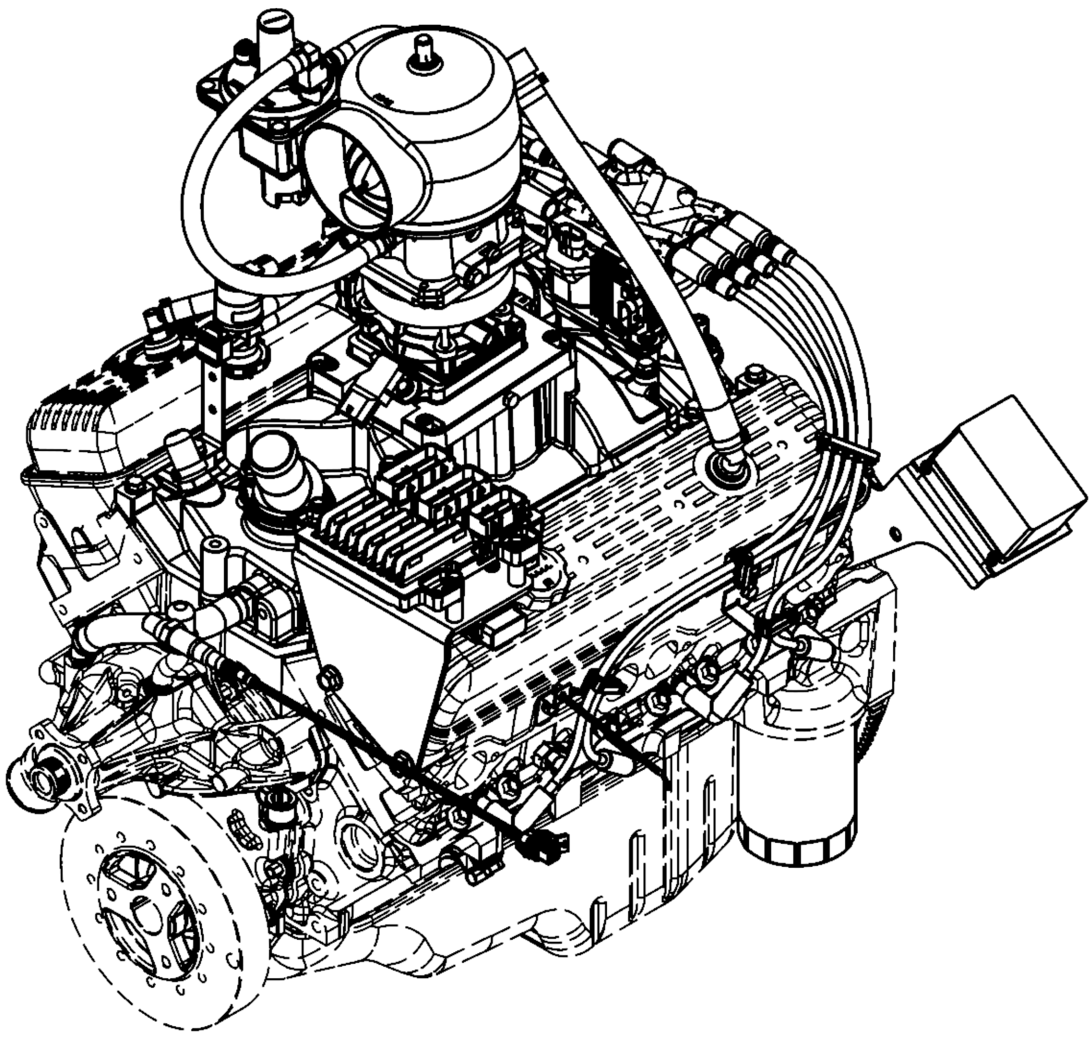
IMPCO
2011 6.2L GM Engine Emission Certified Natural Gas/Propane Fuel System for Stationary Power Generation



Service Manual

Revision A/September, 2011

IMPCO
2011 6.2L GM Engine
Certified Natural Gas/Propane Fuel System for Stationary For Power Generation

Including Labor Time Guide

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General Information

INTRODUCTION

This service manual supplement has been developed to provide the service technician with the basic understanding of the IMPCO fuel systems for the 6.2L GM engine. This manual should be used in conjunction with the base engine manual and the OEM service manual when diagnosing fuel or electrical problems.

The IMPCO GM 6.2L Engine is a V-8 water cooled design that has been specifically configured to run in stationary power generating applications and fueled by either Natural Gas or Propane Vapor. The engine and fuel system components support UL 2200 applications.

The IMPCO GM 6.2L stationary engine features a low pressure single point fuel delivery system along with the Delphi MEFI6 engine control unit which has been programmed and calibrated by IMPCO. By continually monitoring various engine sensors and exhaust gas composition, the air/fuel ratio is constantly modified to maintain the desired power and emission performance using fuel types encountered in North America.

The engine speed is monitored and processed by the ECM to ensure that the electronic throttle is able to control the engine speed within ISO 8582 G3 operating limits.

EMERGENCY STATIONARY ENGINES

An emergency stationary engine is defined as an engine that meets the following definitions below:

- Any stationary Internal Combustion Engine (ICE) whose operation is limited to emergency situations and required testing and maintenance, including:
  An engine used to produce power for critical networks or equipment (including power supplied to portions of a facility) when electric power from the local utility (or the normal power source, if the facility runs on its own power production) is interrupted

  A stationary engine used to pump water in the case of fire or flood, etc.

The following are not emergency engines:

- Stationary engines used for peak shaving
- Stationary ICE used to supply power to an electric grid or that supply power as part of a financial arrangement with another entity.

Emergency stationary ICEs may be operated up to 100 hours/year for the purpose of maintenance checks and readiness testing, provided that the tests are recommended by Federal, State or local government, the manufacturer, the vendor, or the insurance company associated with the engine.

Emergency stationary ICEs may be operated up to 50 hours per year in non-emergency situations, but those 50 hours are counted towards the 100 hours per year provided for maintenance and testing. These 50 hours cannot be used for peak shaving or to generate income for a facility to supply power to an electric grid or otherwise supply power as part of a financial arrangement with another entity.

Any operation other than for emergency situations, maintenance and testing, and operation in non-emergency situations for more than 50 hours per year as permitted in 40 CFR Part 60 is prohibited.

HOW TO IDENTIFY THE ENGINE YEAR

The emission label on the engine will identify the specific model year.

SERVICING YOUR ENGINE

Any maintenance and repair should be performed by trained and experienced service technicians. Proper tools and equipment should be used to prevent injury to the servicing technician and damage to the engine or components. Service repairs should always be performed in a safe environment and the technician should always wear protective clothing to prevent injury.

Natural Gas and Propane installations in the United States must be done in accordance with Federal, state and local law, whichever is applicable and National Fire Protection Association Pamphlet #58, standard for storage and handling of Liquefied Petroleum Gases to the extent these standards are not in violation with Federal, State or Local Law.

For parts or labor to be reimbursed under the IMPCO Technologies Inc. warranty, only work performed by IMPCO or OEM trained technicians using only IMPCO specified parts will qualify for reimbursement. Refer to the IMPCO Labor Time Guide for additional information.

For parts or labor not reimbursed under warranty, a repair shop or person of the owner's choosing may maintain, replace, or repair fuel control devices and systems. It is highly recommended that any replacement parts used for maintenance or for the repair of fuel control systems be new OEM replacement parts. The use of other than genuine IMPCO replacement parts may impair the effectiveness of fuel control systems, therefore, the owner should assure that such parts are warranted by their manufacturer to be equivalent to genuine IMPCO OEM parts in performance and durability.

OPERATING TEMPERATURES

Key fuel system and engine control electrical components are automotive grade, designed to operate in temperatures from -4^0 F (-20^{0}C) to 221^{0}F (105^{0}C). Low temperature starting characteristics: Unassisted start: 0^{0}F (-18^{0}C). Assisted start (block heater active): -20^{0}F (-29^{0}C). High temperature starting characteristics: Unassisted start: 104^{0}F (40^{0}C).

The engine control system features an engine over-temperature and low oil pressure protection function. When the engine overheats or the oil pressure is too low, a Malfunction Illumination Light (MIL) is triggered and the ECM shuts down the engine to prevent damage.

FUEL QUALITY & DELIVERY

Fuel handling and fuel supply components are designed to operate within the performance constraints as outlined in UL 2200.

The IMPCO GM 6.2L Stationary Power Generating engine is configured for operation on Natural Gas, but may easily be configured for Propane vapor.

Natural Gas engines and fuel systems are designed to operate on standard pipe line Natural Gas of approximately 1,000 BTU per cubic foot and <7 pounds of water vapor per million cubic foot.

LPG engines and fuel systems are designed to operate on HD-5 or HD-10 specification LPG fuel. Fuel other than HD-5 or HD-10 may cause harm to the engine's emission control system and a warranty claim may be denied on this basis if operators can readily find the proper fuel.* Use of any other fuel may result in your engine no longer operating in compliance with CARB or EPA emissions requirements.
*Not Applicable in the state of California.

The fuel system relies on fuel pressure to the engine systems low pressure regulator to deliver advertised power levels. Be sure the gas supply pressure is maintained to the fuel systems low pressure shutoff valve(s) as shown:

Natural Gas maximum at engine OFF no load: 13.85" W.C.

Natural Gas minimum at engine ON full load: 6.0" W.C.

Propane Vapor maximum at engine OFF no load: 13.85" W.C.

Propane Vapor minimum at engine ON full load: 6.0" W.C.

FUEL LINE CONNECTIONS

Loctite® 567 is recommended for all NPT connections.

WARNING

Do not use Teflon tape to seal any fuel fittings. Fragments of the tape may enter into the fuel system, causing damage or malfunction of critical fuel system components.

CAUTION

If you turn off the Natural Gas Supply for any reason, a qualified professional must turn it back on. NEVER attempt to turn the gas back on yourself. Contact your local Natural Gas supply company for additional information.

AIR FILTRATION REQUIREMENTS

Dry filtration is required with maximum recommended 4" W.C. restriction @ 75 cfm. IMPCO strongly recommends the use of OEM or factory replacement parts.

WASHING

Caution should be used when pressure washing near or on an engine's electrical system. Avoid direct pressure spray on the system electrical connectors. The electrical connectors are splash resistant, but if high pressure water or steam is sprayed directly at the connectors, moisture can become trapped behind the connector seal and cause serious system problems, many of them showing up as intermittent.

FUEL SYSTEM CAUTIONS

CAUTION

Do not smoke, carry lighted tobacco or use a lighted flame of any type when working on or near any fuel related component. Highly flammable air-fuel mixtures may be present and can be ignited causing personal injury.

CAUTION

Do not allow LPG to contact the skin. LPG is stored in the fuel tank as a liquid. When LPG contacts the atmosphere, it immediately expands into a gas, resulting in a refrigeration effect that can cause severe burns to the skin.

CAUTION

Do not allow LPG to accumulate in areas below ground level such as in a service pit or underground ventilation systems. LPG is heavier than air and can displace oxygen, creating a dangerous condition.

CAUTION

Do not make repairs to the fuel system if you are not familiar with or trained to service Natural Gas or Propane fuel systems. Contact the dealer who sold you the engine to locate a repair facility with trained technicians to repair your fuel system.

WARNING

Unlike gasoline or Propane vapors that will sink downward, Natural Gas is lighter than air and will rise, possibly accumulating inside enclosed spaces. Highly flammable air/fuel mixtures may be present and can be ignited causing personal injury. Always work in well ventilated areas.

WARNINGS, CAUTIONS AND NOTES

This manual contains several different Warnings, Cautions, and Notes that must be observed to prevent personal injury and or damage to the engine, the fuel system or personal property.

A "WARNING" is an advisement that by performing a process or procedure listed in this manual improperly may result in serious bodily injury, death and/or serious damage to the engine or property.

Typical Warning Label:

WARNING

Failure to heed instructions could result in death, injury, or property damage.

A "CAUTION" label or statement is used when it has been determine that by performing a process or procedure defined in the manual improperly a less severe result may occur. It could however, result in serious bodily injury, and or serious damage to the engine or property damage.

CAUTION

Less severe than WARNING but has the potential to cause injury or damage. Also used to notify of situations that could lead to eventual failure, injury or damage.

This caution label may also appear in area of this manual that applies to service and repair procedures. In addition it may also be used to indicate a failure to observe which may influence the terms of the warranty.

An "IMPORTANT" statement generally denotes a situation that requires strict adherence to the assembly, tightening, or service procedure. Failure to observe this procedure could result in an unsafe condition or improper performance of the engine or a component.

A "NOTE" statement applies to a specific item or procedure that is to be followed during the servicing of the engine or its components.

PROPER USE OF THIS SERVICE MANUAL, TOOLS AND EQUIPMENT

To reduce the potential for injury to the technician or others and to reduce damage to the engine during service repairs the technician should observe the following Steps:

- The service procedures defined in this manual, when followed, have been found to be a safe and efficient process to repair the fuel system. In some cases special tools may be required to perform the necessary procedures to safely remove and replace a failed component.

- Tools identified in this manual with the prefix "J" or "BT" can be procured through SPX in Warren, Michigan.
- IMPCO tools identified in this manual with a prefix "ITK" can be acquired through OEM Parts Distribution.

