen sensor heater tests have passed or one of the tests has illuminated the MIL. If the vehicle has 4 heated oxygen sensors, either all 4 heater circuit tests have passed or one of the heater circuit tests has illuminated the MIL. The I/M System Status will indicate NO under the Completed column when any of the required tests for that system have not run. The following is a list of conditions that would set the I/M System Status indicator to NO:

- The vehicle is new from the factory and has not yet been driven through the necessary drive conditions to complete the tests.
- The battery has been disconnected or discharged below operating voltage.
- The control module power or ground has been interrupted.
- The control module has been reprogrammed.
- The control module DTCs have been cleared.

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE SYSTEM CHECK > MONITORED EMISSION CONTROL SYSTEMS

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

- The air conditioning system
- The catalytic converter efficiency
- Comprehensive component monitoring-Emission related inputs and outputs
- The evaporative emission (EVAP) system
- The fuel delivery system
- Heated catalyst monitoring
- Misfire monitoring
- The oxygen sensor system (O2S or HO2S)
- The oxygen sensor heater system (HO2S heater)

For the specific DTCs required for each system, refer to Inspection/Maintenance (I/M) System DTC Table . Systems such as fuel delivery, misfire, and comprehensive components may not be listed in a system status list. These tests run continuously and do not require an I/M System Status indicator.

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE SYSTEM CHECK > CIRCUIT/SYSTEM VERIFICATION

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

1. If any I/M Test DTCs are set

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

1. If no I/M Test DTCs are set

2. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE SYSTEM CHECK > CIRCUIT/SYSTEM TESTING



NOTE:

Many DTC related repairs will instruct the technician to clear the DTC information. Clearing the DTC will reset the I/M System Status indicators to NO. Performing the

I/M Complete System Set Procedure will set each of the I/M System Status indicators to YES.

1. Verify no I/M DTCs are present.

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

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

1. If no I/M DTCs are set

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

1. If a control module re-program or other repair is required,

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

1. If no repair is required

3. Observe the I/M System Status indicators.

1. If any I/M System Status indicators report NO

Perform the Inspection/Maintenance Complete System Set Procedure .

1. If no I/M System Status indicators report NO

4. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE COMPLETE SYSTEM SET PROCEDURE > DIAGNOSTIC INSTRUCTIONS

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

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE COMPLETE SYSTEM SET PROCEDURE > DESCRIPTION

The purpose of the Inspection/Maintenance (I/M) Complete System Set Procedure is to satisfy the enable criteria necessary to execute all of the I/M readiness diagnostics and complete the drive cycles for those particular diagnostics. When all I/M monitored diagnostic tests are completed, the I/M System Status indicators are set to YES. Perform the I/M Complete System Set Procedure if any I/M System Status indicators are set to NO.

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE COMPLETE SYSTEM SET PROCEDURE > CONDITIONS FOR MEETING A COLD START

- The ignition voltage between 11-18 volts.
- The barometric pressure (BARO) is more than 75 kPa.
- The start-up engine coolant temperature (ECT) is between 4-30°C (39-86°F).
- The start-up intake air temperature (IAT) is between 4-30°C (39-86°F).
- The difference between the IAT and the ECT is less than or equal to 6°C (10.8°F).
- The ambient air temperature is between 4-30°C (39-86°F).
- The fuel level is between 15-85 percent.

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE COMPLETE SYSTEM SET PROCEDURE > CIRCUIT/SYSTEM VERIFICATION

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

1. If any I/M Test DTCs are set

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

1. If no I/M Test DTCs are set

2. All OK.

DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE COMPLETE SYSTEM SET PROCEDURE > INSPECTION/MAINTENANCE (I/M) SYSTEM SET PROCEDURE

 NOTE:

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

1. Ensure that the vehicle meets the conditions for a cold start listed above.
2. The evaporative emission (EVAP) I/M System Status indicator should display YES.

1. If the EVAP I/M System Status indicator displays NO, perform the EVAP Service Bay Test, if applicable. If the EVAP Service Bay Test is NOT available, it may take up to 6 drive cycles, with up to 17 hours between drive cycles, for the EVAP I/M System Status indicator to transition to YES.
3. The O2S Heater I/M System Status indicator should display YES.
 1. If the O2S Heater I/M System Status indicator displays NO, ensure that the ignition has been turned OFF for at least 10 hours.
4. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc.
5. Set the vehicle parking brake and ensure the vehicle is in Park for automatic transmission or Neutral for manual transmission.
6. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc.
7. Start and idle the engine for at least 2 minutes and until 65°C (149°F) is achieved.
8. Run the engine for 6.5 minutes within the following conditions:
 1. MAF parameter between 4-30 g/s
 2. Engine speed steady between 1, 000-3, 000 RPM
9. Return the engine to idle for 1 minute.
10. Apply and hold the brake pedal, and shift to Drive for automatic transmission, or apply the clutch pedal for manual transmission and operate the vehicle within the following conditions for 2 minutes:
 1. Depress the accelerator pedal until throttle position (TP) sensor angle is more than 2 percent.
 2. Mass air flow (MAF) signal between 15-30 g/s
 3. RPM steady between 1, 200-2, 000 RPM

 NOTE:

DO NOT touch the accelerator pedal during the idle period. A change in TP sensor angle or an increase in engine speed may invalidate this portion of the test.

11. Release the accelerator pedal and shift the vehicle to Park for automatic transmission, or Neutral and release the clutch pedal for manual transmission, and allow the engine to idle for 2 minutes.
12. Quickly depress the accelerator pedal until TP sensor angle is more than 8 percent and return to idle, repeat 3 times.
13. Allow engine to idle for at least 2 minutes.



WARNING:

Refer to Road Test Warning .

14. Release the parking brake and drive vehicle at 24 km/h (15 mph) or slower for 2 minutes.
15. Continue to drive the vehicle for at least 5.5 miles between 45-112 km/h (28-70 mph) with the vehicle reaching at least 80 km/h (50 mph).
16. Release the accelerator pedal for at least 2 seconds. This will allow the vehicle to enter decel fuel cut-off.
17. Depress the accelerator pedal until the TP sensor angle is increased 3-20 percent and maintain a safe speed for 1 minute.
18. Safely stop the vehicle, with the engine in Drive for automatic transmission or in Neutral with the clutch pedal depressed and parking brake applied for manual transmission, idle for 2 minutes.
19. Shift to Park for automatic and apply the parking brake, or neutral and release clutch pedal for manual.



NOTE:

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

20. Turn OFF the ignition and exit the vehicle. Do NOT disturb the vehicle for 60 minutes.
21. Observe the Inspection/Maintenance (I/M) System Status with a scan tool. All of the I/M System Status indicators should display YES.
 1. If the EVAP I/M System Status indicator displays NO, turn OFF the ignition for 17 hours, ensure that the vehicle meets the conditions for a cold start, and repeat steps 12-18 six more times, or until the EVAP I/M System Status indicator transitions to YES. If the indicator continues to display NO, refer to the Inspection/Maintenance (I/M) System DTC Table to identify the DTCs that did not run. Follow the Conditions for Running the DTC in order to set the EVAP I/M System Status indicator
 1. If any of the I/M System Status indicators display NO, refer to the Inspection/Maintenance (I/M) System DTC Table for the indicator which did not display YES. The I/M System DTC Table identifies the DTCs associated with each I/M System Status Indicator. Follow the Conditions for Running the DTC in order to set the associated status indicator.
22. Observe the engine DTC information with a scan tool. Verify no DTCs are present.
 1. If a DTC is set, diagnose using the Diagnostic Trouble Code (DTC) List - Vehicle . After repairs, perform the Inspection/Maintenance Complete System Set Procedure to verify no further DTCs are set.

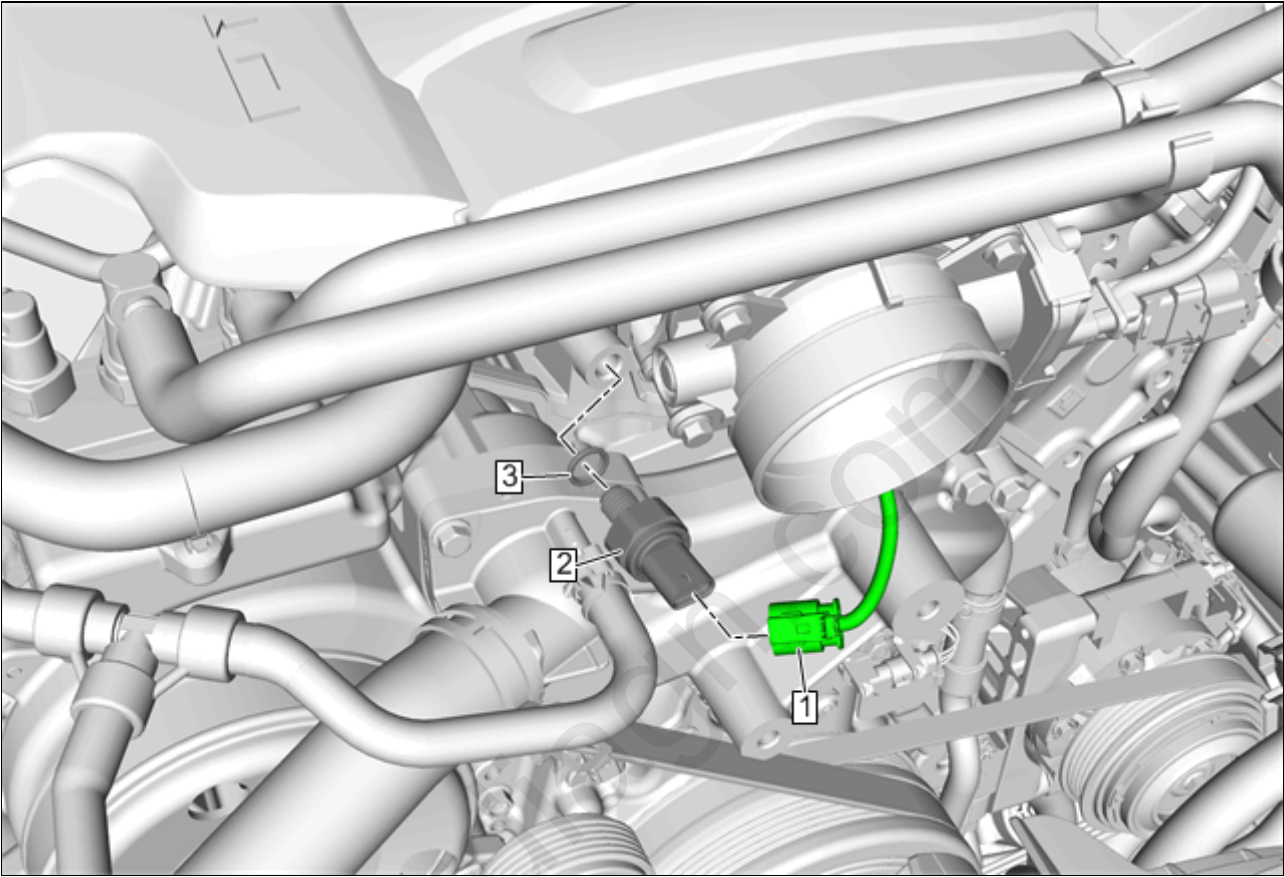
DIAGNOSTIC INFORMATION AND PROCEDURES > INSPECTION/MAINTENANCE

(I/M) SYSTEM DTC TABLE

System	DTCs Required to Set System Status to YES
If an I/M System Status indicator did NOT update to YES during the Inspection/Maintenance Complete System Set Procedure , review each indicator and reference this table to determine each DTC associated with the I/M System Status Indicator. Each DTC listed below has specific conditions that must be met for the diagnostic to run. Included within the conditions are additional DTCs which, if set, may inhibit the DTCs listed below from running. Reviewing and operating the vehicle within the Conditions for Running for each DTC listed below will allow the I/M System Status Indicators to transition to YES.	
Catalyst	DTC P0420 or P0430
EVAP	• DTC P0442 • DTC P0446 • DTC P0455
Fuel System	DTC P219A or P219B
Oxygen Sensor	• DTC P0131, P0132, P0137, P0138, P0151, P0152, P0157, or P0158 • DTC P0133, P013A-P013F, P014A, P014B, P0153, P015A-P015D, P1133, P1153, or P2270-P2273
Oxygen Sensor Heater	DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, or P0161
Camshaft System	DTC P0011

REPAIR INSTRUCTIONS > ENGINE OIL PRESSURE SENSOR REPLACEMENT

Fig 1: Engine Oil Pressure Sensor



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Throttle Body Assembly Replacement	
1	Electrical Connector
2	Engine Oil Pressure Sensor <i>CAUTION:</i> <i>Refer to Component Fastener Tightening Caution .</i> Tighten 35 N.m (26 lb ft)