IMPORTANT
It is important to remember that there may be a combination of Metric and Imperial fasteners used in the installation of the IMPCO fuel system. Check to insure proper fit when using a socket or wrench on any fastener to prevent damage to the component being removed or injury from "slipping off" the fastener.

The fuel system utilizes fuel lines and hoses with high pressure connectors. Always use a wrench of the proper size and torque to the correct value. For hoses with swivel fittings, be sure not to turn the fixed fitting which may cause a twisting or kinking of the hose, possibly resulting in fuel line restriction and/or leak.

WARNING

Always leak check any fuel system connection after servicing! Use an electronic leak detector and/or a liquid leak detection solution. Failure to leak check could result in serious bodily injury, death, or serious property damage.

Maintenance

MAINTENANCE

The maintenance of an engine and related components are critical to its operating performance and lifespan. Industrial engines operate in environments that often include hot and cold temperatures and extreme dust. The recommended maintenance schedule is listed in this section, however, environmental operating conditions and additional installed equipment may require more frequent inspection and servicing. The owner and/or service agent should review the operating conditions of the equipment to determine the inspection and maintenance intervals.

CAUTION

When performing maintenance on the engine, turn the ignition OFF and disconnect the battery negative cable to avoid injury or damage to the engine.

PERIODIC RUNNING OF THE ENGINE

As a stand-by generator, the engine may inactive for long periods of time. It is recommended, that the engine be started every 30 days and run until it reaches normal operating temperature.

ENGINE BELTS

The engine installed in this equipment uses drive belt(s) that drive the water pump, alternator and additional pumps or devices. It is important to note that the drive belt(s) is/are an integral part of the cooling and charging system and should be inspected according to the maintenance schedule in this section. When inspecting the belt(s) check for:

- Cracks
- Chunking of the belt
- Splits
- Material hanging loose from the belt
- Glazing, hardening

If any of these conditions exist the belt should be replaced with the recommended OEM replacement belt.

SERPENTINE BELT SYSTEM

Serpentine belts utilize a spring-loaded tensioner to keep the belt properly adjusted. Serpentine belts should be checked according to the maintenance schedule in this section.

IMPORTANT:
The use of “belt dressing” or “anti-slipping agents” on belts is not recommended.

COOLING SYSTEM

It is important that the cooling system of the engine be maintained properly to ensure proper performance and longevity.

WARNING

Alcohol or Methanol based anti-freeze or plain water are not recommended for use in the cooling system at anytime.

WARNING

Do not remove the cooling system pressure cap (radiator cap) when the engine is hot. Allow the engine to cool and then remove the cap slowly to allow pressure to vent. Hot coolant under pressure may discharge violently.

The cooling system must be maintained according to the recommend maintenance schedule in this section and also include:

- The regular removal of dust, dirt and debris from the radiator core and fan shroud.
- Inspection of coolant hoses and components for leaks, especially at the radiator hose connections. Tighten hose clamps if necessary.
- Check radiator hoses for swelling, separation, hardening, cracks or any type of deterioration. If any of these conditions exist the hose should be replaced with a recommended OEM replacement part.
- Inspect the radiator cap to ensure proper sealing.

COOLANT

Check coolant level in coolant recovery tank and add coolant as required. Add 50/50 mixture of antifreeze and water or coolant per engine manufacturer's instructions. Do not add plain water. Replace coolant per the recommended schedule.

IMPORTANT:
The manufacturers of the engine and fuel system do not recommend the use of "stop leak" additives to repair leaks in the cooling system. If leaks are present the radiator should be removed and repaired or replaced.

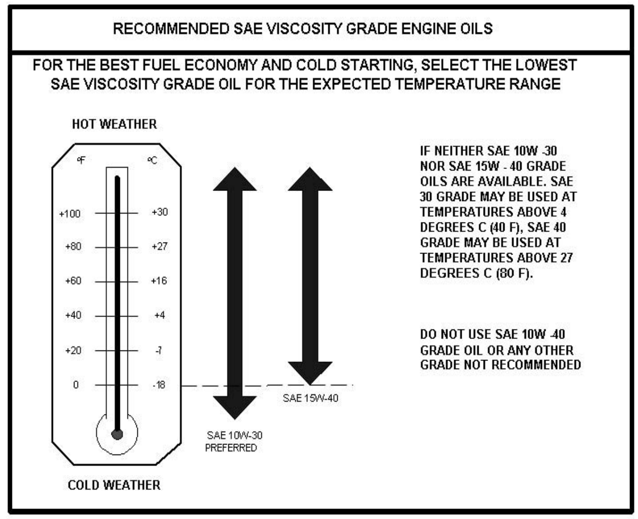
ENGINE ELECTRICAL SYSTEM MAINTENANCE

The engine's electrical system incorporates computers to control various related components. The electrical system connections and ground circuits require good connections. Follow the recommended maintenance schedule in this section to maintain optimum performance. When inspecting the electrical system check the following:

- Check Positive and Negative battery cables for corrosion, rubbing, chafing, burning and ensure tight connections at both ends.
- Check battery for cracks or damage to the case and replace if necessary.
- Inspect engine wire harness for rubbing, chafing, pinching, burning, and cracks or breaks in the wiring.
- Verify that engine harness connectors are correctly locked in by pushing in and then pulling the connector halves outward.
- Inspect ignition coil wire for hardening, cracking, arcing, chafing, burning, separation, split boot covers.
- Check spark plug wires for hardening, cracking, chafing, arcing or burning, separation, and split boot covers.
- Replace spark plugs at the required intervals per the recommended maintenance schedule.
- Verify that all electrical components are securely mounted to the engine or chassis.
- Verify that any additional electrical services installed by the owner are properly installed in the system.
- Verify that the MIL, charging, and oil pressure lights illuminate momentarily during the start of the engine.

ENGINE CRANKCASE OIL
OIL RECOMMENDATION

Select an engine oil viscosity that will best match the prevailing daytime temperature:



The oil must meet GM specification 9986231. Motor oils meeting this spec receive the API (American Petroleum Institute) starburst symbol:

ILSAC GF-4 oils are highly recommended. Oils meeting the SL-4 spec are improved over the previous generation GF-3 oils in many ways

- Reduced Phosphorous levels (20%) for reduced catalyst poisoning
- Improved oxidation resistance (4X oxidation inhibitor treat level = 100% improvement)
- Improved hi temp deposit control (1.5X detergents = 25% improvement)

It is noted that the GF-4 oils are also "backward compatible" and are equal or better than previous grades of oil in all aspects.

OEM's may opt for higher viscosity oils based on their application experience however GF-4 oils may not be available in these viscosity ranges. In this case it is recommended the OEM utilize high quality oil (API rating SM).

CAUTION: Do not to operate your engine with an oil level below the normal operating range. Severe engine damage could occur.

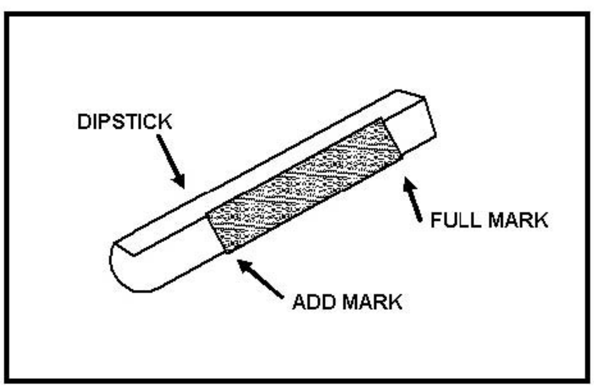
SYNTHETIC OILS

Synthetic oils have been available for use in industrial engines for a relatively long period of time and may offer advantages in cold and hot temperatures. However, it is not known if synthetic oils provide operational or economic benefits over conventional petroleum-based oils in industrial engines. Use of synthetic oils does not permit the extension of oil change intervals.

CHECKING/FILLING ENGINE OIL LEVEL

IMPORTANT:
Care must be taken when checking engine oil level. Oil level must be maintained between the "ADD" mark and the "FULL" mark on the dipstick. To ensure that you are not getting a false reading, make sure the following steps are taken before checking the oil level.

1. Stop engine.
2. Allow approximately five minutes for the oil to drain back into the oil pan.
3. Remove the dipstick. Wipe with a clean cloth or paper towel and reinstall. Push the dipstick all the way into the dipstick tube.
4. Remove the dipstick and note the amount of oil on the dipstick. The oil level must be between the "FULL" and "ADD" marks.



Engine Oil Dip Stick (Typical)

5. If the oil level is below the "ADD" mark reinstall the dipstick into the dipstick tube and proceed to Step 6.
6. Remove the oil filler cap from the valve cover.
7. Add the required amount of oil to bring the level up to, but not over, the "FULL" mark on the dipstick. Reinstall the oil filler cap to the valve rocker arm cover and wipe any excess oil clean.

CHANGING THE ENGINE OIL

IMPORTANT:
When changing the oil, always change the oil filter.

1. Start the engine and run until it reaches normal operating temperature.

CAUTION

An overfilled crankcase (oil level being too high) can cause an oil leak, a fluctuation or drop in oil pressure. When overfilled, the engine crankshafts splash and agitate the oil, causing it to aerate or foam.

IMPORTANT:
Change oil when engine is warm and the old oil flows more freely.

2. Stop engine

WARNING

Engine oil will be hot. Use protective gloves to prevent burns. Engine oil contains chemicals which may be harmful to your health. Avoid skin contact.

3. Remove drain plug and allow the oil to drain.
4. Remove and discard oil filter and its sealing ring.
5. Coat sealing ring on the new filter with clean engine oil, wipe the sealing surface on the filter mounting surface to remove any dust, dirt or debris. Tighten filter securely (follow filter manufacturer's instructions). Do not over tighten.
6. Check sealing ring on drain plug for any dam-

age, replace if necessary, wipe plug with clean rag, wipe pan sealing surface with clean rag and re-install plug into the pan. Tighten to the OEM specification.

7. Fill crankcase with oil.
8. Start engine and check for oil leaks.
9. Dispose of oil and filter in a safe manner.

FUEL SYSTEM INSPECTION AND MAINTENANCE

NATURAL GAS/PROPANE FUEL SYSTEM

The Natural Gas/Propane fuel system installed on this industrial engine has been designed to various standards to ensure performance and reliability. To ensure compliance to these standards, follow the recommended maintenance schedule contained in this section.

PRESSURE REGULATOR MAINTENANCE AND INSPECTION

IMPORTANT:
The Pressure Regulator components have been specifically designed and calibrated to meet the fuel system requirements of the engine.

If the Regulator fails to operate or develops a leak, it should be repaired or replaced with the OEM recommended replacement parts. When inspecting the regulator check for the following items:

- Check for any fuel leaks at the inlet and outlet fittings.
- Check for any fuel leaks in the regulator body.
- Check the inlet and outlet fittings of the coolant supply lines for water leaks.
- Check to ensure the Regulator is securely mounted and the mounting bolts are tight.
- Check the Regulator for external damage.

AIR FUEL MIXER/THROTTLE CONTROL DEVICE MAINTENANCE AND INSPECTION

IMPORTANT:
The Air Fuel Mixer components have been specifically designed and calibrated to meet the fuel system requirements of the emission certified engine

When inspecting the mixer check for the following items:

- Leaks at the inlet fitting.
- Fuel inlet hose for cracking, splitting or chaffing, replace if any of these condition exist.
- Ensure the mixer is securely mounted.
- Inspect air inlet hose connection and clamp. Also inspect inlet hose for cracking, splitting or chafing. Replace if any of these conditions exist.
- Inspect Air cleaner element according to the Recommended Maintenance Schedule found in this section.
- Check Fuel lines for cracking, splitting or chafing. Replace if any of these conditions exist.
- Verify Throttle body return action to ensure throttle shaft is not sticking. Repair if necessary.
- Check for leaks at the throttle body and intake manifold.

EXHAUST SYSTEM INSPECTION AND MAINTENANCE

When inspecting the Exhaust system, check the following:

- Exhaust manifold at the cylinder head for leaks and that all retaining bolts and shields (if used) are in place.
- Manifold to exhaust pipe fasteners to ensure they are tight and that there are no exhaust leaks repair if necessary.
- HEGO electrical connector to ensure connector is seated and locked, check wires to ensure there is no cracking, splits chafing or “burn through.” Repair or replace if necessary.
- Exhaust pipe connection for leaks. Tighten if necessary.

ENGINE EXTERIOR

Periodically inspect the engine exterior for contamination and potential damage from dirt, leaves, rodents, spider webs, insects, etc. and remove.

CERTIFIED EMERGENCY STATIONARY ENGINE MAINTENANCE REQUIREMENTS

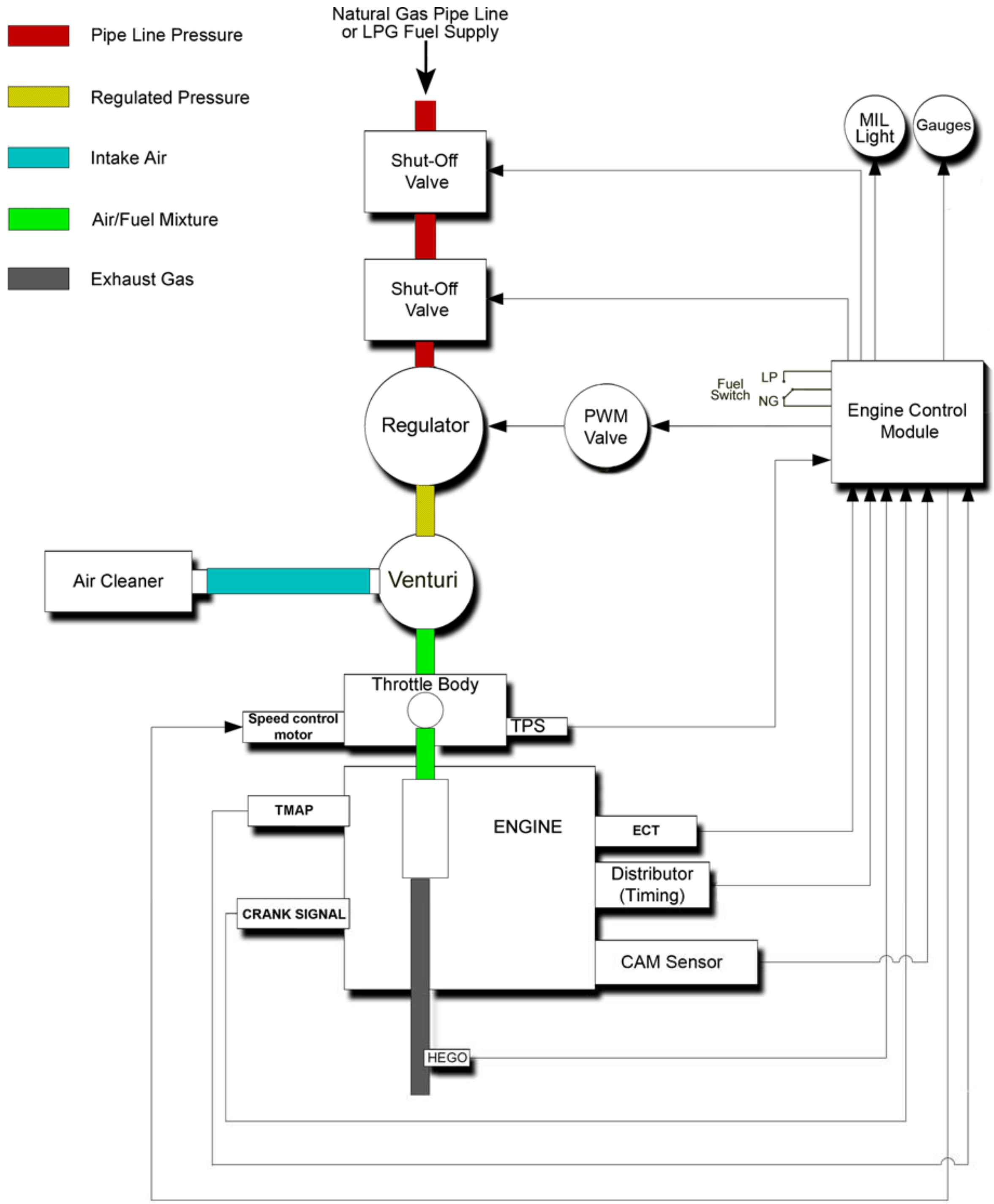
For maintenance or other work that is <u>not</u> performed under warranty, maintenance, replacement, or repair of the emission control devices and systems may be performed by any engine repair establishment or individual.

Perform the following maintenance on the engine at the hours indicated and at equivalent hour intervals thereafter.										
This maintenance schedule represents the manufacturer's recommended maintenance intervals to maintain proper engine/equipment function. Federal, State, or Local regulations may require additional or more frequent inspection or maintenance intervals than those specified above. Check with the authority having jurisdiction for details.	Interval Hours									
	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
General Maintenance Section										
Visual check for fluid leaks	Inspect Periodically									
Check engine oil level	Inspect Periodically									
Check coolant level	Inspect Periodically									
Change engine oil and oil filter	**Every 100 hours or 60 days* of operation**									
Leak check fuel system for leaks	**Before and after any service or maintenance activity**									
Inspect accessory drive belts for cracks, breaks, splits or glazing		X		X		X		X		X
Inspect electrical system wiring for cuts, abrasions or corrosion				X				X		
Inspect all vacuum lines and fittings for cracks, breaks or hardening				X				X		
Engine Coolant Section										
Clean debris from radiator core	**Every 100 hours or 60 days* of operation**									
Change coolant (50-50 mixture with distilled water)		X		X		X		X		X
Inspect coolant hoses for cracks, swelling or deterioration		X				X				X
Replace coolant hoses and accessory drive belt	**Every 2,000 Hours or two years, whichever occurs first**									
Engine Ignition System										
Inspect battery case for leaks or damage		X		X		X		X		X
Inspect battery cables for damage corrosion or contamination		X		X		X		X		X
Check all electrical connector retainer locks		X		X		X		X		X
Replace spark plugs			X			X			X	
Inspect crank sensor timing wheel for debris or damage	**Every 100 hours or 60 days* of operation**									
Replace distributor cap and rotor				X				X		
Clean secondary ignition coil tower		X		X		X		X		X
Check spark plug wires for cuts abrasions or hardening				X						
Replace spark plug wires								X		
Fuel System Maintenance										
Inspect air cleaner	**Every 200 hours, or every 100 hours in severe environments**									
Check fuel Shut-off Valve function				X				X		
Replace inline LPG Filter**		X		X		X		X		X
Check shut off solenoid valve function				X				X		
Check air induction system for leaks				X				X		
Check intake manifold for vacuum leaks					X					X
Engine Exhaust System										
Inspect exhaust manifold for leaks				X				X		
Inspect exhaust piping for leaks				X				X		
Check HEGO sensor connector & wires for burns, cuts or damage				X				X		

*A "day" is any 24 hour period in which the engine was run, if only for a few minutes. Not to be confused with calendar days

**Only required when LPG fuel is used.

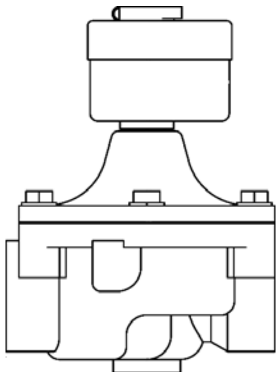
Natural Gas/Propane Fuel System



Pipe Line Pressure
Regulated Pressure
Intake Air
Air/Fuel Mixture
Exhaust Gas
Natural Gas Pipe Line
or LPG Fuel Supply
Shut-Off Valve
Shut-Off Valve
MIL Light
Gauges
Fuel Switch
LP
NG
Engine Control Module
Regulator
PWM Valve
Air Cleaner
Venturi
Throttle Body
Speed control motor
TPS
TMAP
ENGINE
ECT
Distributor (Timing)
CRANK SIGNAL
CAM Sensor
HEGO

DESCRIPTION AND OPERATION OF THE FUEL SYSTEMS

FUEL SHUT-OFF VALVES



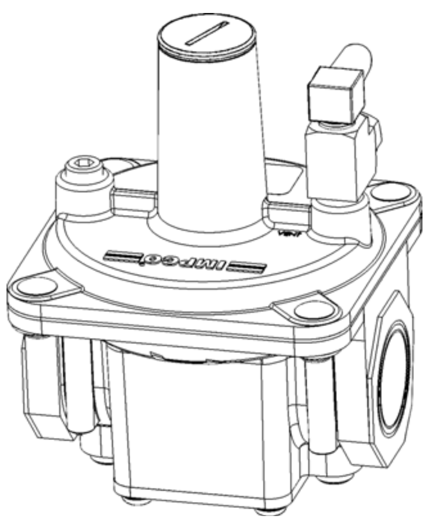
Shut-off Valve*

Two Fuel Shut-Off Valves are used, each with an integrated assembly consisting of a 12 volt solenoid and a normally closed valve. When energized, the solenoid opens the valve and allows the Natural Gas/Propane vapor fuel to flow through the valve. The valve opens during cranking and engine run cycles. Voltage to the Fuel Shut-Off Valves is controlled by the engine control module (ECM).

**Actual Valve may be different from one depicted.*

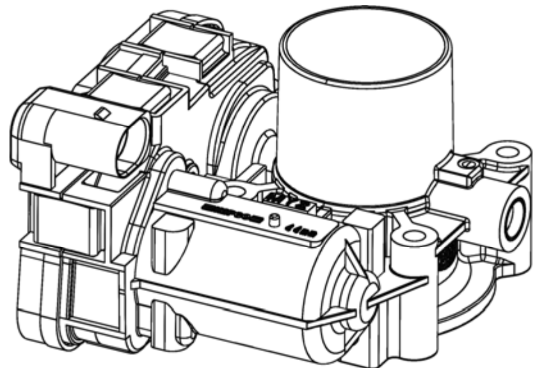
FUEL PRESSURE REGULATOR

The Fuel Pressure Regulator regulates pressure of Natural Gas or Propane vapor to the Mixer.



Regulator

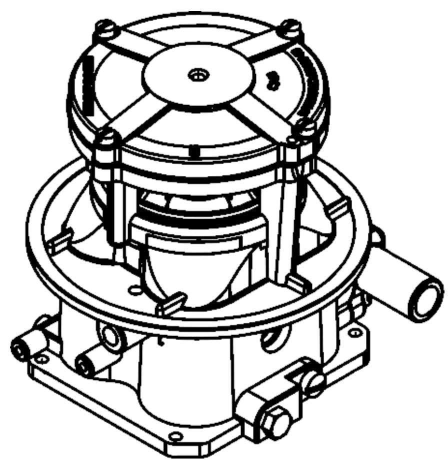
THROTTLE CONTROL DEVICE



Throttle Body

Engine speed control is maintained by the ECM. Defaults programmed into the ECM software and throttle position sensors allow the ECM to maintain safe operating control over the engine while maintaining speed and load control. In a drive by wire application, the Electronic Throttle Control device or throttle body assembly is mounted to the engine. The electronic throttle control device utilizes an electric motor connected to the throttle blade. The ECM then sends an electrical signal to the motor on the electronic throttle control to increase or decrease the angle of the throttle blade thus increasing or decreasing the air supply to the engine. The electronic throttle control device incorporates an internal Throttle Position Sensor (TPS) which provides output signals to the ECM as to the location of the throttle shaft and blade. The TPS information is used by the ECM to correct for speed and load control.

MIXER



Mixer

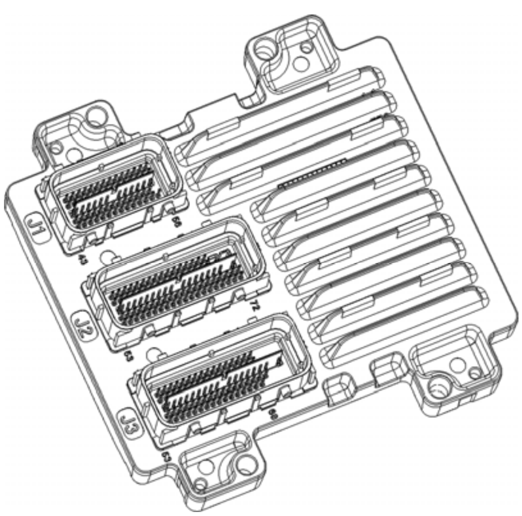
AIR FUEL MIXER

The air valve mixer is an air-fuel metering device and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop to draw fuel into the mixer from cranking to full load. The mixer is mounted in the air stream ahead of the throttle control device. When the engine begins to crank it draws in air with the air valve covering the inlet, and negative pressure begins to build. This negative pressure signal is communicated to the top of the air valve chamber through vacuum ports in the air valve assembly.

CAUTION

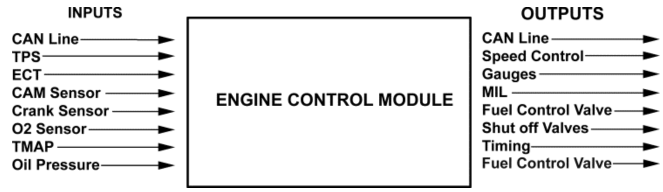
The air/fuel mixer is an emission control device. Components inside the mixer are specifically calibrated to meet the engine's emissions requirements and should never be disassembled or rebuilt. If the mixer fails to function correctly, replace with an OEM replacement part.

ENGINE CONTROL MODULE



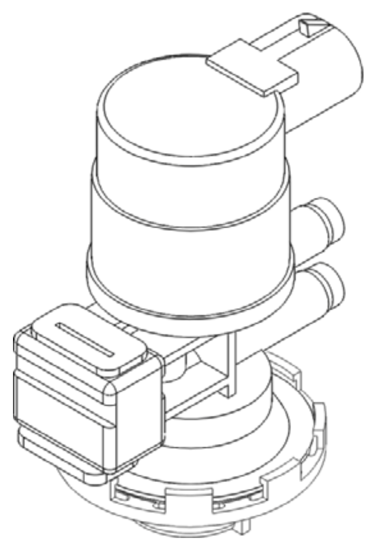
Engine Control Module (ECM)

To obtain maximum and accurate control of the air fuel ratio, the engine is equipped with an onboard computer or Engine Control Module (ECM). The ECM is a controller which receives input data from sensors mounted to the engine and fuel system and then outputs various signals to control engine operation.