3

O-Ring

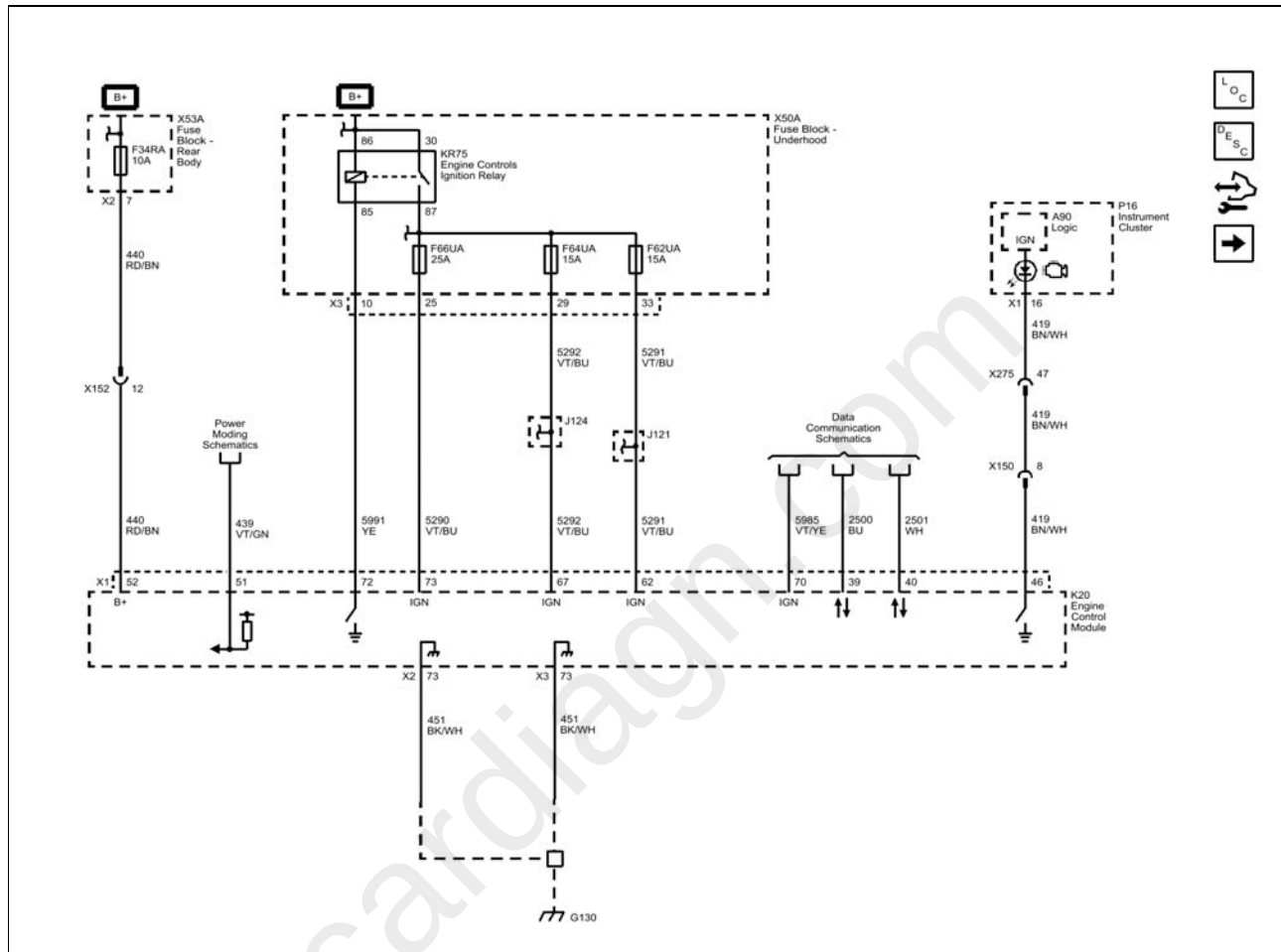
Procedure

Install a NEW O-ring seal.

cardiagn.com

**SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS >
MODULE POWER, GROUND, SERIAL DATA, AND MIL**

Fig 1: Module Power, Ground, Serial Data, and MIL



Courtesy of GENERAL MOTORS COMPANY

**SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS >
5V1, AND LOW REFERENCE BUS (1 OF 2)**

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > 5V2, 5V3, 5V4, AND LOW REFERENCE BUS (2 OF 2)

Courtesy of GENERAL MOTORS COMPANY

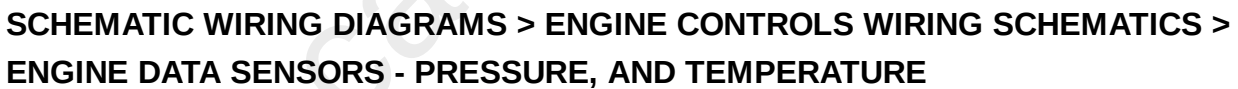
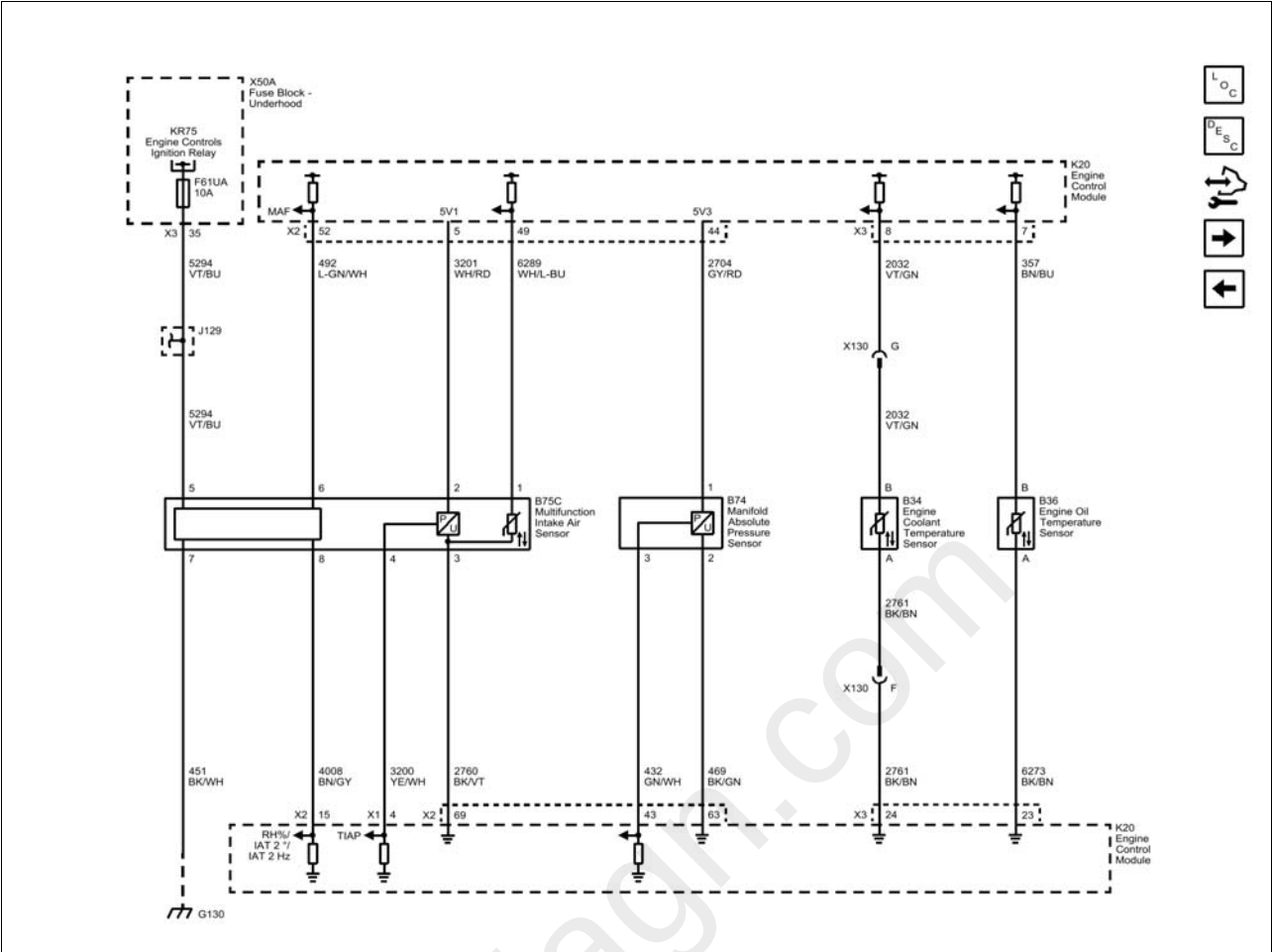


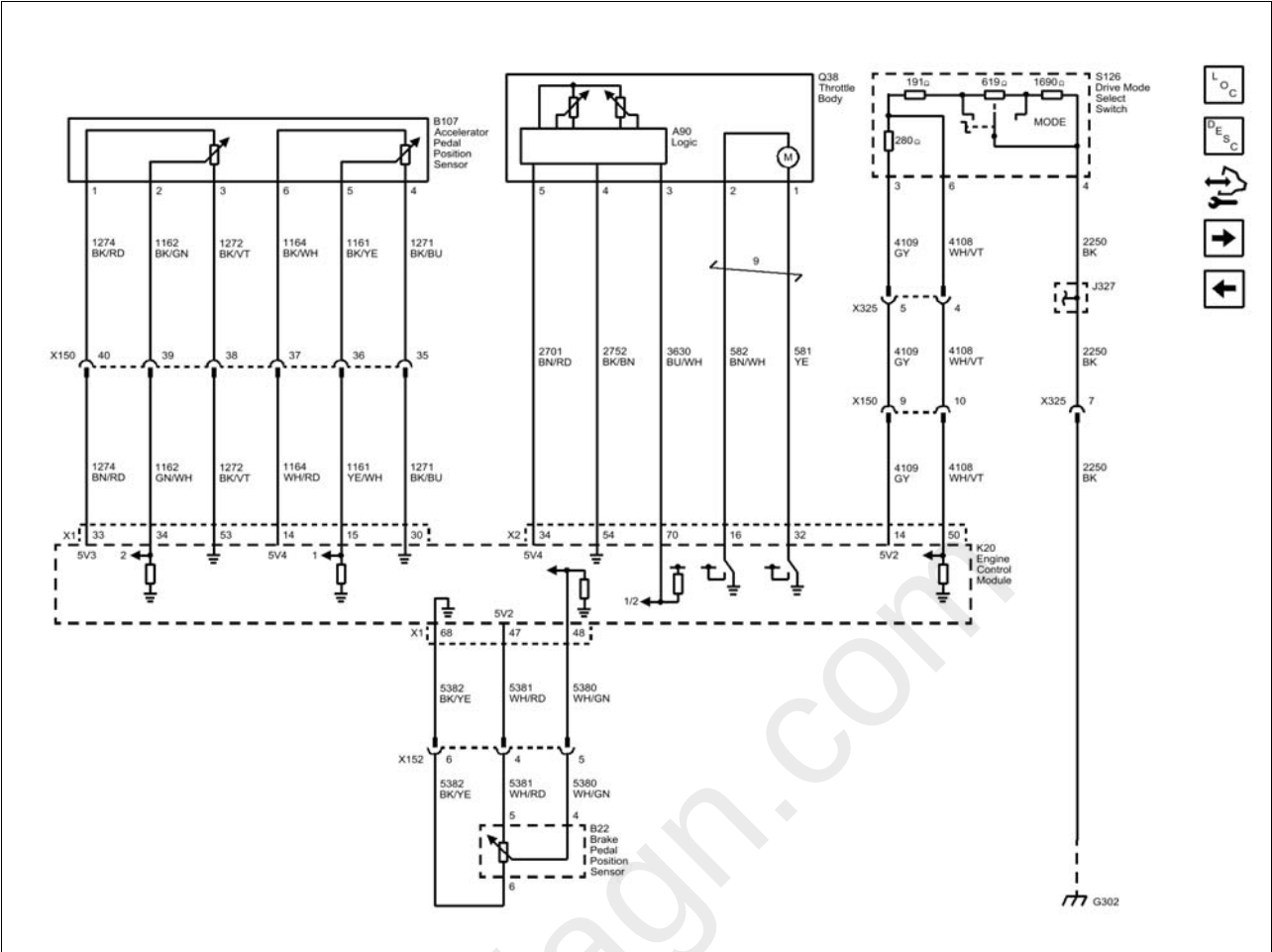
Fig 1: Engine Data Sensors - Pressure, and Temperature



Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > ENGINE DATA SENSORS - THROTTLE CONTROLS

Fig 1: Engine Data Sensors - Throttle Controls

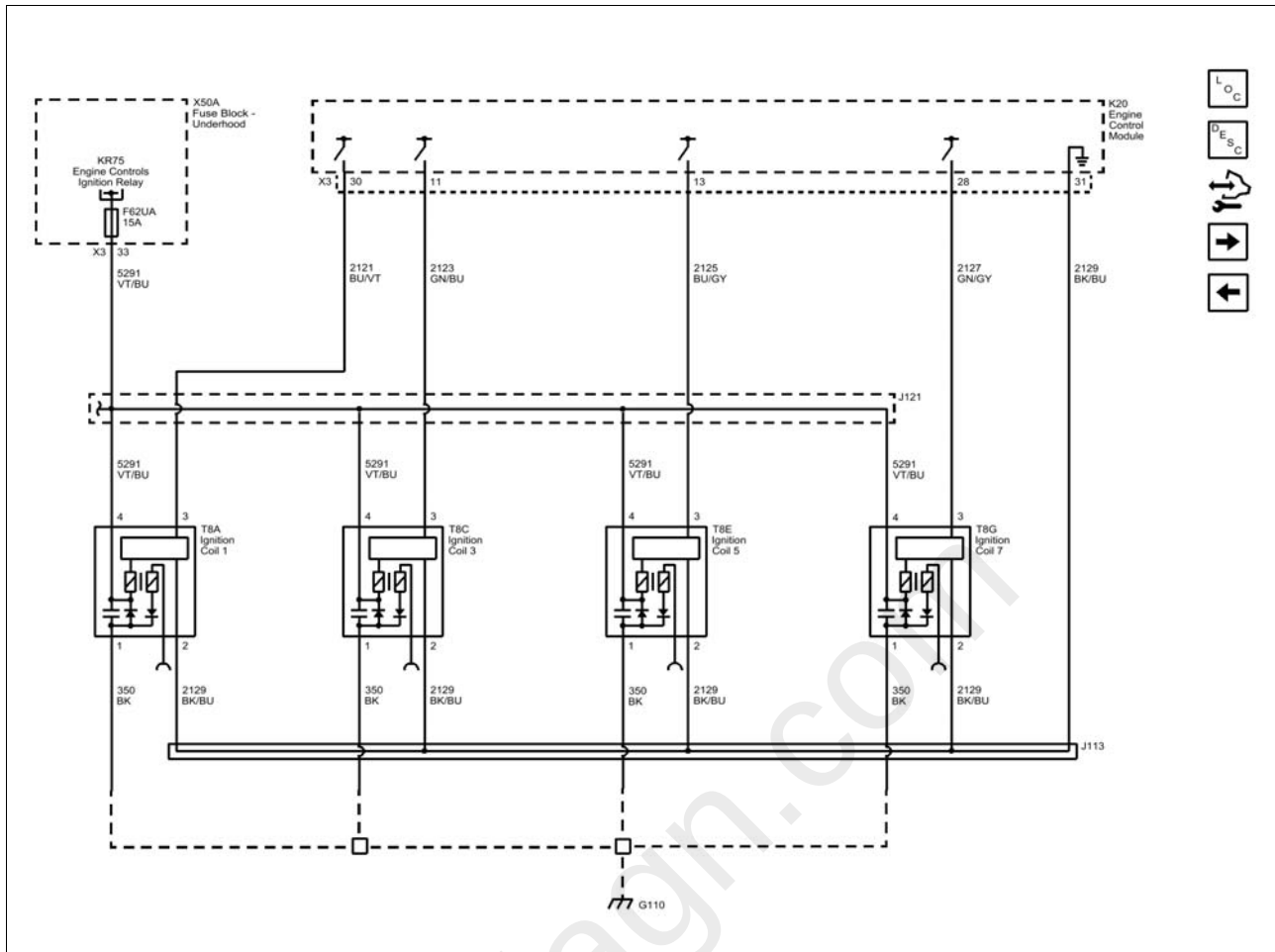


Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > ENGINE DATA SENSORS - OXYGEN SENSORS