Engine Control Module (ECM) Inputs & Outputs

A function of the controller is to maintain a closed loop fuel control which is accomplished by use of the Heated Exhaust Gas Oxygen sensor (HEGO) mounted in the exhaust system. The HEGO sensor sends a voltage signal to the ECM. The ECM then signals the Fuel Control Valve to modify the vacuum signal to the Regulator, changing the amount of fuel delivered to the Mixer. The controller also performs diagnostic functions on the fuel system and notifies the operator of engine malfunctions by illuminating a Malfunction Indicator Light (MIL). Malfunctions in the system are identified by one or more Diagnostic Trouble Code (DTC) number(s) and stored in its memory. A technician can than utilize a computerized diagnostic scan tool to retrieve the stored diagnostic code and use the diagnostic charts in this manual to determine the cause of the malfunction.

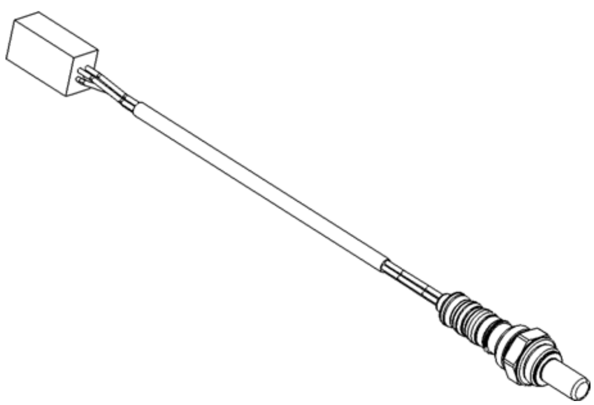


Fuel Control Valve

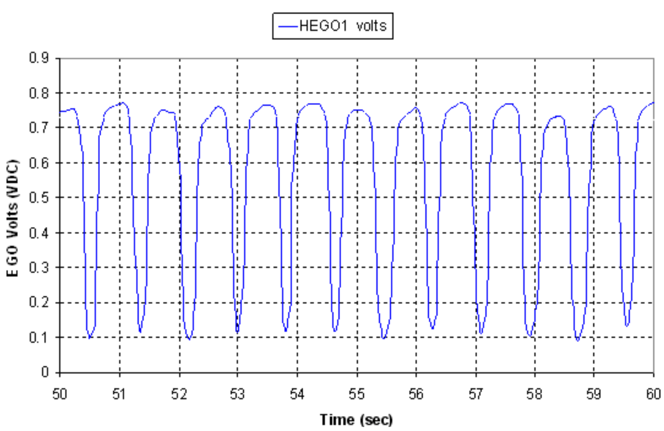
The Fuel Control Valve is an ECM controlled vacuum switch that meters manifold vacuum delivered to the atmospheric pressure reference of the Regulator. Based on the fuel requirements of the engine, the ECM signals the Valve to open or close, altering the fuel pressure delivered from the Regulator to the Mixer.

HEATED EXHAUST GAS OXYGEN SENSOR

The Heated Exhaust Gas Oxygen (HEGO) Sensor is mounted in the exhaust system and is used to measure the amount of oxygen present in the exhaust stream to determine whether the fuel air ratio is too rich or too lean. It then communicates this measurement to the ECM. If the HEGO sensor signal indicates that the exhaust stream is too rich, the ECM will decrease or lean the fuel mixture during engine operation. If the mixture is too lean, the ECM will richen the mixture. If the ECM determines that a rich or lean condition is present for an extended period of time which cannot be corrected, the ECM will set a diagnostic code and turn on the MIL light in the dash.



The Heat Exhaust Gas Oxygen (HEGO) Sensor



HEGO voltage output, depicting switching.

CAUTION

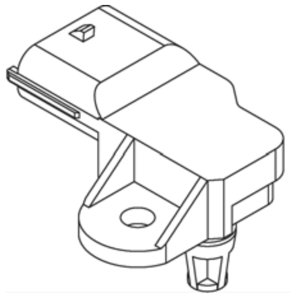
Contamination of the HEGO sensor can result from the use of an inappropriate RTV sealer or silicone spray products. Do not use silicone sprays or hoses which are assembled using silicone lubricants. Always use "oxygen sensor safe" RTV sealant for repair procedures. Silicon contamination will cause a high but false HEGO signal voltage (rich exhaust indication). The ECM will then reduce the amount of fuel delivery to the engine, causing a severe performance problem. If silicone contamination is suspected, remove and visually inspect the sensor element. If contaminated, the portion of the sensor exposed to the exhaust stream will have a white powdery coating. Always be sure to eliminate the cause of contamination before replacing the sensor.

TMAP SENSOR

The Air Temperature/Manifold Absolute Pressure or TMAP sensor is a combination of two sensors:

1) A variable resistor used to monitor the difference in pressure between the intake manifold and outside or atmospheric pressure. The ECM monitors the resistance of the sensor to determine engine load (the vacuum drops when the engine is under load or at wide open throttle). When the engine is under load, the computer may alter the fuel mixture to improve performance and emissions.

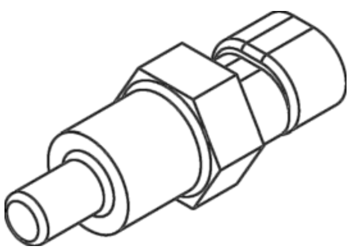
2) The intake air temperature or IAT sensor is a variable resistance thermistor located in the air intake passage which measures the temperature of the incoming air. The ECM uses the resistance value to monitor incoming air temperature and calculate the engine's airflow requirement. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads a higher voltage, and lower when warm. On cold starts, the ECM richens the fuel/air mixture.



TMAP Sensor

COOLANT TEMPERATURE SENSOR

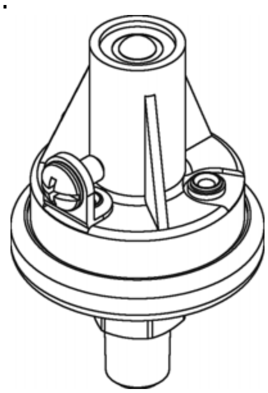
The Engine Coolant Temperature sensor or ECT is a variable resistance thermistor that changes resistance as the engine's coolant temperature changes. The sensor's resistance is monitored by the ECM to determine a cold start condition and to regulate various fuel and emission control functions via a closed loop emission system.



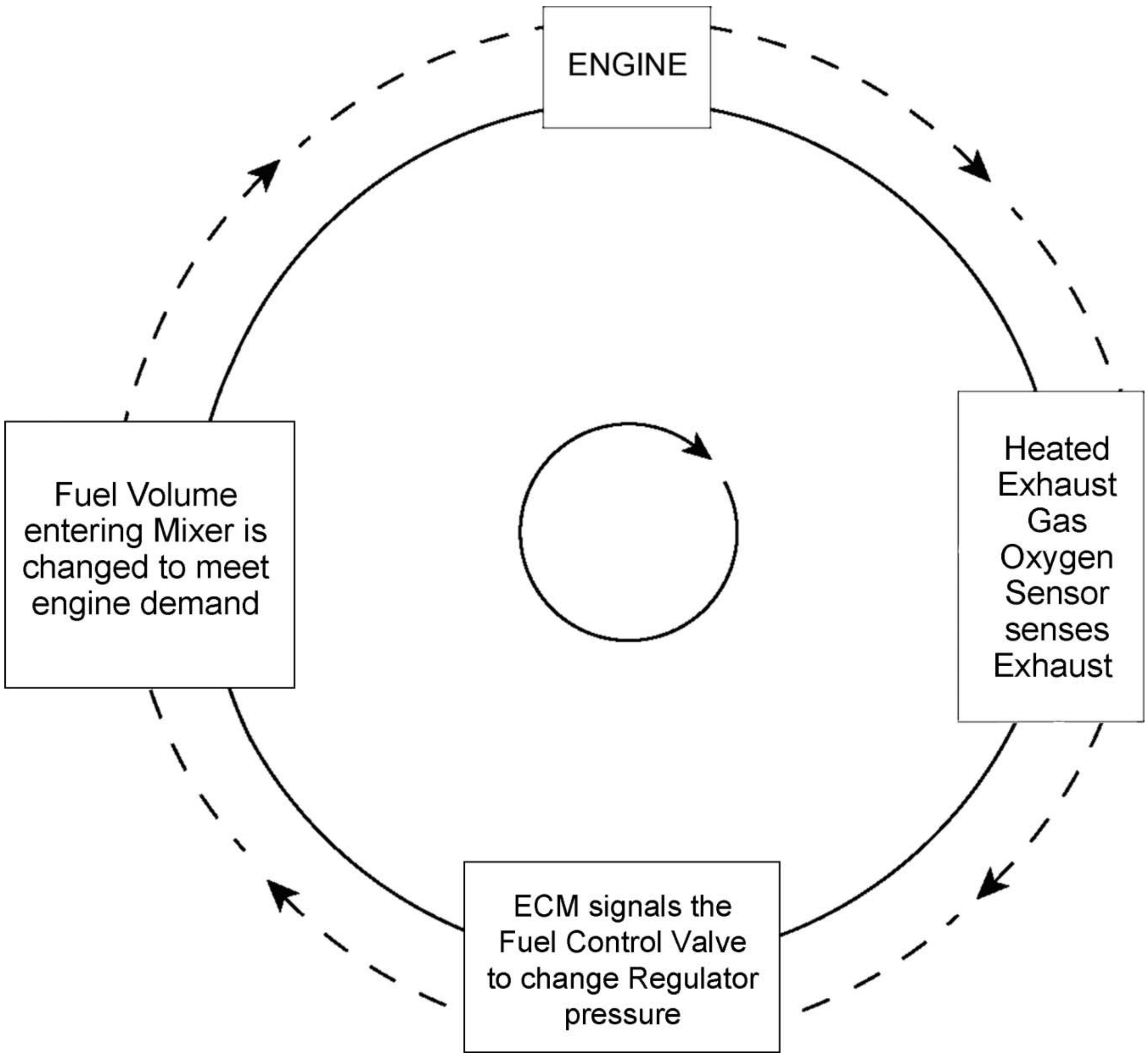
Coolant Temperature Sensor

OIL PRESSURE SENDER

The Engine Oil Pressure Sender is designed to ensure adequate lubrication throughout the engine. It provides a pressure value and is monitored by the ECM. If the pressure drops, a MIL will occur.



Oil Pressure Sender



Closed Loop Schematic

DST (Diagnostic Scan Tool)

DST (Diagnostic Scan Tool)
Software Installation Instructions

- Installation of the USB to CAN adapter driver and utility.
- Installation of the Spectrum series IV DST software program.
- Software login and password functionality.

DST INSTALLATION INSTRUCTIONS

Before installing the DST software, please be sure your computer meets the minimum system requirements.

Supported operating systems are:

- Windows 7 (32 bit)
- Windows Vista (32 bit)
- Windows XP (32 bit)

Minimum processor speed:

- Pentium III 1.0 GHz

Minimum RAM requirement:

- Windows 7 1 GB
- Windows Vista 512 MB
- Windows XP 256 MB

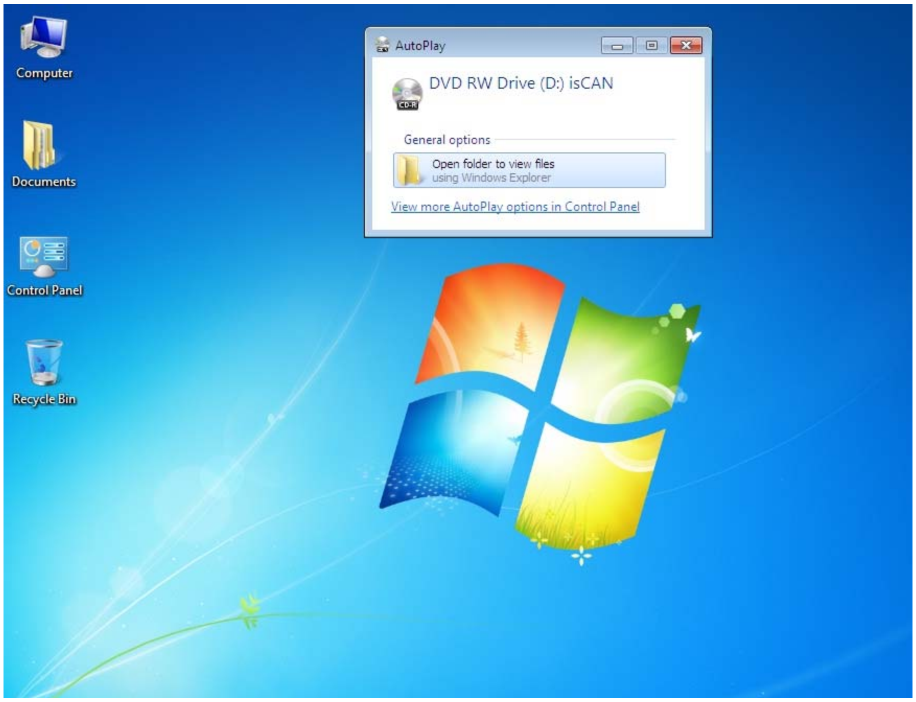
Additional:

- Display capable of at least 1024 x 768 screen resolution and one available USB port.

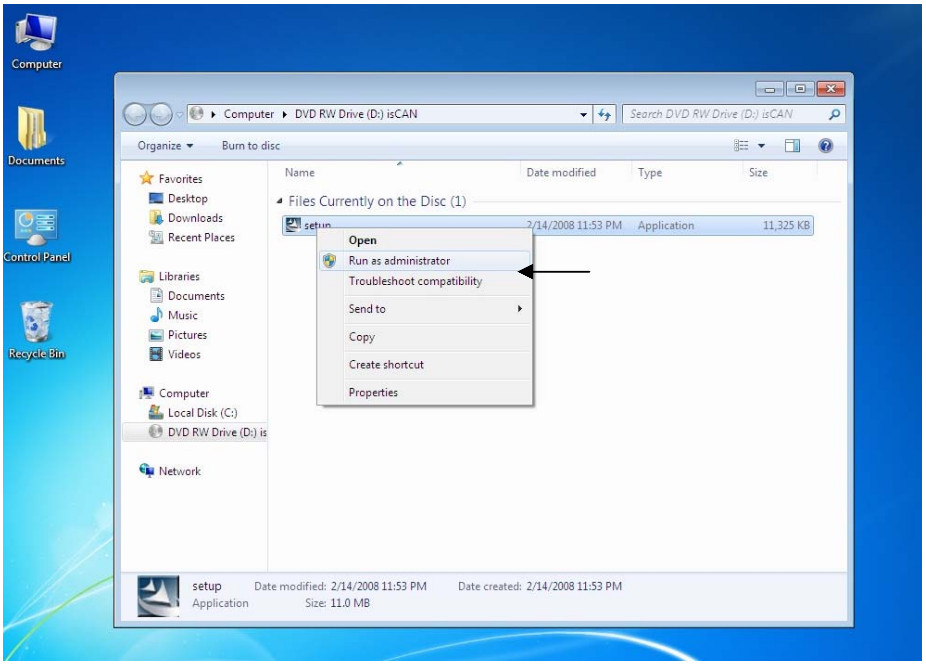
Examples and snapshots used in this manual are based off of the initial DST tool release as of August, 2010 using the Windows 7 operating system. This tool is used for multiple fuel systems and is frequently updated. Snapshot illustrations may vary depending on the installed operating system and changes included in any updated DST display Interface. This software has the ability to automatically detect functions that may or may not be used in any one particular fuel system. In this instance unused or irrelevant values and graphic displays will be shaded in gray on the DST display screens. Terms, names and descriptions of systems and other servicing procedures may be updated periodically with new DST installation software.

Ifak Driver and Utility Installation:

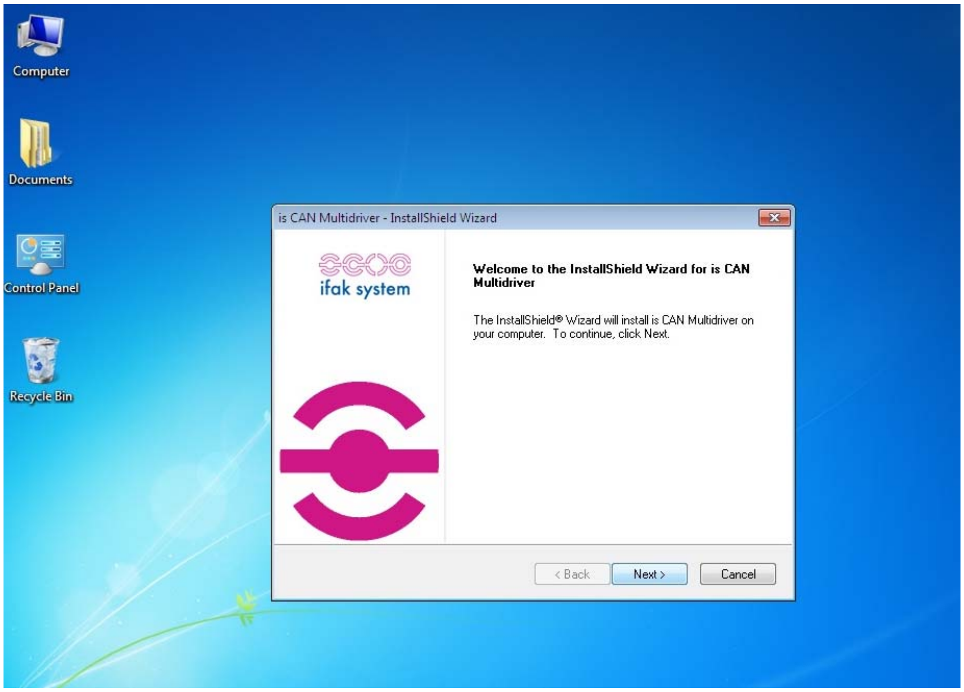
NOTE: Close any open applications prior to installing the DST.



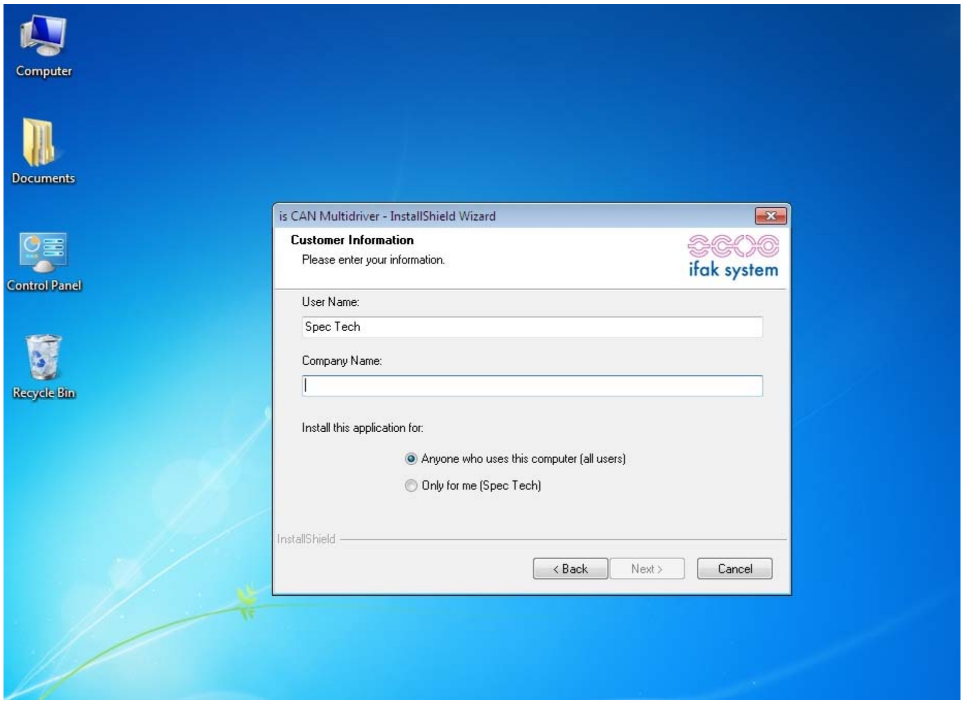
Insert the Ifak CD included with your USB to CAN adapter and open the file folder.



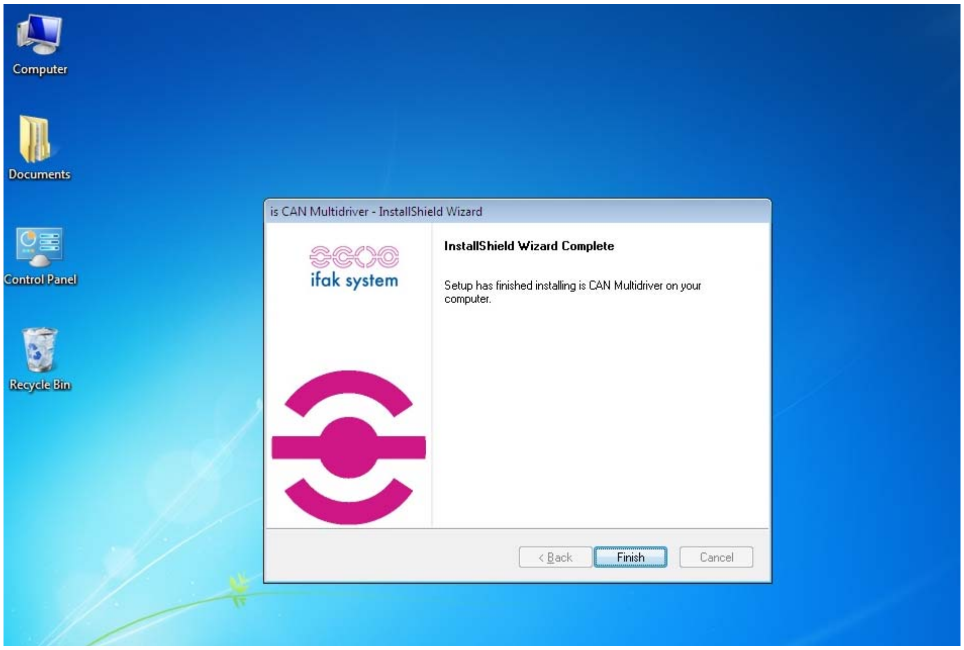
For users with restricted rights using Windows 7 or Windows Vista, select **Run as administrator** as shown above. For all others, select the **Setup file**. You may receive a Windows message asking you to confirm the installation request by an unknown publisher. You must select **Yes** to continue the installation.



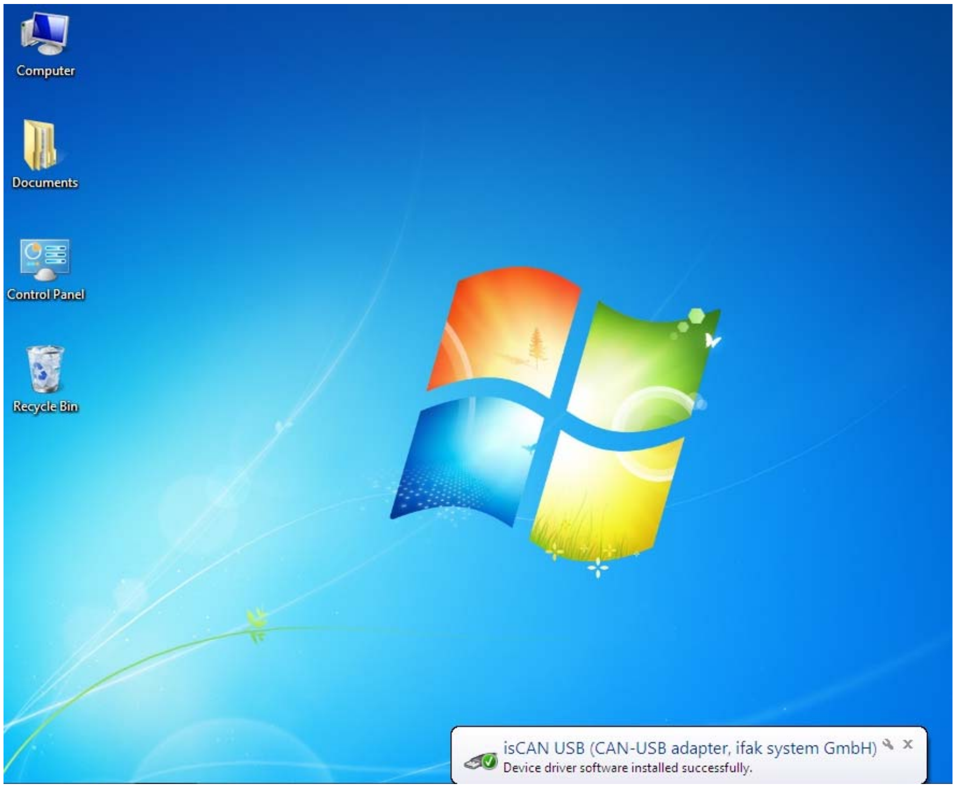
Select the **Next** box to continue with the installation.