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > IGNITION CONTROLS - IGNITION COILS 1, 3, 5, AND 7

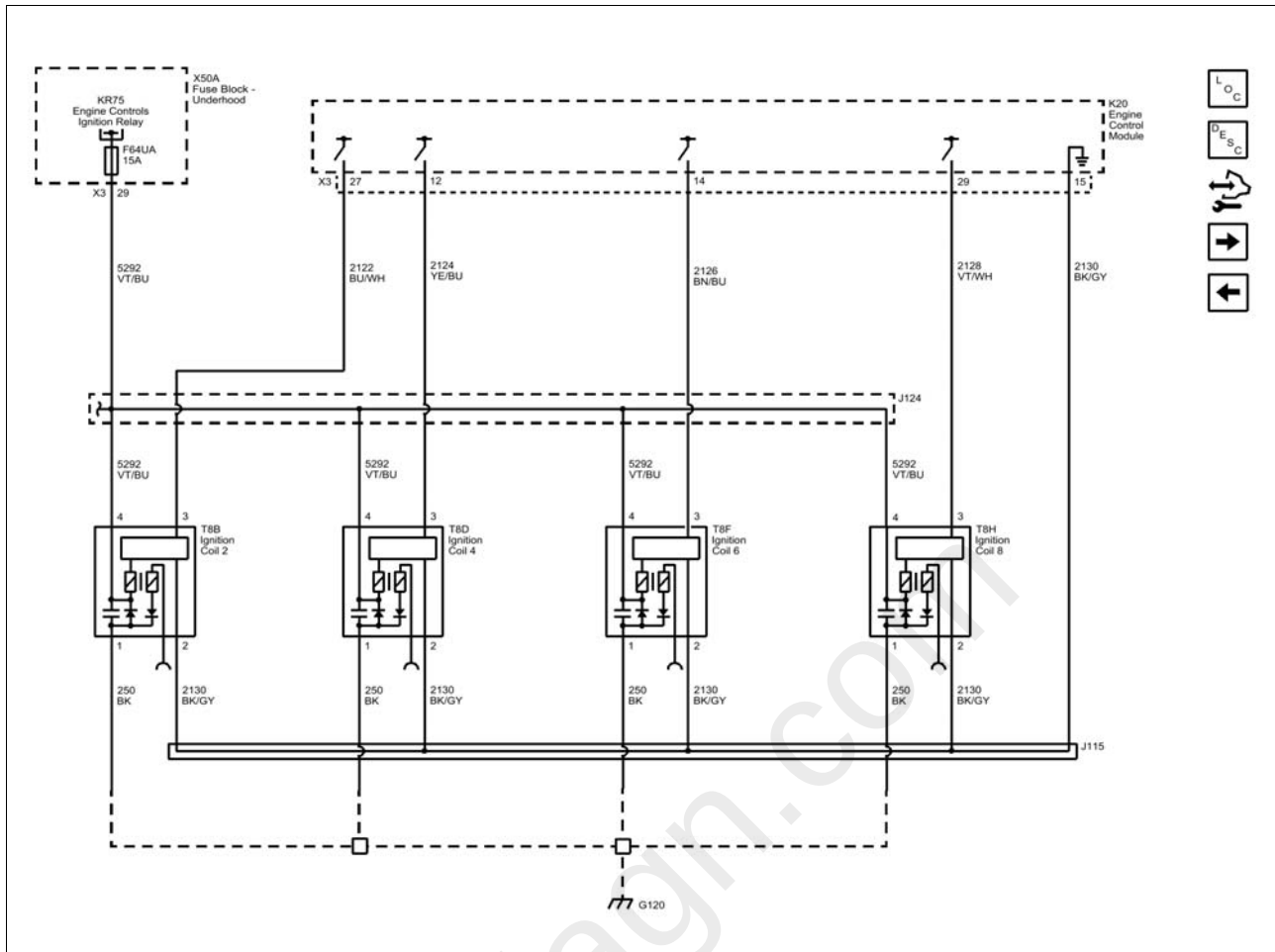
Fig 1: Ignition Controls - Ignition Coils 1, 3, 5, and 7



Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > IGNITION CONTROLS - IGNITION COILS 2, 4, 6, AND 8

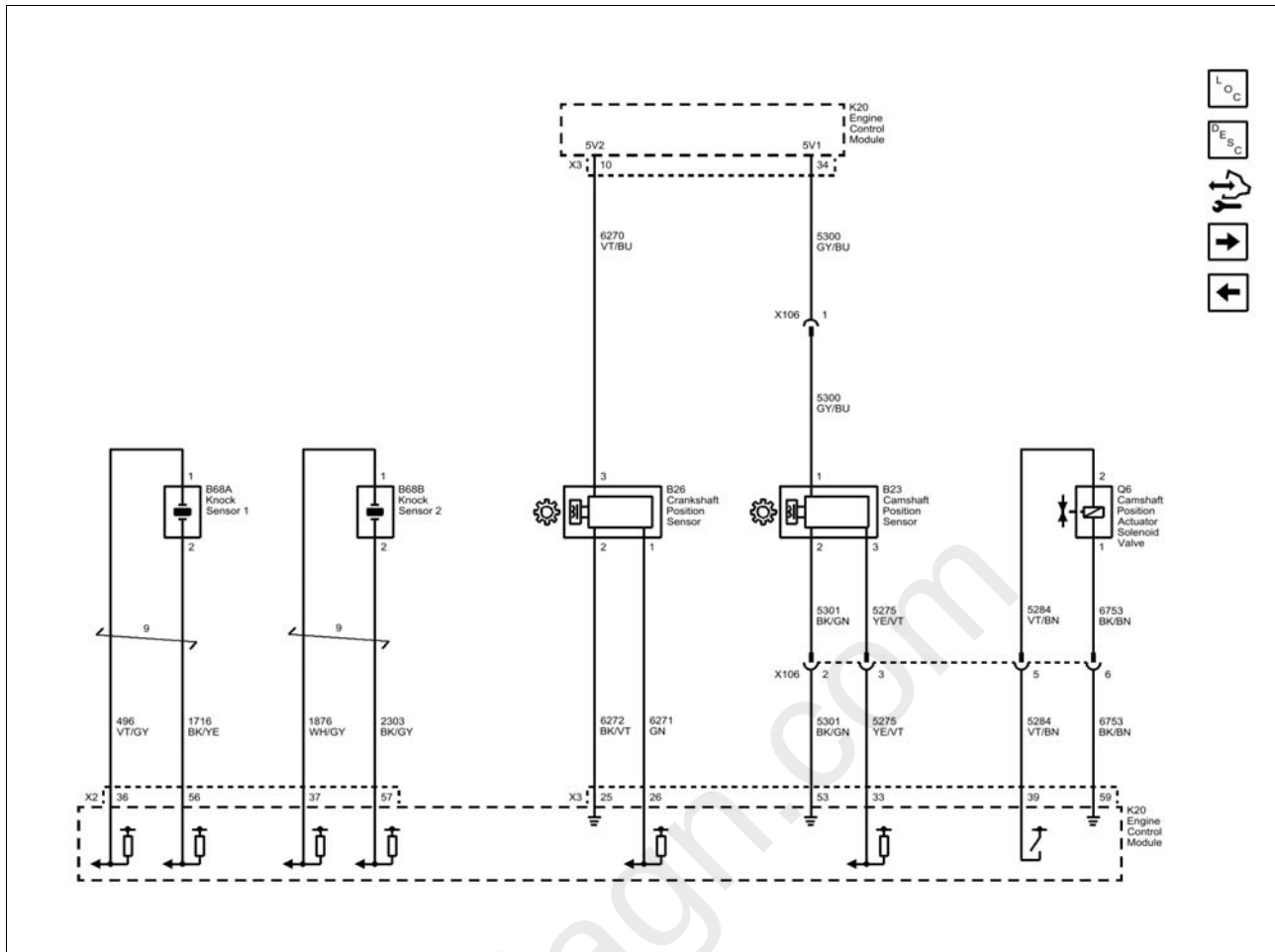
Fig 1: Ignition Controls - Ignition Coils 2, 4, 6, and 8



Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > IGNITION CONTROLS - CAMSHAFT, CRANKSHAFT AND KNOCK SENSORS, CAMSHAFT ACTUATOR

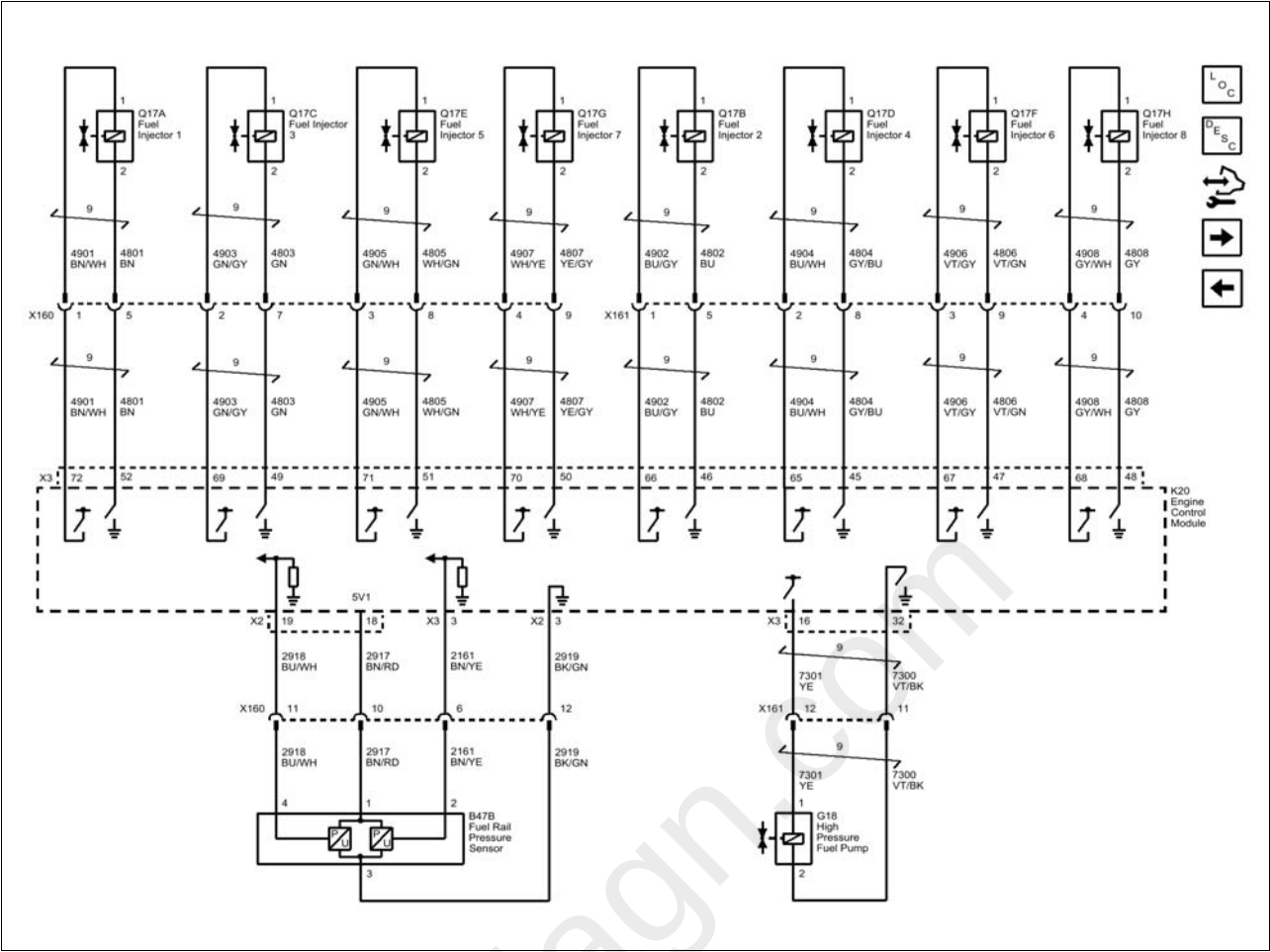
Fig 1: Ignition Controls - Camshaft, Crankshaft and Knock Sensors, Camshaft Actuator



Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > FUEL CONTROLS - FUEL INJECTORS, FRP SENSOR, HIGH PRESSURE FUEL PUMP