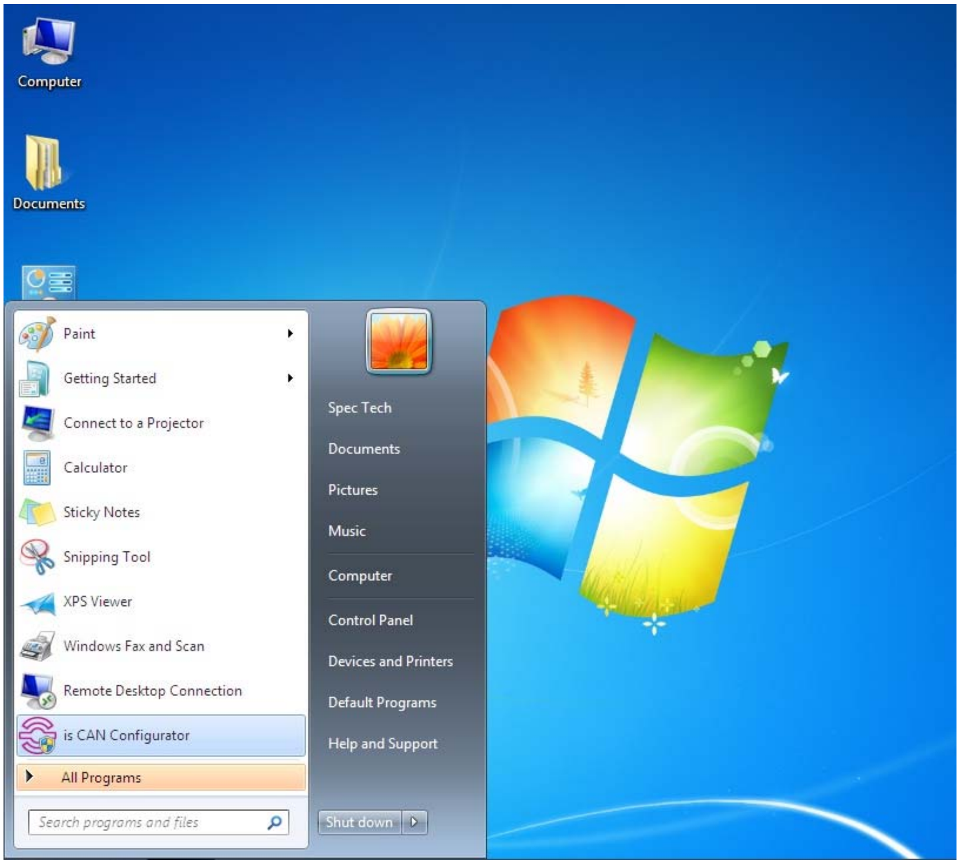
Enter your company name or organization and click the **Next** box. Follow the next steps using the recommended defaults.



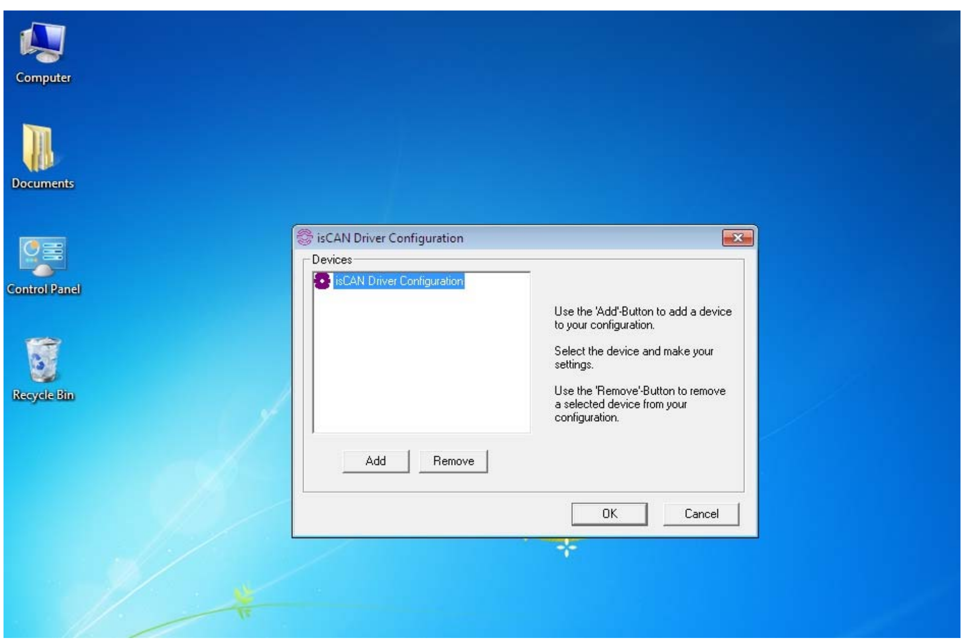
Click the **Finish** box to complete the installation. It is now recommended you re-boot your computer.



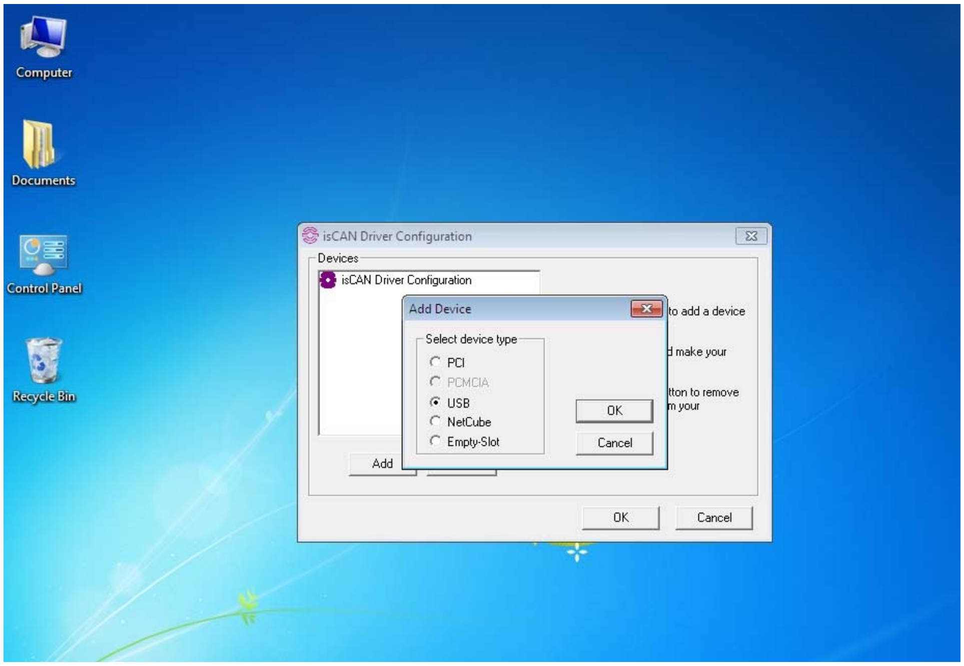
Connect the Ifak adapter to an available USB port. You may see a message confirming you wish to make changes to the computer from an unknown publisher. If so, you must select the **Yes** box to continue the installation. Windows will now install the Ifak driver to your computer. You should see a message confirming the driver was successfully installed as shown above.



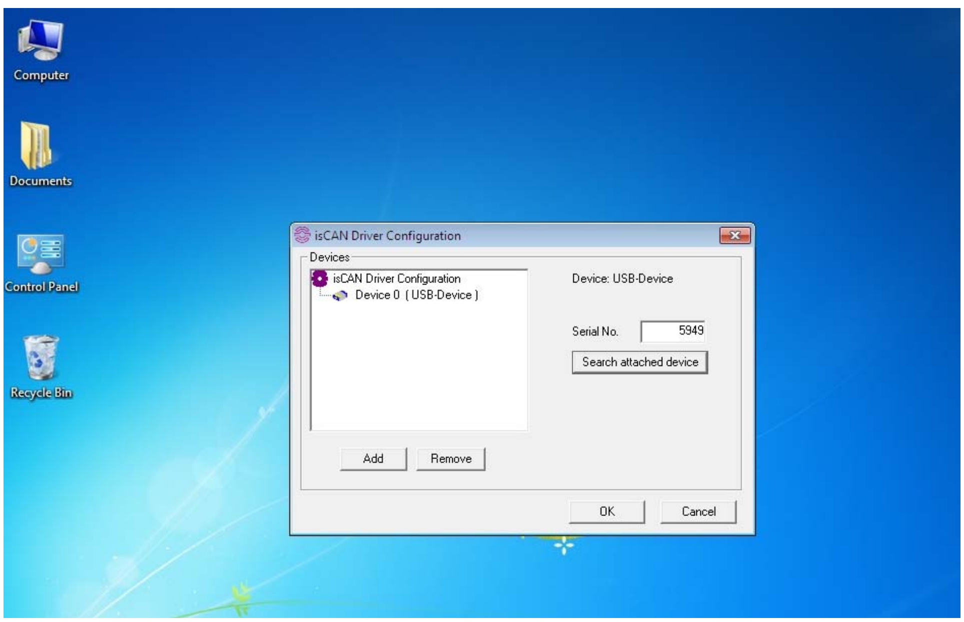
Open the **Start** menu. You should see the is CAN Configuration utility confirming the utility installation. Select the **is CAN Configurator**.



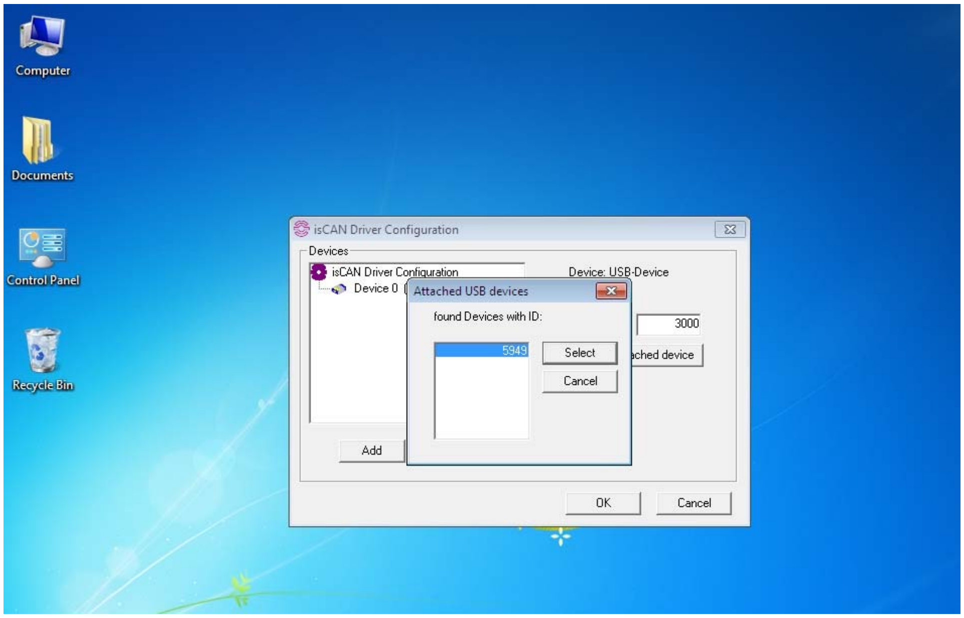
Click the **Add** box.



Select the **USB** button, then click the **OK** box.



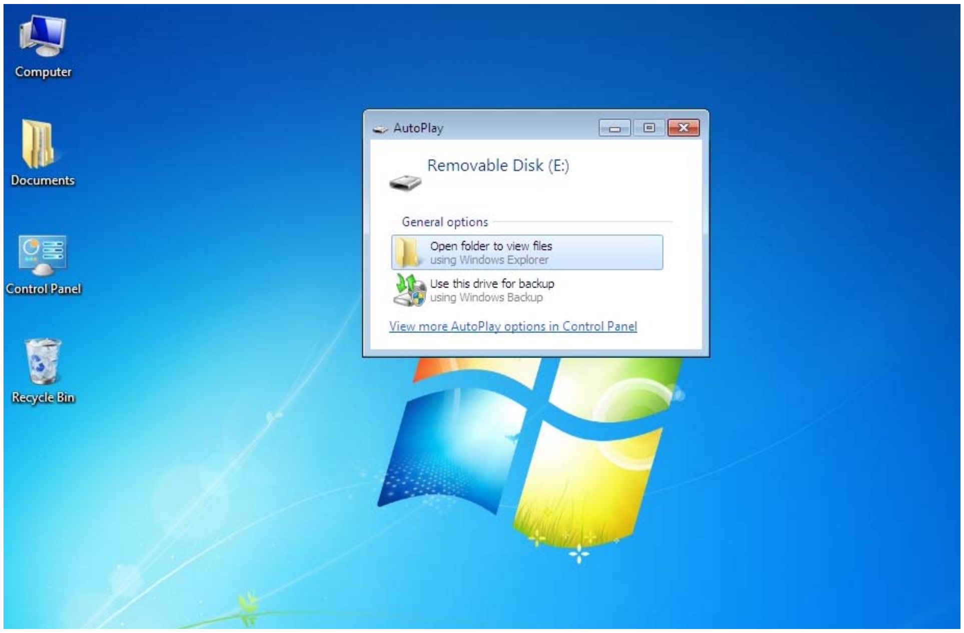
Click on the **Search attached device** box.



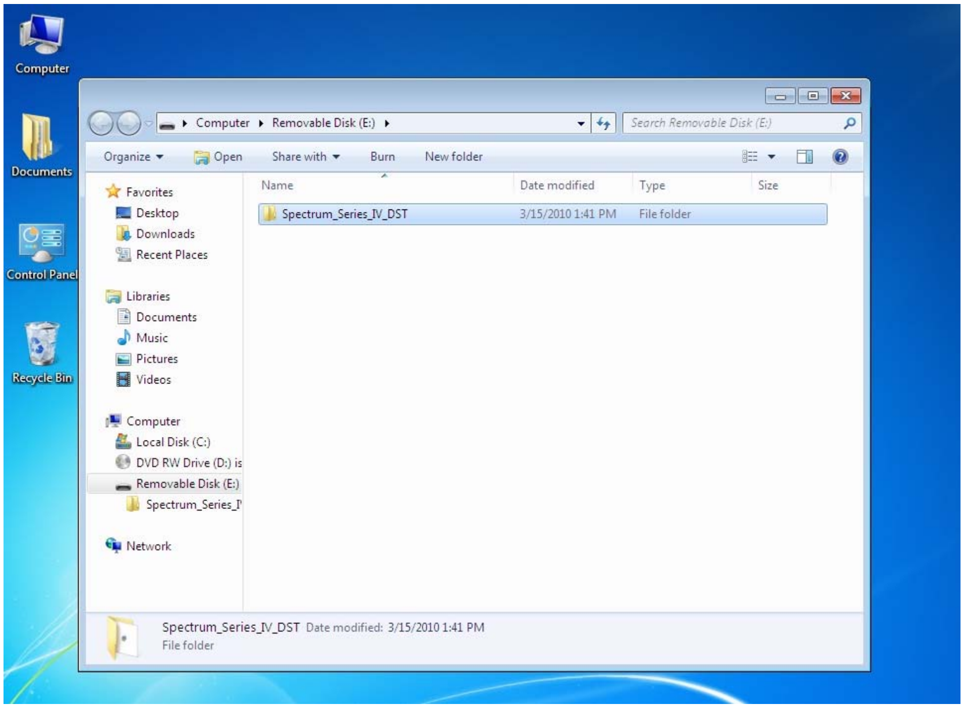
When the Ifak device serial number is shown, click the **Select** box, then click the **OK** box. The Ifak driver and utility installation is now complete. If you had problems during this installation please see the additional information and test instructions for your Ifak adapter included with your service test kit.

Spectrum Series IV DST Software Installation:

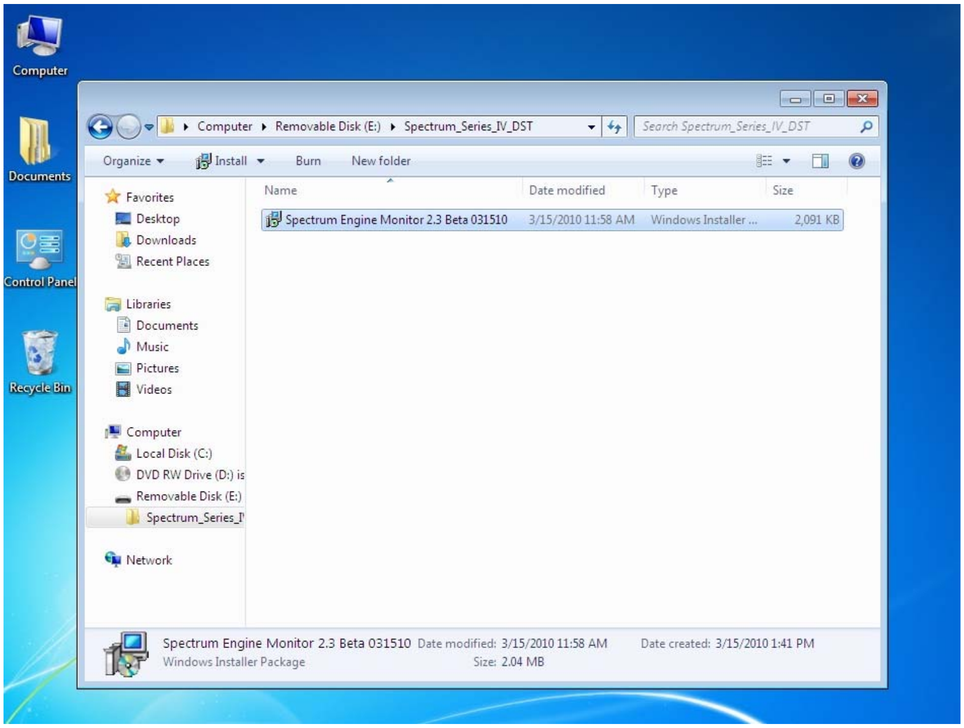
In most instances the OEM manufacturer will have supplied you the DST software installation files. The installation files may have been provided to you by internet download, CD or other media storage. Regardless of the delivery system, please follow the instructions to install the DST software below. If the files were supplied to you in a .zip file format it is strongly recommended that the files are first unzipped before proceeding with the DST software installation.



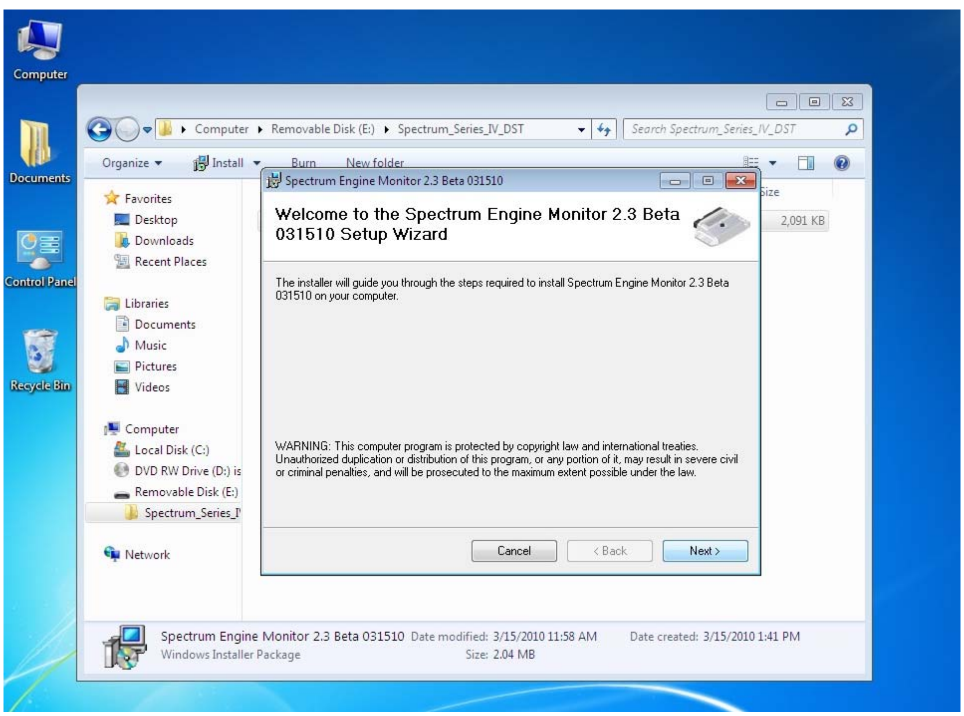
Insert the CD, USB flash drive, other storage media or find the location where the DST software has been saved on your computer.



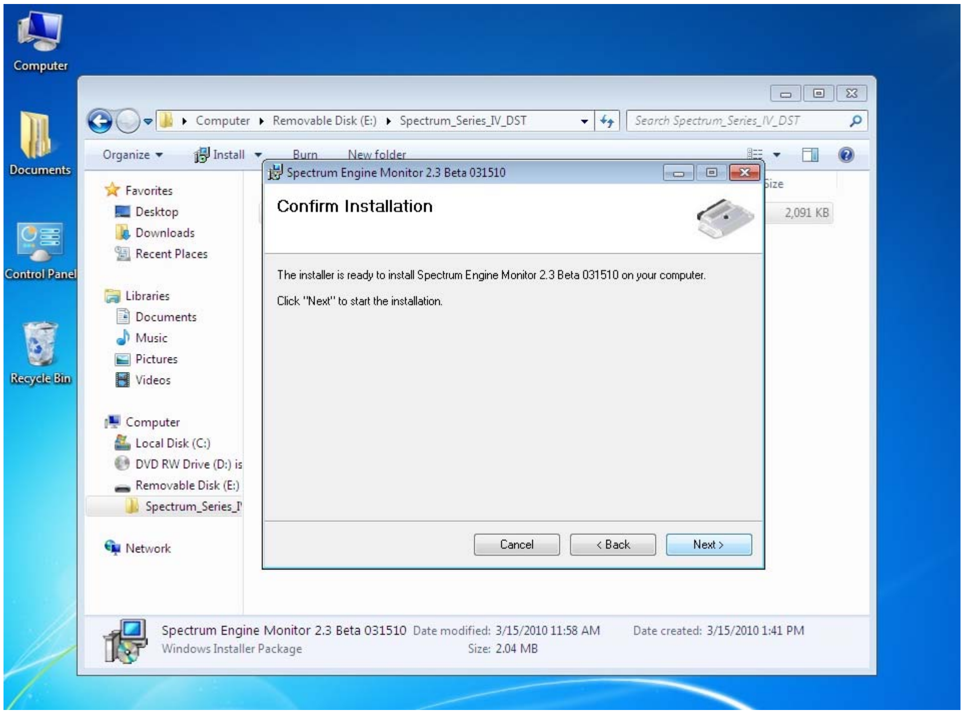
Open the **Spectrum_Series_IV_DST** file folder.



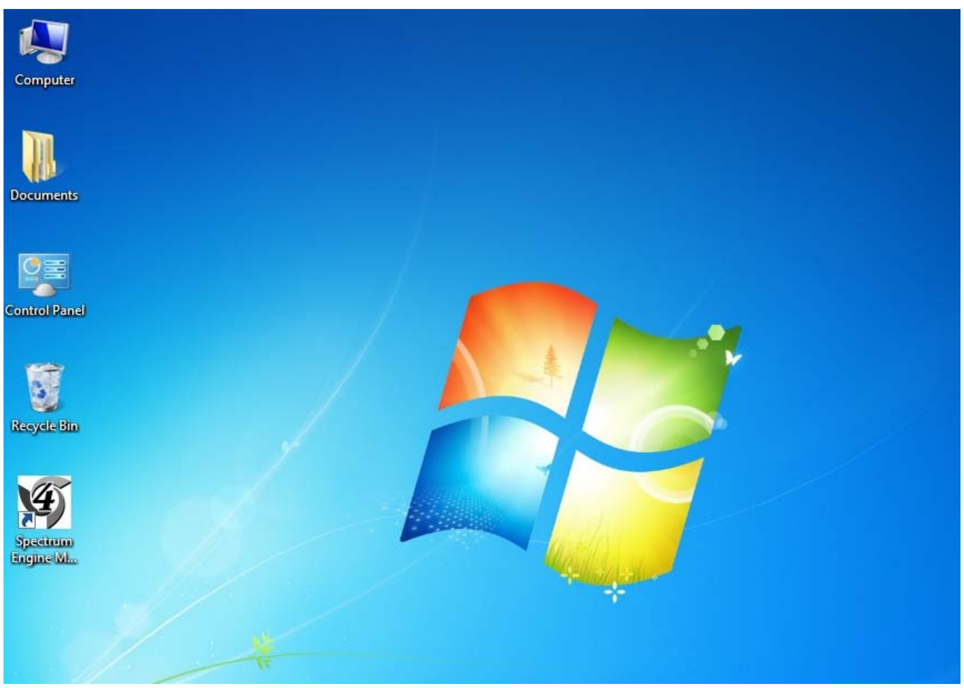
For users with restricted rights using Windows 7 or Windows Vista, it may be necessary to select the **Run as administrator** box similar to the Ifak USB driver installation. For all others, click the **Spectrum Engine Monitor.msi** file. You may receive a Windows message asking you to confirm the installation request by an unknown publisher. If so, you must select the **Yes** box to continue the installation.



Click the **Next** box.

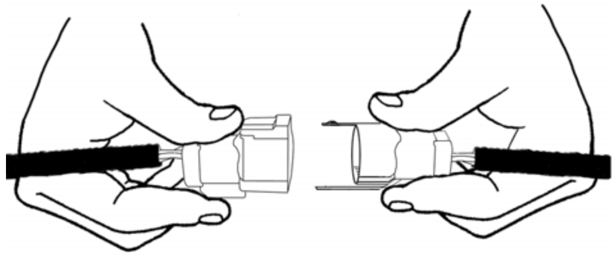


Follow the on screen prompts that will guide you through the installation.

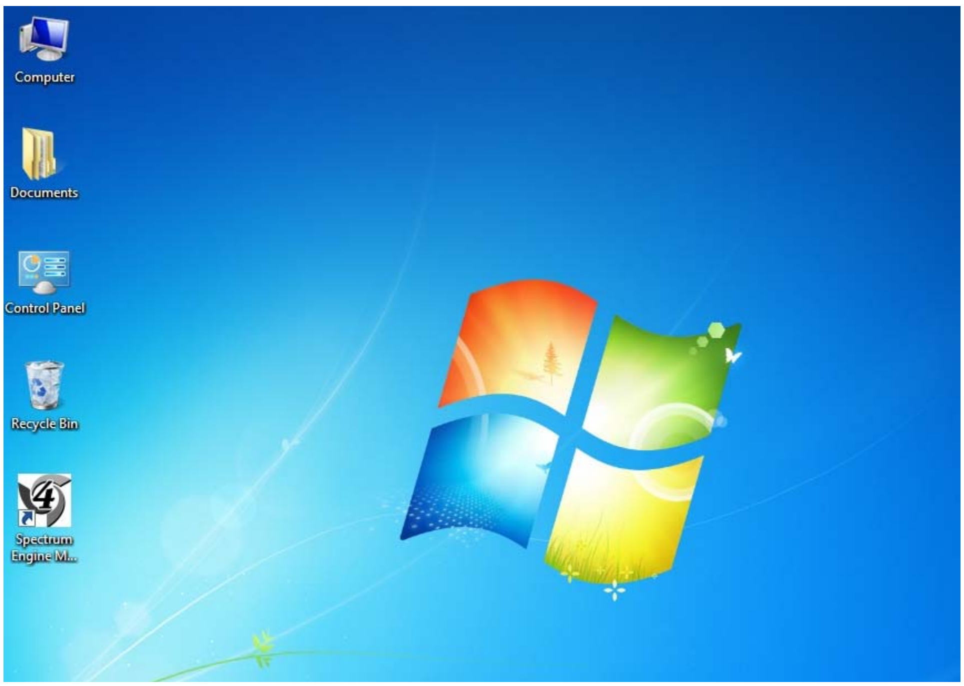


The Spectrum 4 logo shortcut is placed on the desktop confirming the installation is complete. It is now recommended that you re-boot your computer.