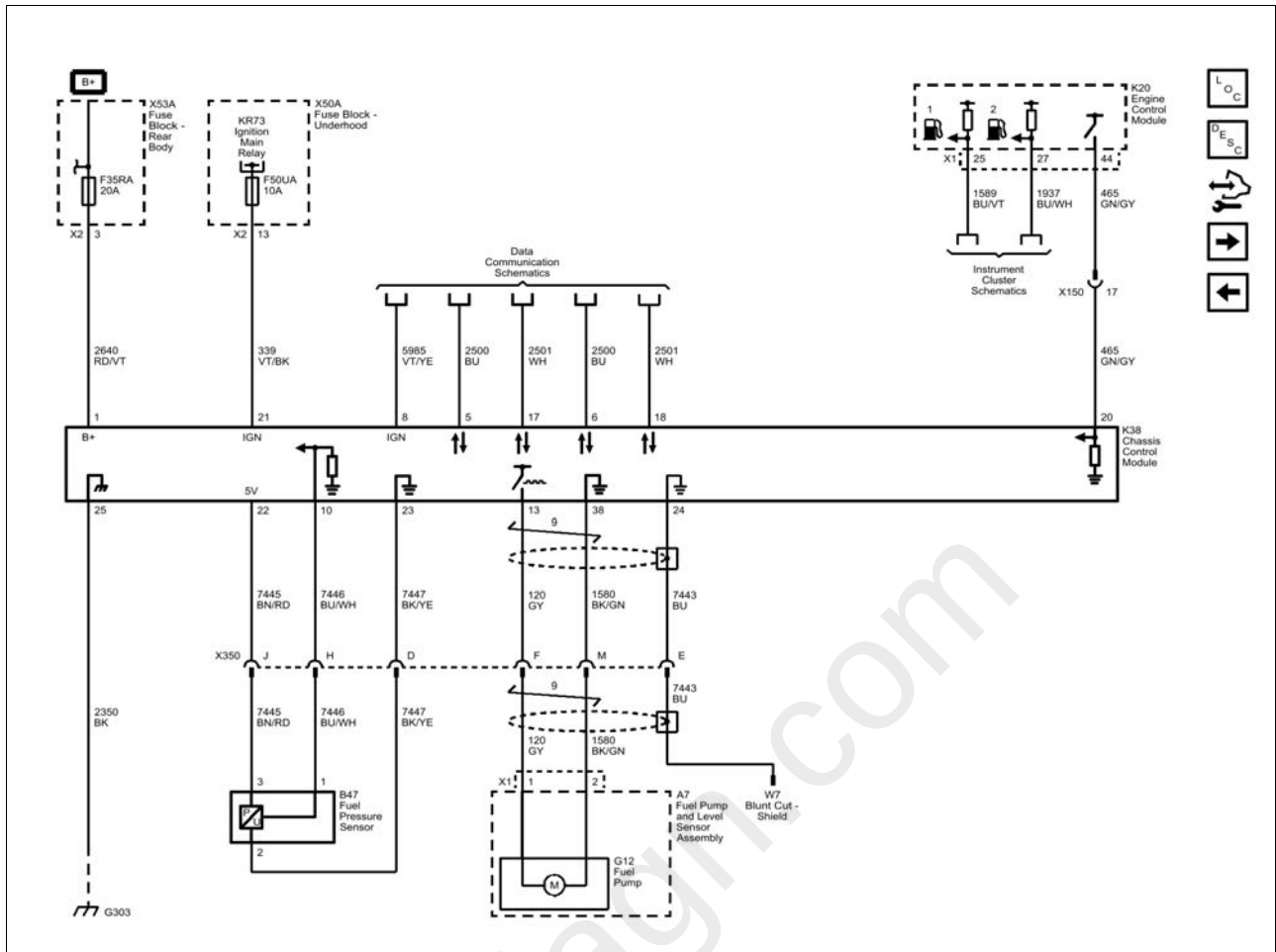
Fig 1: Fuel Controls - Fuel Injectors, FRP Sensor, High Pressure Fuel Pump



Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS >
FUEL CONTROLS - FUEL PUMP CONTROLS

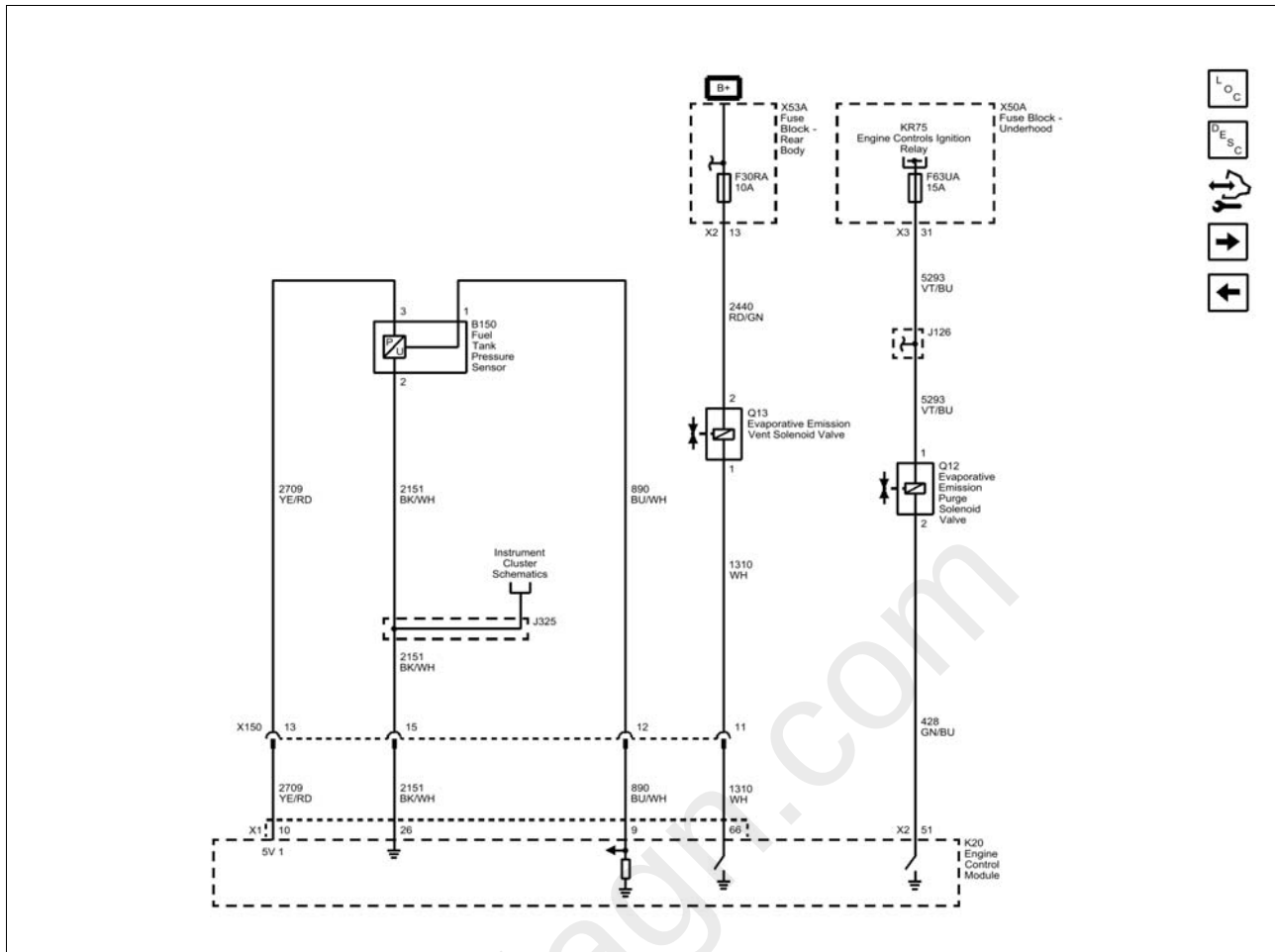
Fig 1: Fuel Controls - Fuel Pump Controls



Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > FUEL CONTROLS - EVAPORATIVE EMISSION CONTROLS

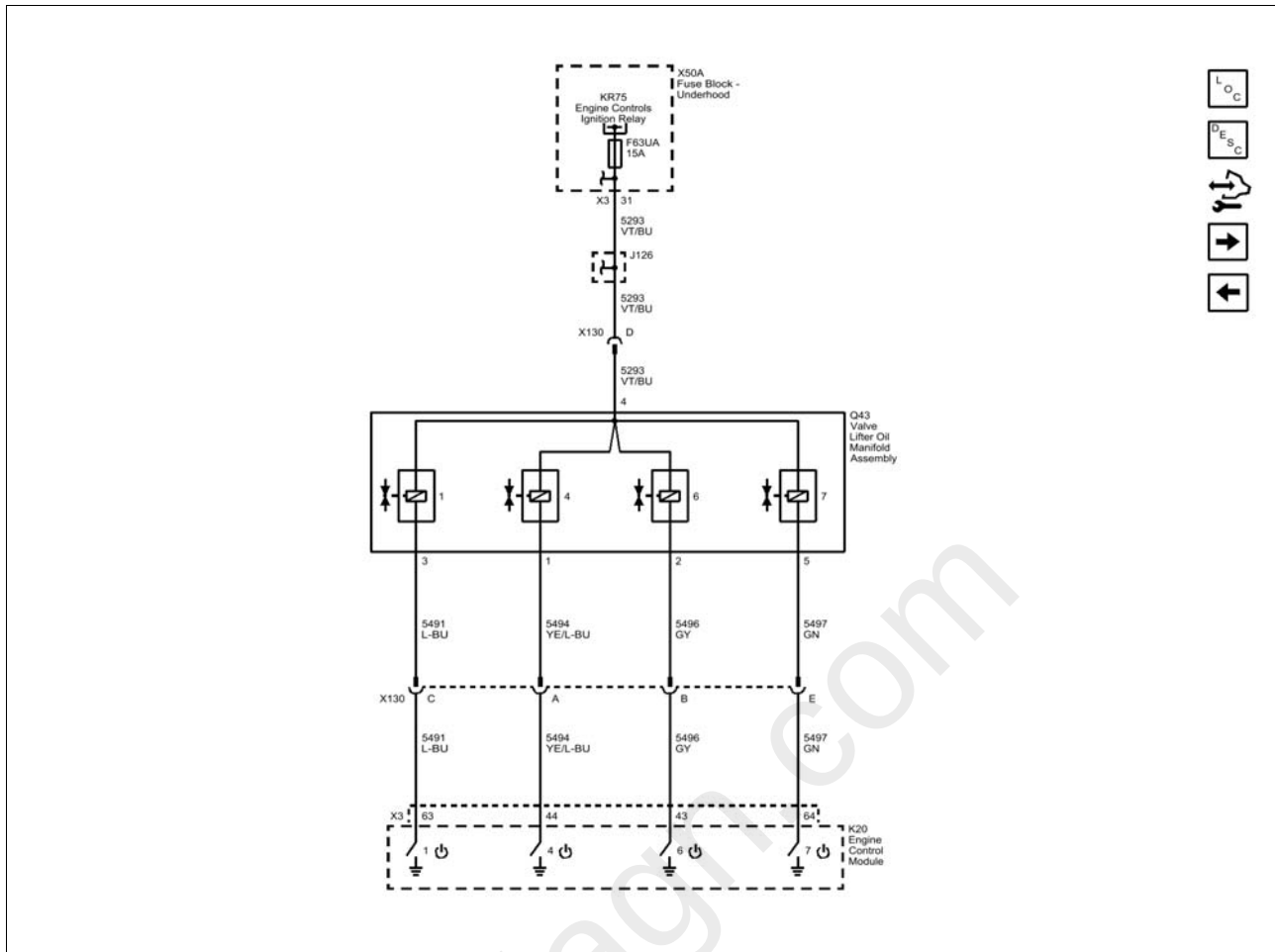
Fig 1: Fuel Controls - Evaporative Emission Controls



Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > VALVE LIFTER OIL MANIFOLD ASSEMBLY

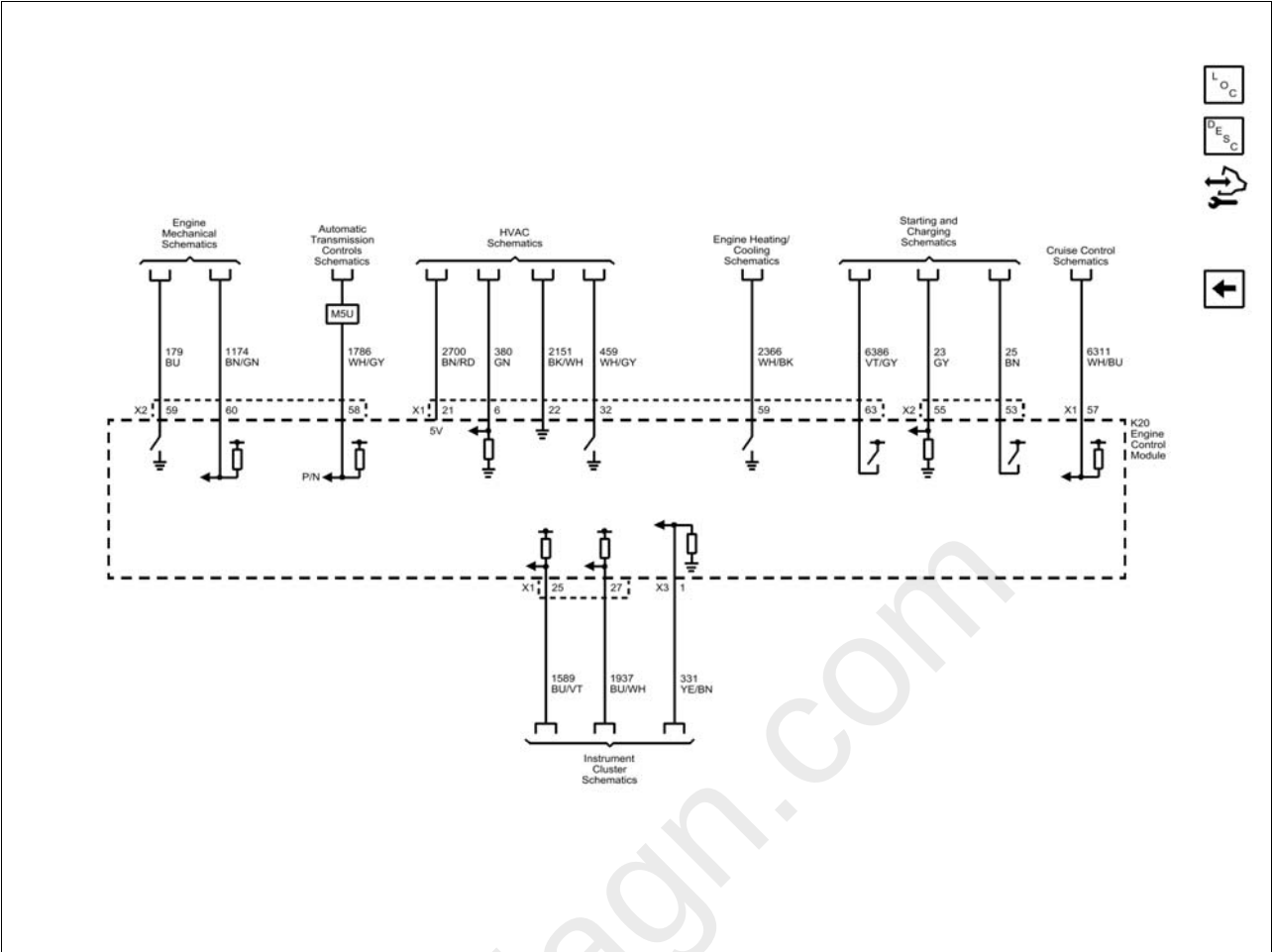
Fig 1: Valve Lifter Oil Manifold Assembly



Courtesy of GENERAL MOTORS COMPANY

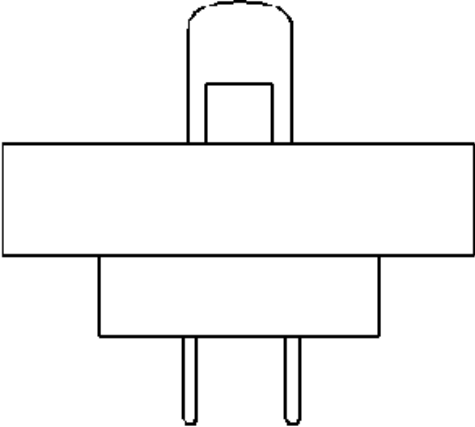
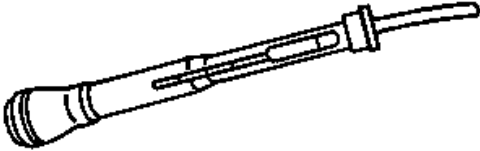
SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > CONTROLLED/MONITORED SUBSYSTEM REFERENCES

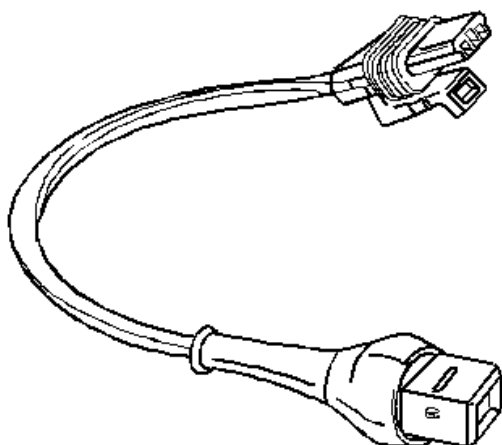
Fig 1: Controlled/Monitored Subsystem References



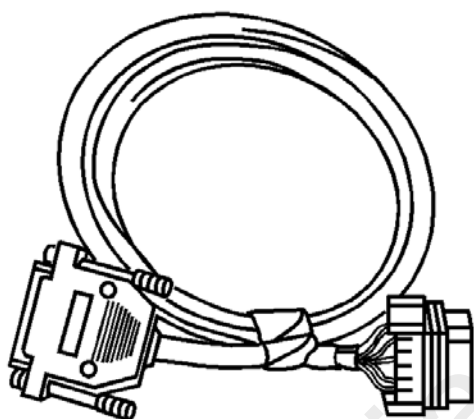
Courtesy of GENERAL MOTORS COMPANY

SPECIAL TOOLS AND EQUIPMENT > SPECIAL TOOLS (DIAGNOSTIC TOOLS)

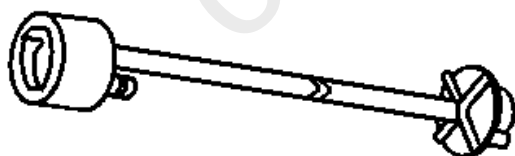
Illustration	Tool Number/Description
	CH-34730-2C J-34730-2C Injector Test Lamp
	CH-37287-1A Fuel Pressure Gauge Adapter 3/8"
	CH-38641-B J-38641-B Diesel Fuel Quality Tester



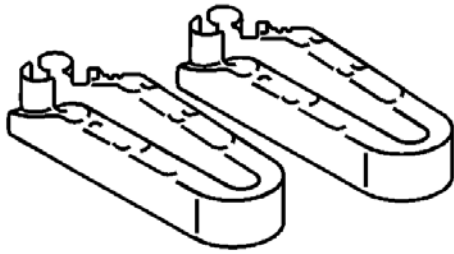
CH-39021-301
J-39021-301
Fuel Injector Harness Adapter



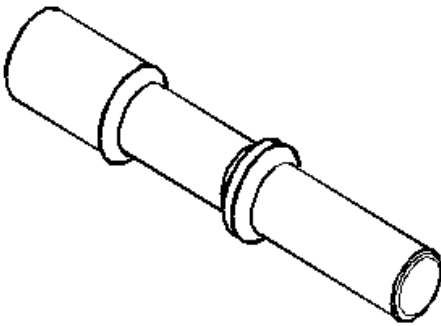
CH-39021-460
J-39021-460
Fuel Injector Test Adapter



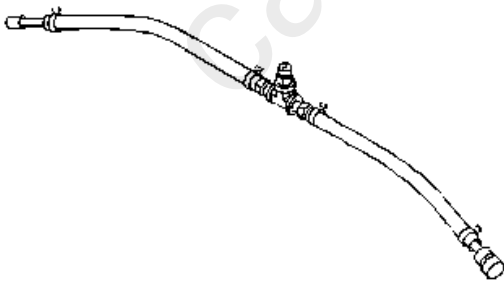
CH-41415-30
GE-41415-30
J-41415-30
Fuel Tank Cap Adapter



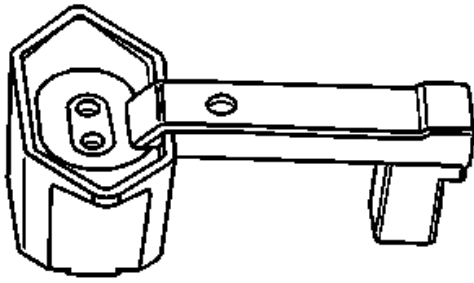
CH-41769
J-41769
Fuel Line Quick Disconnect Tool



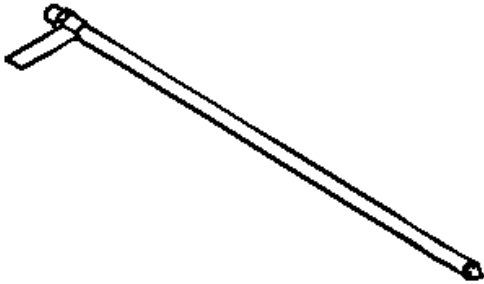
CH-42960-2
J-42960-2
Fuel Flapper Door Holder



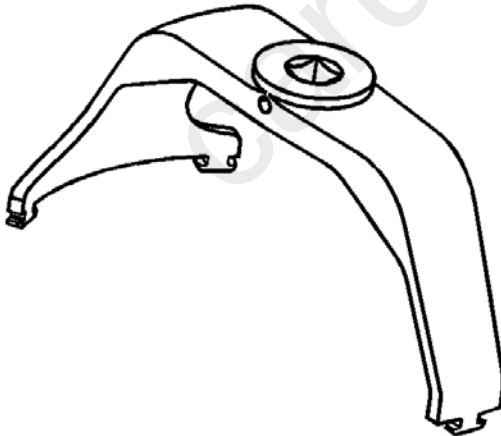
CH-42982
J-42982
Fuel Pressure Gauge Adapter



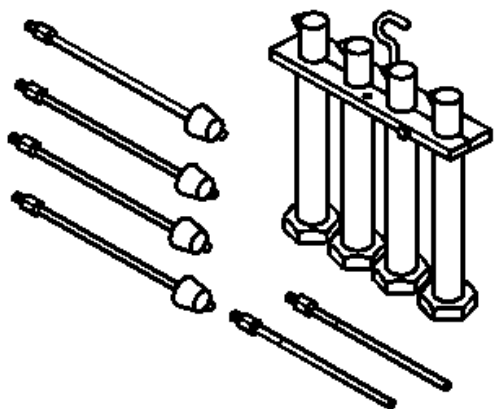
CH-44175-A
J-44175-A
Fuel Composition Tester



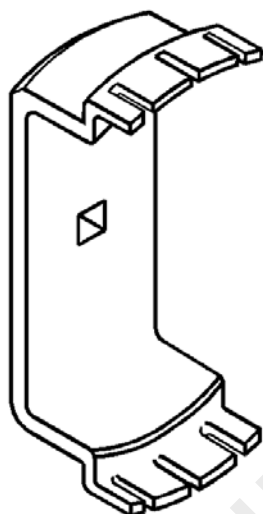
CH-45004
J-45004
Fuel Tank Drain Hose



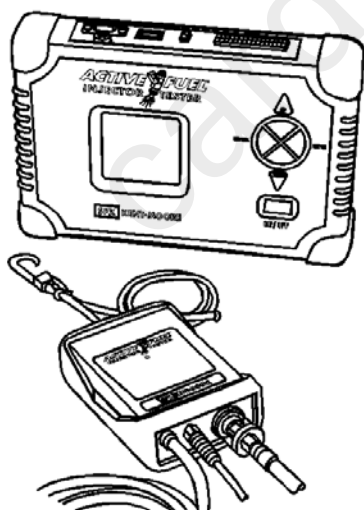
CH-45722
J-45722
Fuel Sender Lock Ring Wrench



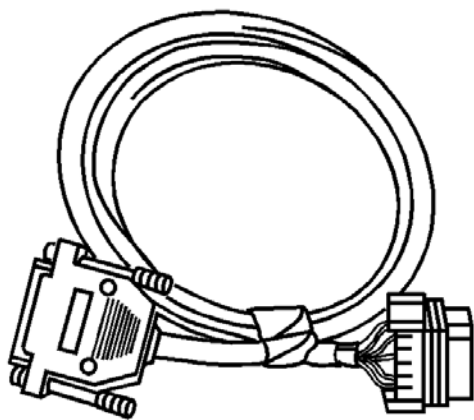
CH-45873
J-45873
Fuel Return Volume Test Kit



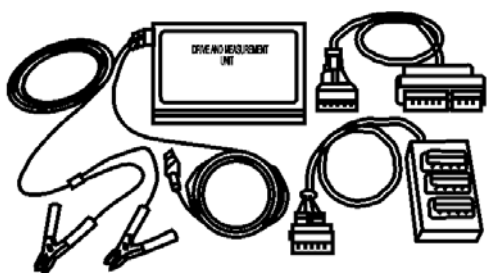
CH-47717
Lock Ring Wrench



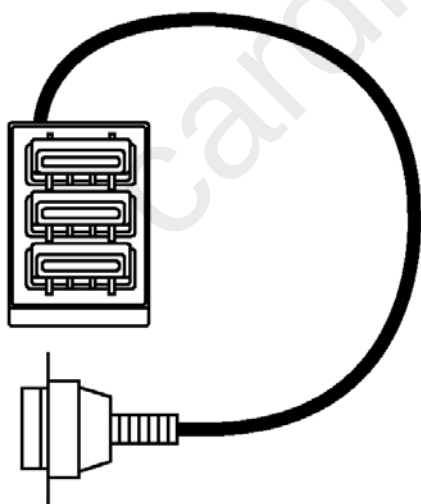
CH-47976
Active Fuel Injector Tester (AFIT)



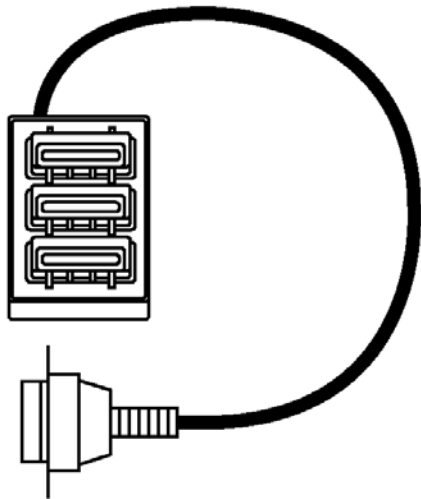
CH-47976-75
Fuel Injector Harness Adapter



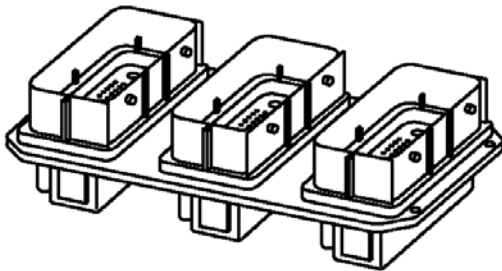
CH-47976-500A
Active Fuel Injection Tester (AFIT) SIDI
Adapter Kit



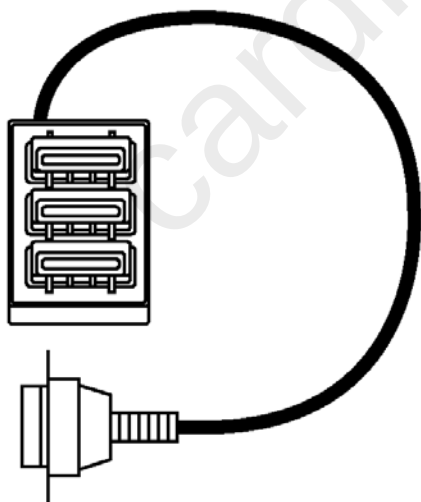
CH-47976-502A
AFIT SIDI E92 G2A Adapter Cable



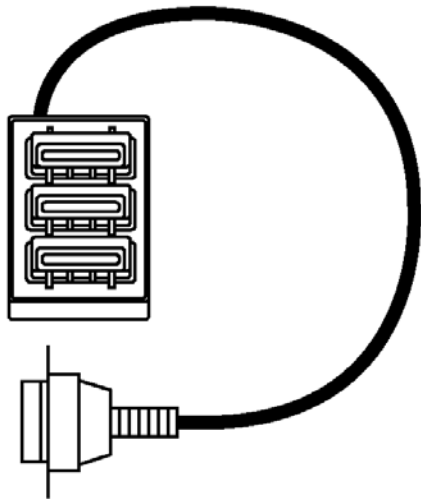
CH-47976-503
AFIT SIDI E80 G3 Adapter Cable



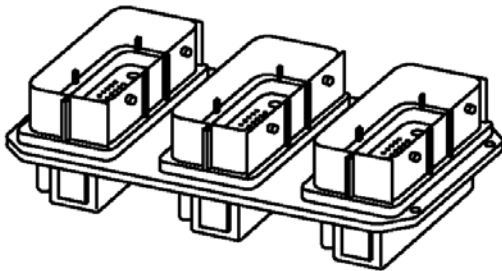
CH-47976-504
E92/E39A G2B Start/Stop Adapter



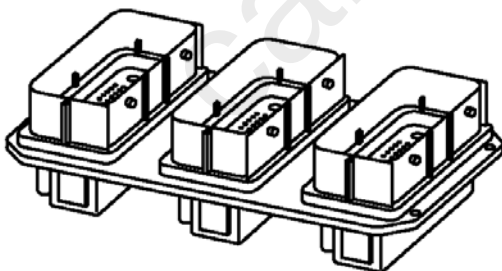
CH-47976-509
AFIT SIDI E81 G4 Adapter Cable



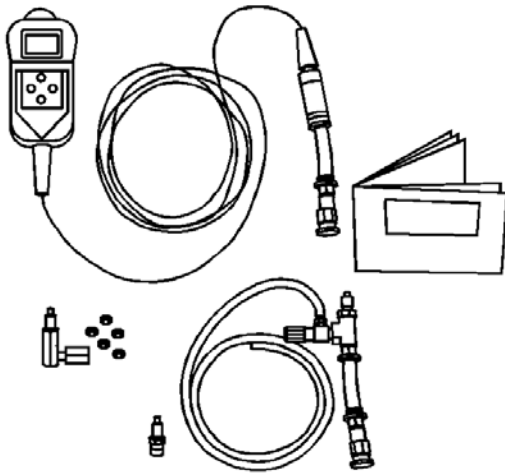
CH-47976-511
AFIT SIDI E82 G5 Adapter Cable



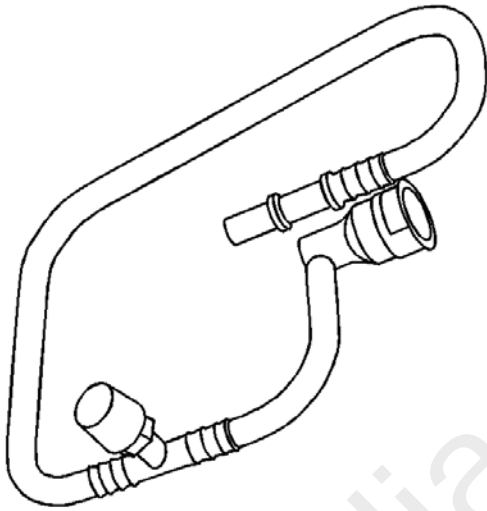
CH-47976-512
E80 G3B Stop/Start Adapter



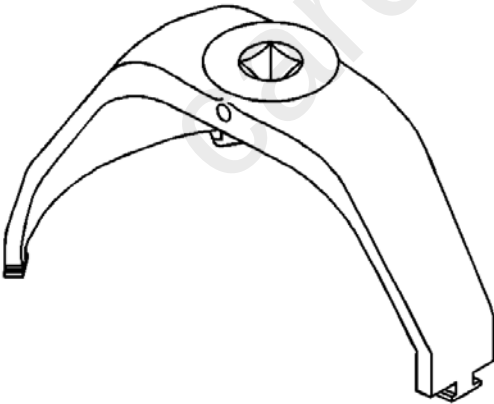
CH-47976-513
E92 G2C Stop/Start and SENT Adapter



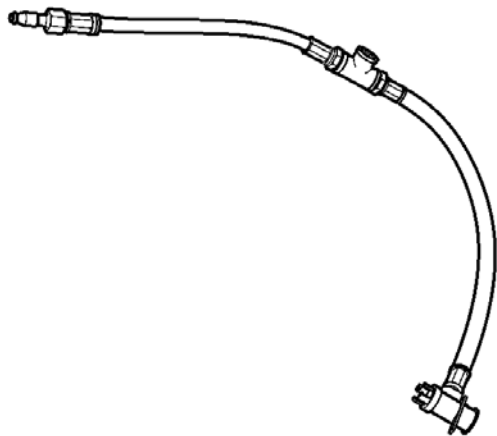
CH-48027
Fuel Pressure Gauge



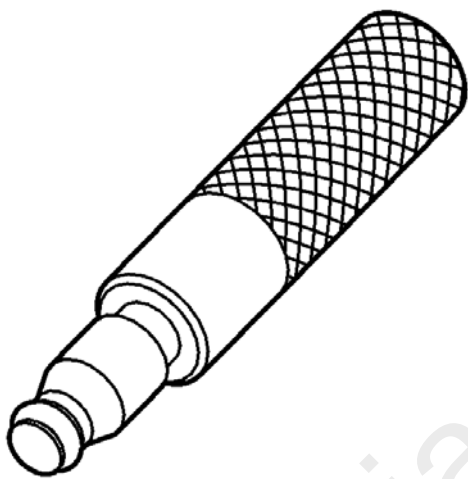
CH-48096
EVAP Service Access Port Tool



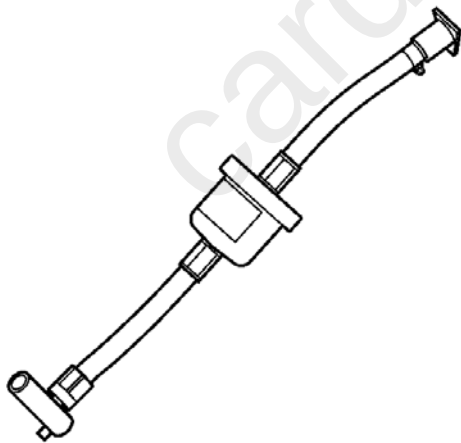
CH-48482
Fuel Sender Lock Ring Wrench



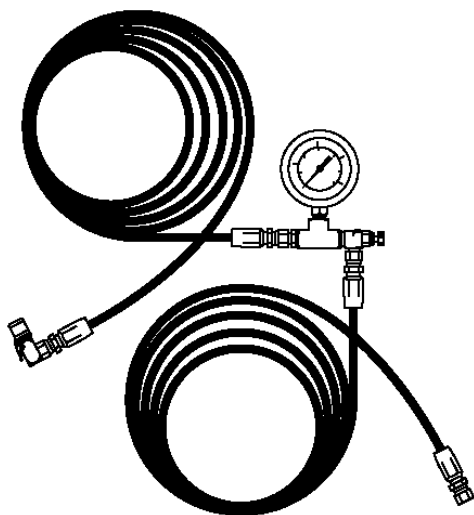
CH-50375
Diesel Injector Return Line Pressure
Adapter



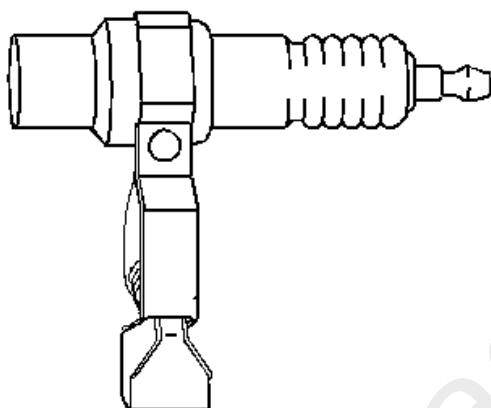
CH-50377-A
Injector Return Line Cap



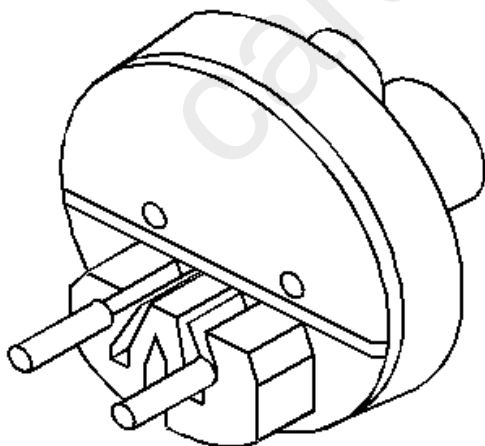
CH-50378
Injector Return Leakage Test Adapter



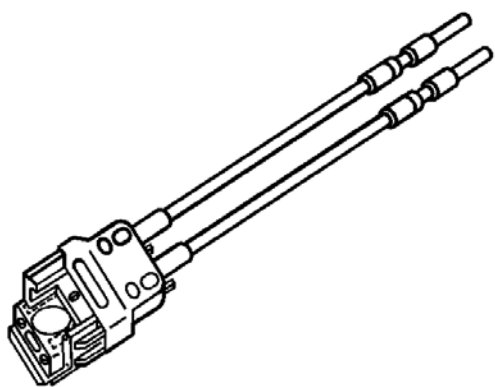
CH-50933
Gauge Assembly, Liquid Propane Gas
(LPG)



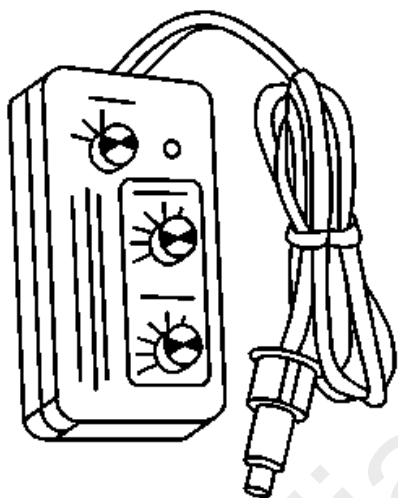
EL-26792
J-26792
HEI Spark Tester



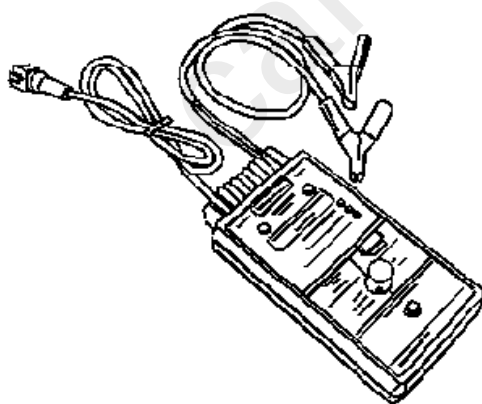
EL-34730-405
J-34730-405
Injector Test Lamp



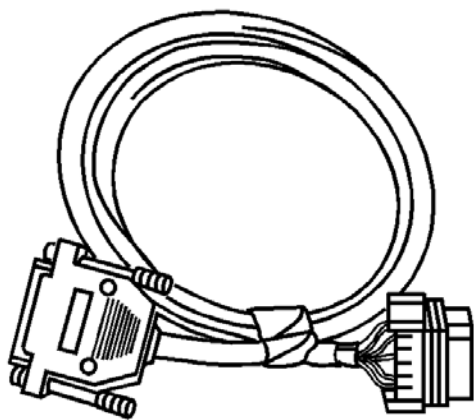
EL-36169-HD
Heavy Duty Fused Jumper



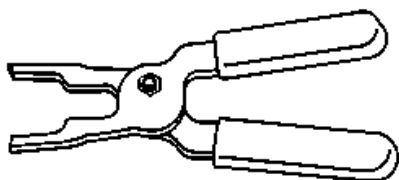
EL-38522-A
J-38522-A
Variable Signal Generator



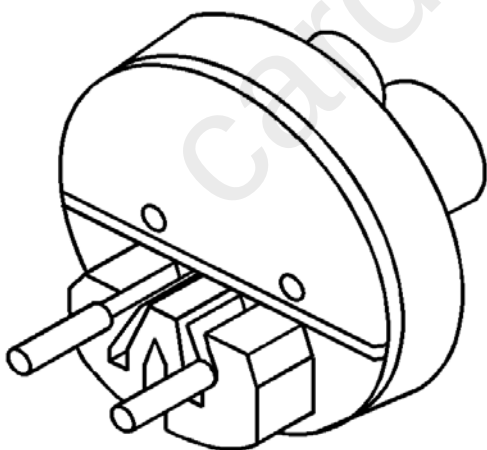
EL-39021
J-39021
Fuel Injector Coil Balance Tester



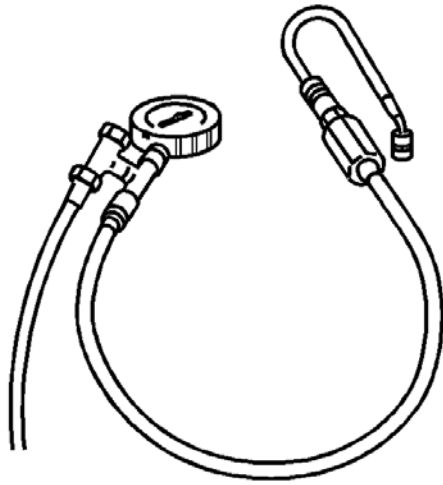
EL-39021-460
J-39021-460
Fuel Injector Test Adapter



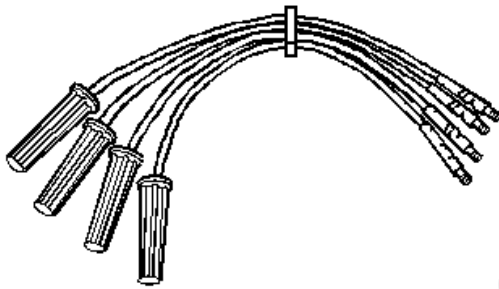
EL-43244
J-43244
Relay Puller Pliers



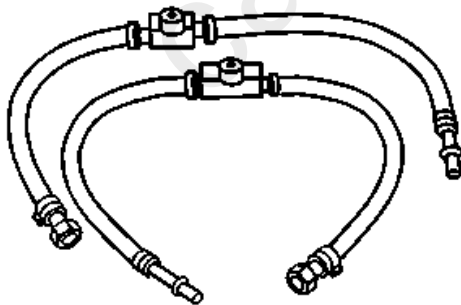
EL-44603
J-44603
Injector Test Lamp



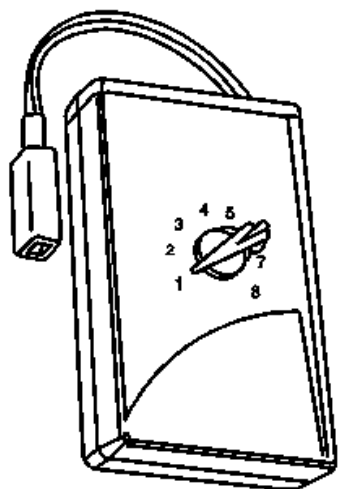
EN-34730-91
J-34730-91
KM-J-34730-91
Pressure Tester



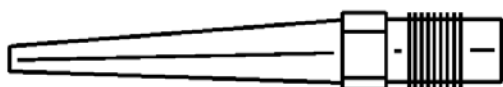
EN-36012-A
J-36012-A
Ignition System Diagnosis Harness



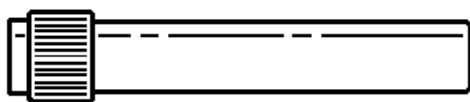
EN-37287
J-37287
Fuel Line Shut-off Adapters



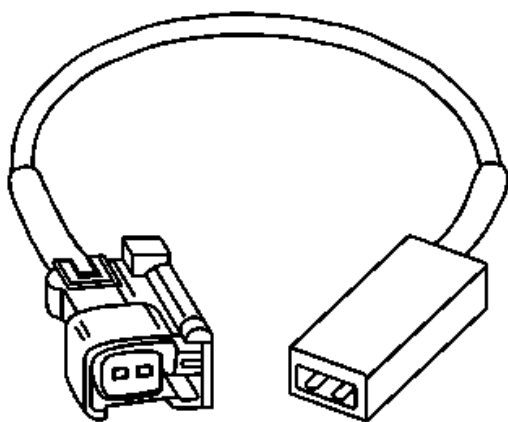
EN-39021-210
J-39021-210
Injector Tester Adapter Box



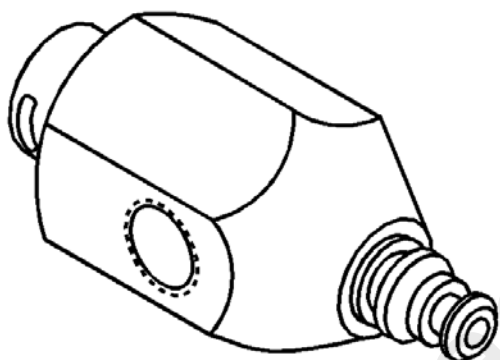
EN-41413-311
J-41413-311
EVAP Plug



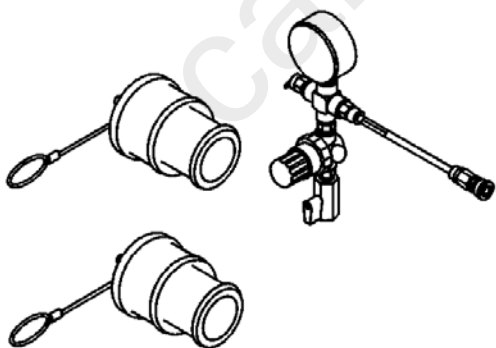
EN-41413-VLV
J-41413-VLV
EVAP Service Port Vent Fitting



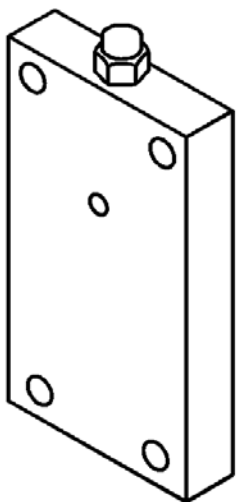
EN-44602
J-44602
Injector Test Adapter



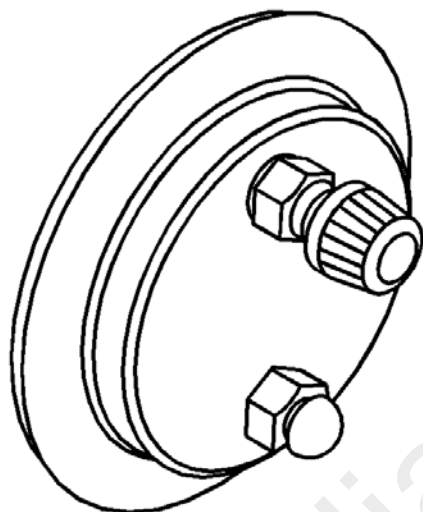
EN-45873-30
J-45873-30
Injector Flow Test Adapter



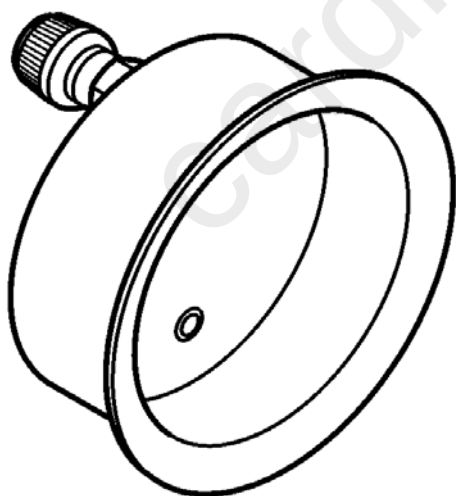
EN-46091
J-46091
Charge Air Cooler Tester



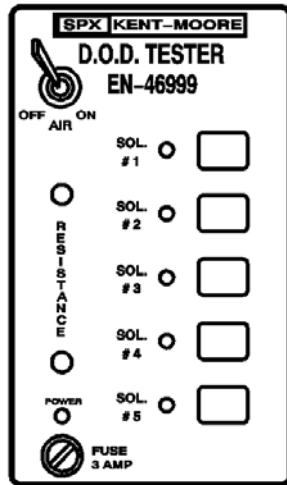
EN-46091-5
J-46091-5
Charge Air Cooler Tester Adapter



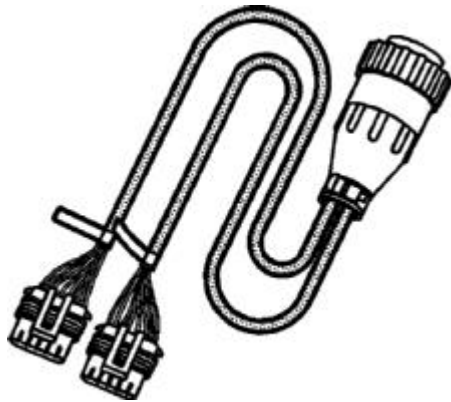
EN-46091-15
J-46091-15
Engine Pressure Test Adapter



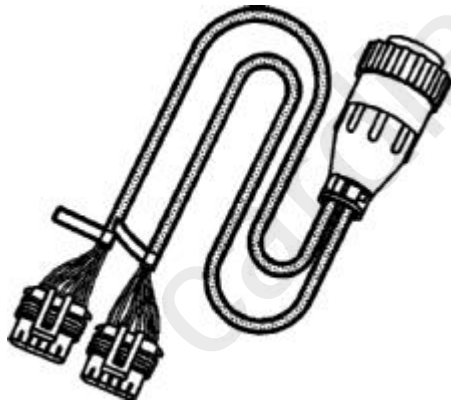
EN-46091-15A
J-46091-15A
Diesel Engine Pressure Test Adapter



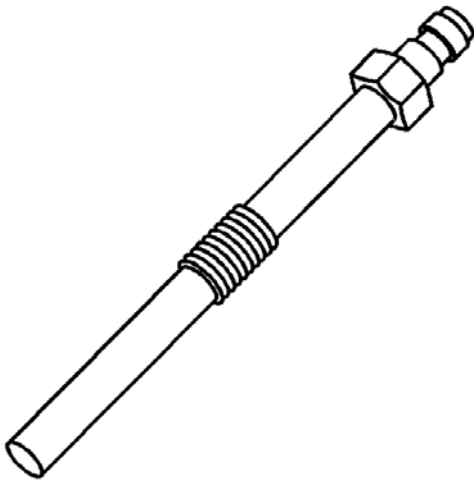
EN-46999
Displacement On Demand Electric Tool



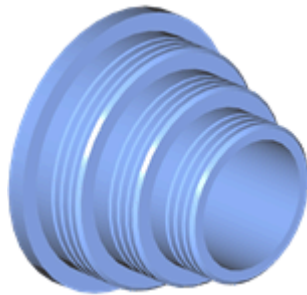
EN-46999-15
Active Fuel Management Tester Harness -
V6



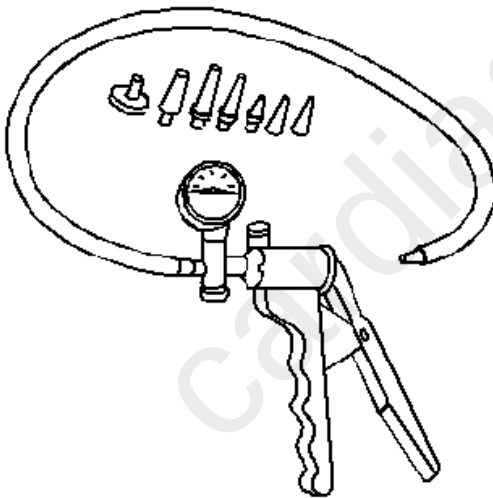
EN-46999-20
Active Fuel Management Tester Harness -
Small Block V8



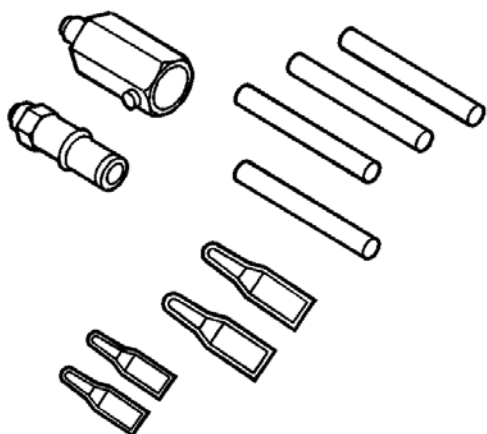
EN-47603
Compression Gauge Adapter



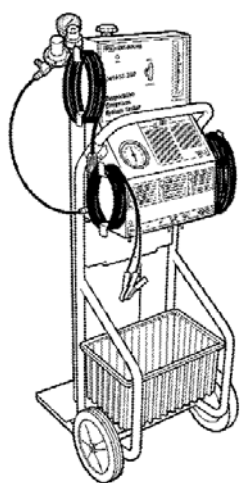
EN-47656-NA
Pressure Test Plugs



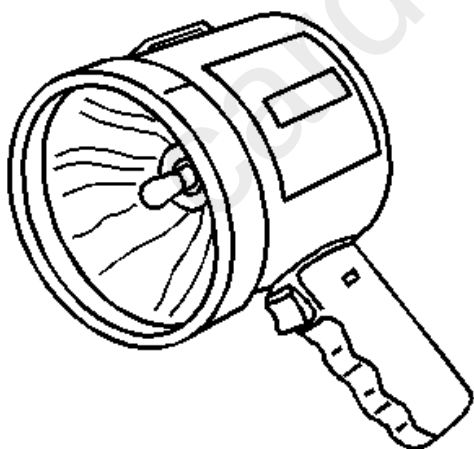
GE-23738-A
J-23738-A
Vacuum Pump



GE-41413-300
EN-41413-300
J-41413-300
EVAP Cap and Plug Kit



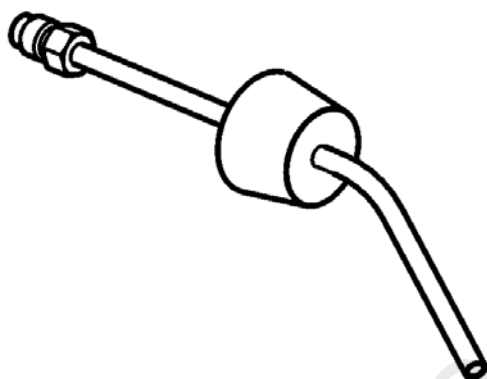
GE-41413-A
EN-41413-A
J-41413-A
Evaporative Emissions System Tester
(EEST)



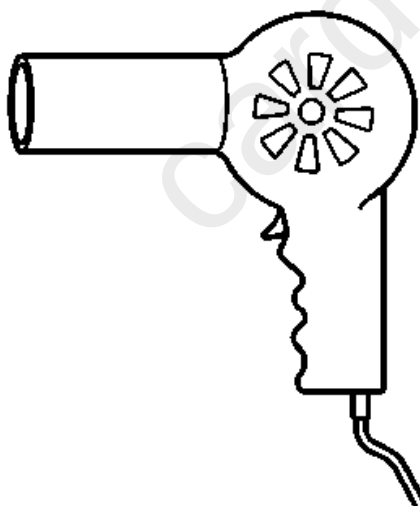
GE-41413-SPT
J-41413-SPT
High Intensity White Light



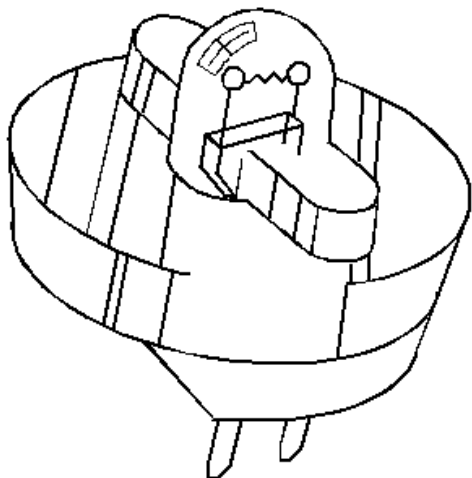
GE-41415-50
J-41415-50
Fuel Tank Cap Adapter



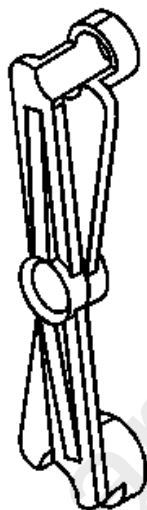
GE-41415-60
Engine Induction System Leak Test
Adapter/Capless Fuel Fill Adapter



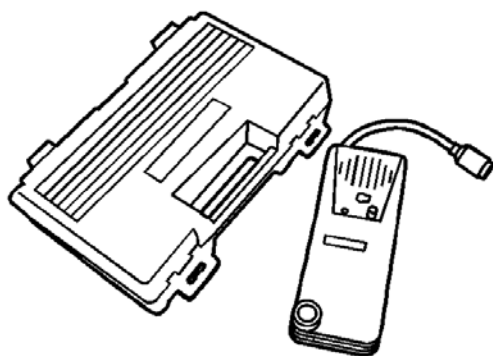
J-25070
Heat Gun 260-399°C (500-750°F)



J-34730-375
Injector Test Lamp

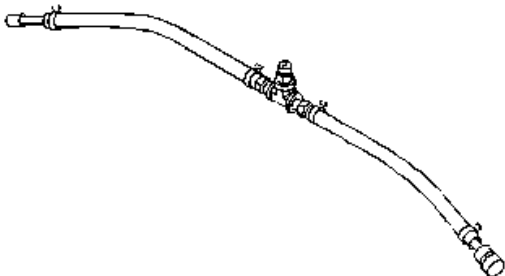
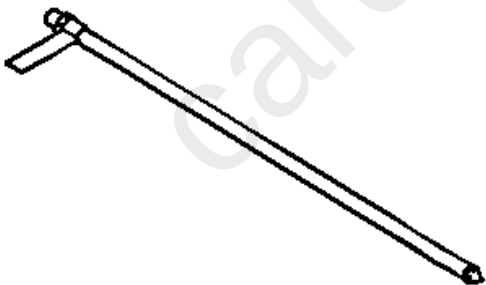


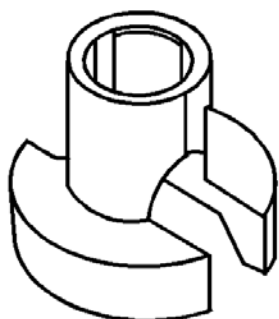
J-44581
Fuel Line Disconnect Tool



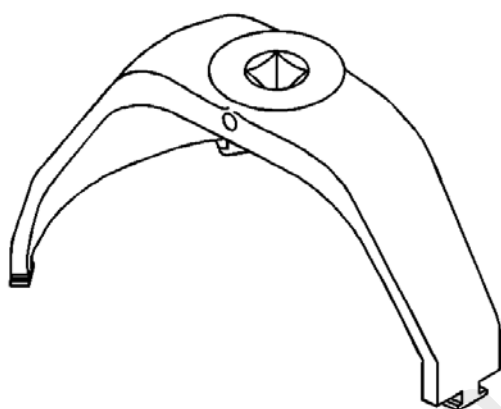
J-45878
Combustible Gas Detector

SPECIAL TOOLS AND EQUIPMENT > SPECIAL TOOLS (MECHANICAL TOOLS)

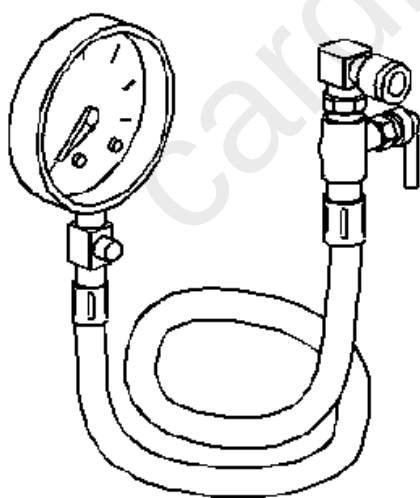
Illustration	Tool Number/Description
	CH-37287-1A Fuel Pressure Gauge Adapter 3/8"
	CH-42982 Fuel Pressure Gauge Adapter
	CH-45004 J45004 Fuel Tank Drain Hose



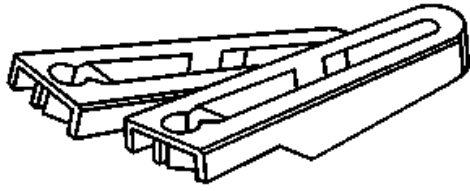
CH 47831
Fuel Line Disconnect Tool



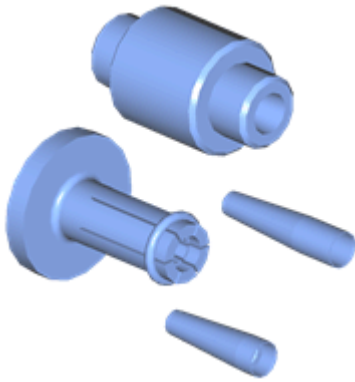
CH-48482
Fuel Sender Lock Ring Tool



EN-34730-1A
Fuel Pressure Gauge



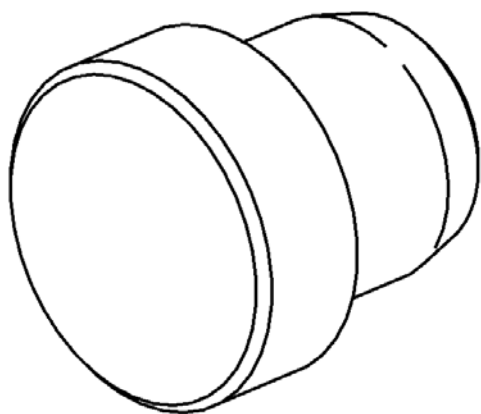
EN-37088-A
J37088
Fuel Line Disconnect Tool Set



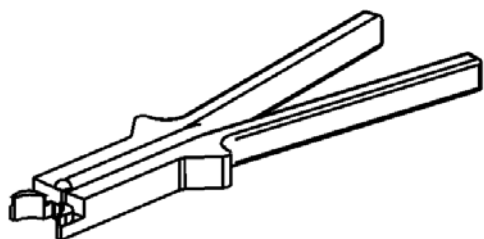
EN 49245
Fuel Injection Seal Installer Sizer



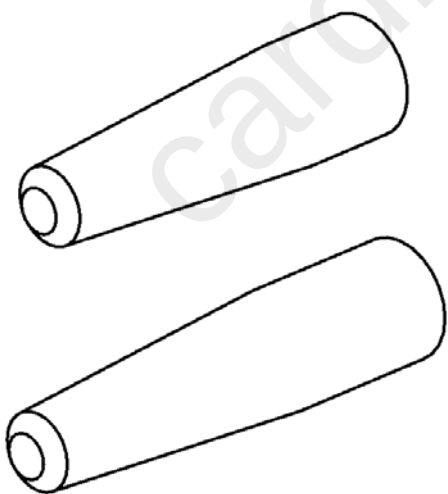
EN 49248
Injector Rail Assembly Remover



EN 51092
Fuel Pump Installation Gauge



EN 51097
Injector Retaining Clip Installer



EN-51105 Injector Seal Installer Adapters

**SPECIFICATIONS > TEMPERATURE VERSUS RESISTANCE - INTAKE AIR
TEMPERATURE SENSOR (HITACHI SENSOR)**

Temperature C°/F°	Resistance Minimum Ohms	Resistance Maximum Ohms
Hitachi Intake Air Temperature (IAT) Sensor		
-40/-40	37, 527	49, 882
-20/-4	13, 110	16, 329
-10/14	8, 145	9, 851
0/32	5, 205	6, 122
20/68	2, 298	2, 570
25/77	1, 900	2, 100
40/104	1, 073	1, 226
60/140	537	639
80/176	289	356
100/212	165	210
120/248	99	129
140/284	62	83
150/302	49	67

**SPECIFICATIONS > TEMPERATURE VERSUS RESISTANCE - INTAKE AIR
TEMPERATURE SENSOR (DELCO SENSOR)**

Temperature C°/F°	Resistance Minimum Ohms	Resistance Maximum Ohms
Delco Intake Air Temperature (IAT) Sensor		
-40/-40	42, 661	54, 224
-20/-4	14, 039	17, 333
-10/14	8, 529	10, 399
0/32	5, 358	6, 458
20/68	2, 308	2, 727

25/77	1, 904	2, 236
40/104	1, 113	1, 292
60/140	571	655
80/176	309	351
100/212	175	197
120/248	103	116
140/284	67	73
150/302	54	59

SPECIFICATIONS > TEMPERATURE VERSUS RESISTANCE (ENGINE COOLANT TEMPERATURE SENSOR)

Temperature	Resistance
150°C (302°F)	47 to 49 Ω
140°C (284°F)	58 to 62 Ω
130°C (266°F)	76 to 80 Ω
120°C (248°F)	98 to 104 Ω
110°C (230°F)	130 to 136 Ω
100°C (212°F)	174 to 182 Ω
90°C (194°F)	237 to 247 Ω
80°C (176°F)	327 to 341 Ω
70°C (158°F)	459 to 479 Ω
60°C (140°F)	656 to 686 Ω
50°C (122°F)	958 to 1002 Ω
45°C (113°F)	1167 to 1223 Ω
40°C (104°F)	1430 to 1500 Ω
35°C (95°F)	1763 to 1849 Ω
30°C (86°F)	2185 to 2295 Ω
25°C (77°F)	2725 to 2865 Ω
20°C (68°F)	3418 to 3604 Ω
15°C (59°F)	4318 to 4564 Ω
10°C (50°F)	5493 to 5823 Ω
5°C (41°F)	7041 to 7485 Ω

0°C (32°F)	9097 to 9701 Ω
-5°C (23°F)	11844 to 12678 Ω
-10°C (14°F)	15540 to 16700 Ω
-15°C (5°F)	20559 to 22183 Ω
-20°C (-4°F)	27439 to 29725 Ω
-30°C (-22°F)	50264 to 54924 Ω
-40°C (-40°F)	95953 to 105777 Ω

SPECIFICATIONS > 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

SPECIFICATIONS > IGNITION SYSTEM SPECIFICATIONS

Application	Specification
Ignition Type	Individual Ignition Coils
Firing Order	1-8-7-2-6-5-4-3
Spark Plug Wire Resistance	170-220 Ω per 25.4 mm (1.0 in)
Spark Plug Torque	Refer to Fastener Specifications
Spark Plug Gap	Refer to Engine Mechanical Specifications (LT1)
Spark Plug Type	Refer to Electronic Parts Catalog

SPECIFICATIONS > ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number
Anti-Seize Compound	Lubricant	GM P/N 88862477 (Canadian P/N 88862478)
Camshaft Gear Access Hole Plug	Sealant	GM P/N 12346004 (Canadian P/N 10953480)
Coolant Temperature Sensor Threads	Sealant	GM P/N 12346004 (Canadian P/N 10953480)
Dielectric Grease for Spark Plug Wires	Lubricant	GM P/N 19260901 (Canadian P/N 19260902)
Fuel Injection Fuel Rail Bolt	Threadlocker	GM P/N 12345382 (Canadian P/N 10953489)
High Pressure Fuel Pump Bolt	Threadlocker	GM P/N 12345382 (Canadian P/N 10953489)
Silicon Free Engine Oil	5W-30	GM P/N 19293000 (Canadian P/N 19386321)
Top Engine Cleaner	Cleaner	GM P/N 1052626 (Canadian P/N 993026)

SPECIFICATIONS > FASTENER SPECIFICATIONS

Application	Specifications	
	Metric	English
Accelerator Control Assembly to Floor Fasteners	20 N.m	15 lb ft
Camshaft Position (CMP) Sensor Bolt	25 N.m	18 lb ft
Crankshaft Position (CKP) Sensor Bolt	25 N.m	18 lb ft

Engine Coolant Temperature (ECT) Sensor	20 N.m	15 lb ft
EVAP Canister Bracket Bolt	7 N.m	62 lb in
Fuel and EVAP Pipe Retainer Nut	6 N.m	53 lb in
Fuel Crossover Hose Clamps	4 N.m	35 lb in
Fuel Filter and Fuel Pressure Regulator Bracket Nut	5 N.m	44 lb in
Fuel Pipe Assembly Clip Nuts	3 N.m	27 lb in
Fuel Rail Attaching Bolts	10 N.m	89 lb in
Fuel Tank Fill and Vent Pipe Bolts	3 N.m	22 lb in
Fuel Tank Fill Hose Clamp	4 N.m	35 lb in
Fuel Tank Fill Pipe Ground Strap Bolt	8 N.m	71 lb in
Fuel Tank Shield Mount Bolt	25 N.m	18 lb in
Fuel Tank Shield Nut	12 N.m	106 lb in
Fuel Tank Strap and Shield Bolts	25 N.m	18 lb ft
Heated Oxygen Sensor (HO2S)	41 N.m	30 lb ft
Ignition Coil Harness Mounting Bolt	12 N.m	106 lb in
Ignition Coil Mounting Bolts	12 N.m	106 lb in
Knock Sensor (KS)	20 N.m	15 lb ft
PCV Hose Assembly Mounting Cable Nut	12 N.m	106 lb in
Powertrain Control Module (PCM) Electrical Connector Fasteners	8 N.m	70 lb in
Powertrain Control Module (PCM) Retaining Fastener	2 N.m	17 lb in
Secondary Air Injection (AIR) Check Valves	23 N.m	17 lb ft
Secondary Air Injection (AIR) Check Valve to the AIR Pipe	23 N.m	17 lb ft
Secondary Air Injection (AIR) Pipe to Exhaust Manifold Bolts	20 N.m	15 lb ft
Secondary Air Injection (AIR) Pump to Bracket	9 N.m	80 lb in
Secondary Air Injection (AIR) Solenoid Valve Retaining Nut	7 N.m	62 lb in
Spark Plug	15 N.m	11 lb ft
Spark Plug in New Cylinder Head	20 N.m	15 lb ft
Tank Crossover Hose Clamp	4 N.m	35 lb in
Throttle Actuator Control (TAC) Module to PCM Bracket	2 N.m	17 lb in

Throttle Actuator Control (TAC) Module to PCM Bracket Fasteners	2 N.m	17 lb in
Throttle Body Attaching Bolts	10 N.m	89 lb in

SPECIFICATIONS > APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
Fuel Tank Capacity	71.0 liters	18.8 gallons

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