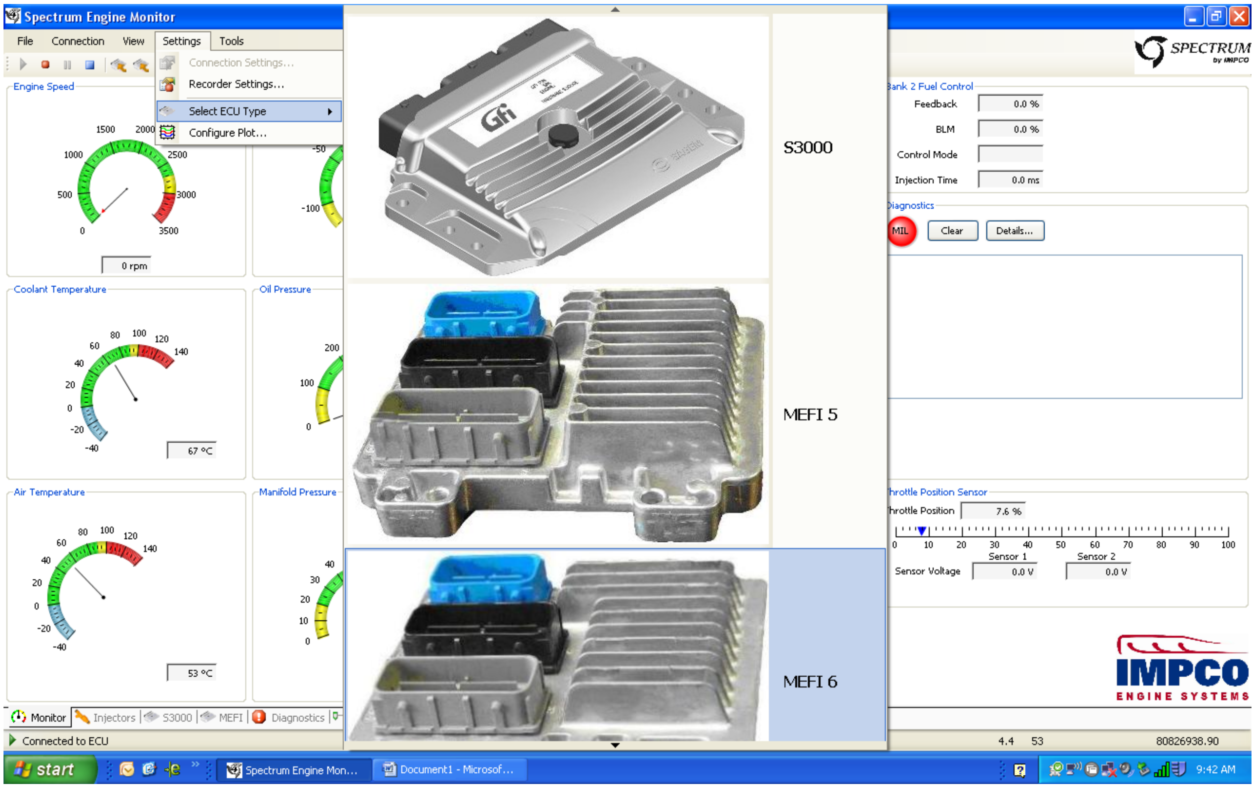
Connecting the DST:



Connect the Diagnostic Link Connector or DLC (orange cable) to the Ifak adapter's DB-9 pin connector. Connect the other end of the DLC connector to the engine harness (3 pin connector).

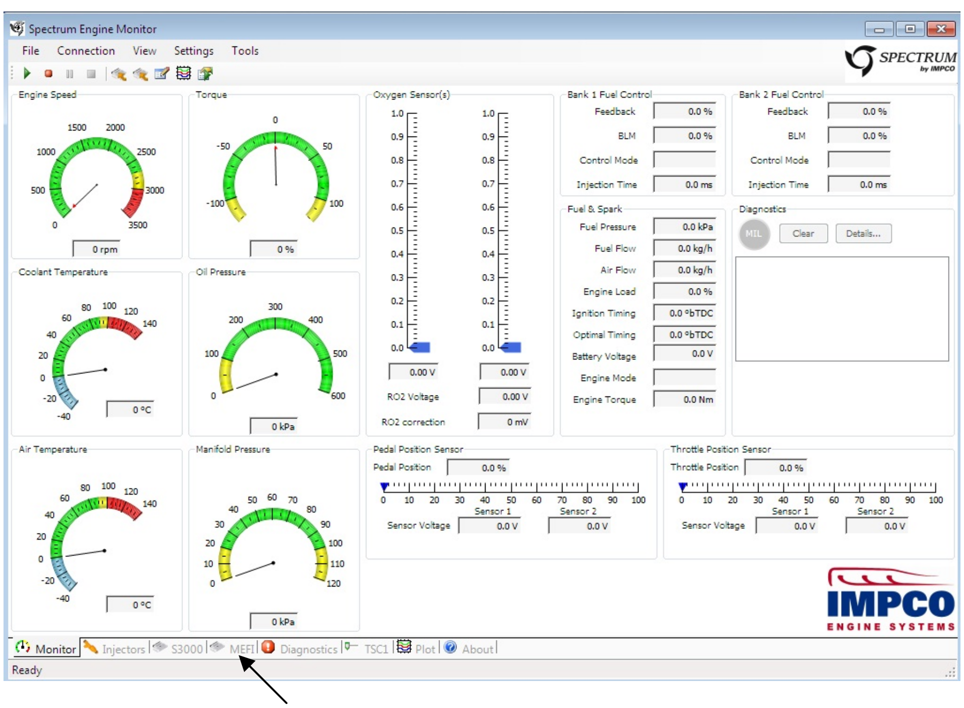


Click on the Spectrum 4 shortcut to open the DST software program. Turn the engine ignition power ON.

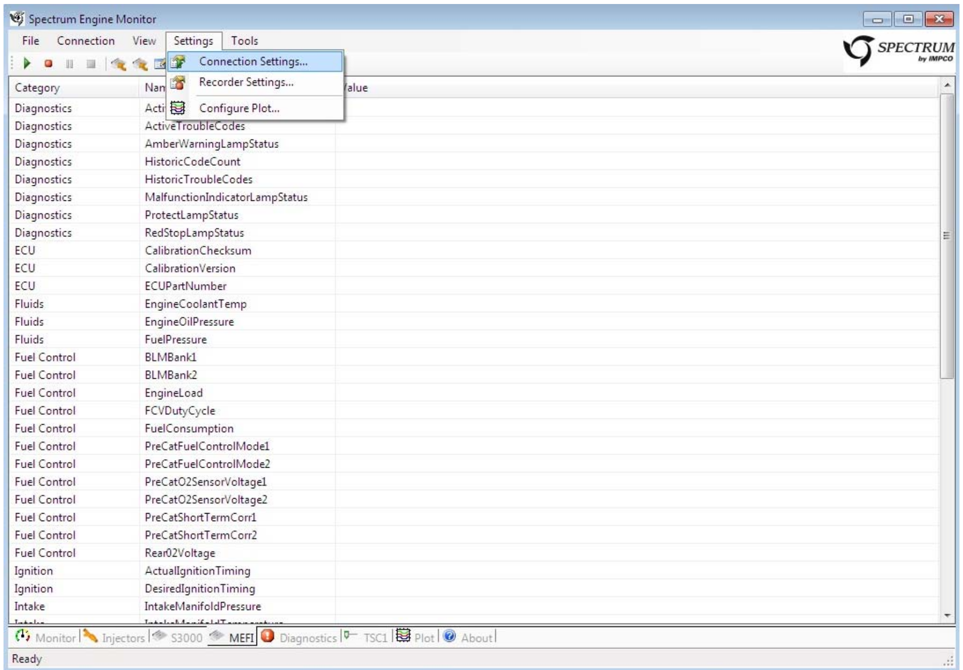


Select the Settings pulldown menu from the top, and mouse over the Select ECU Type, then mouse over to the MEFI 6 controller.

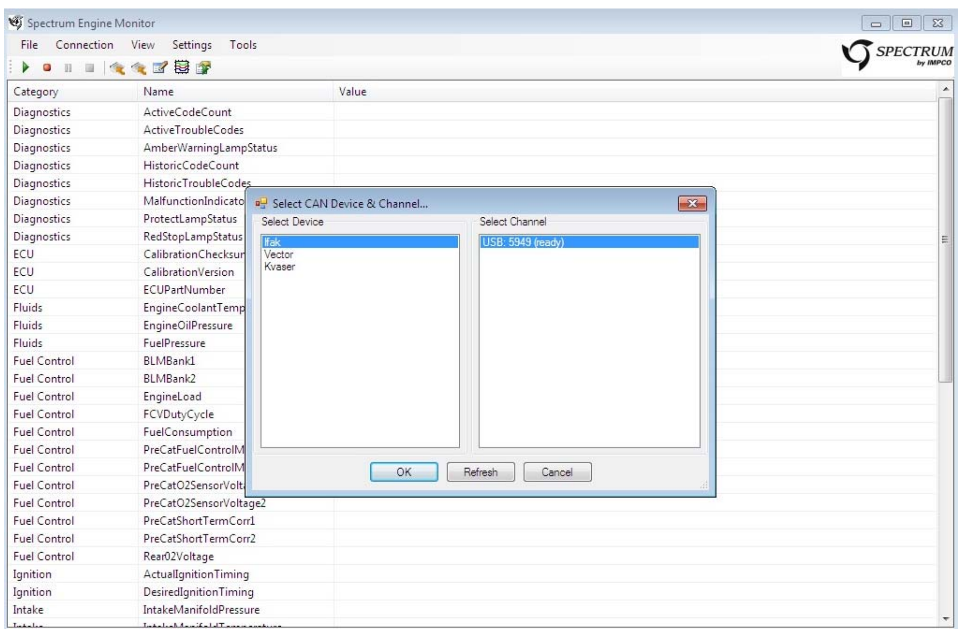
Turn the engine ignition power ON.



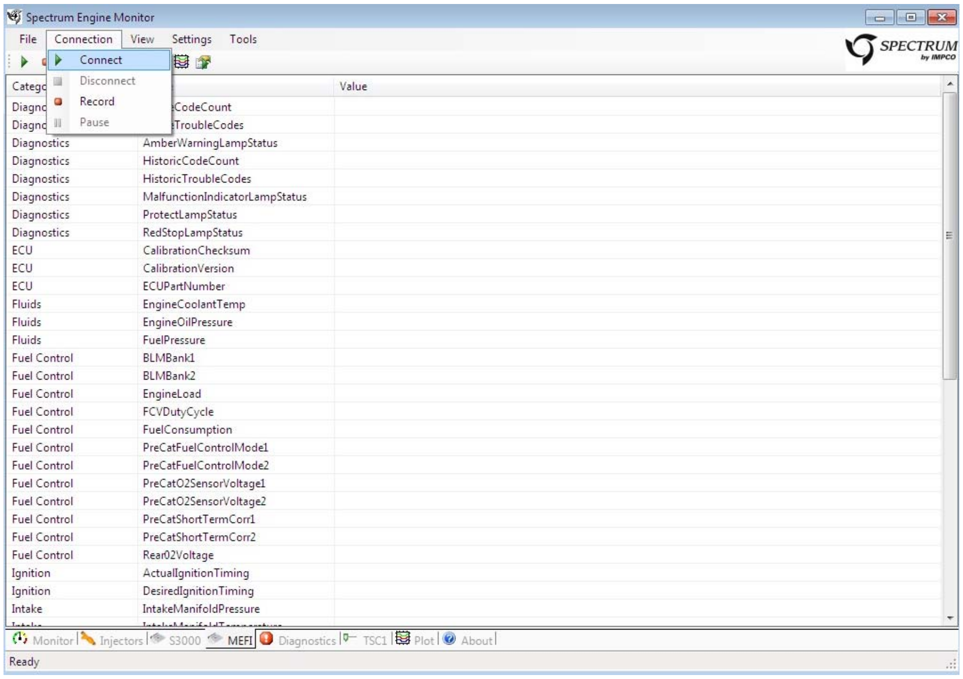
Click on the **MEFI** tab at the lower left of the Spectrum Engine Monitor page.



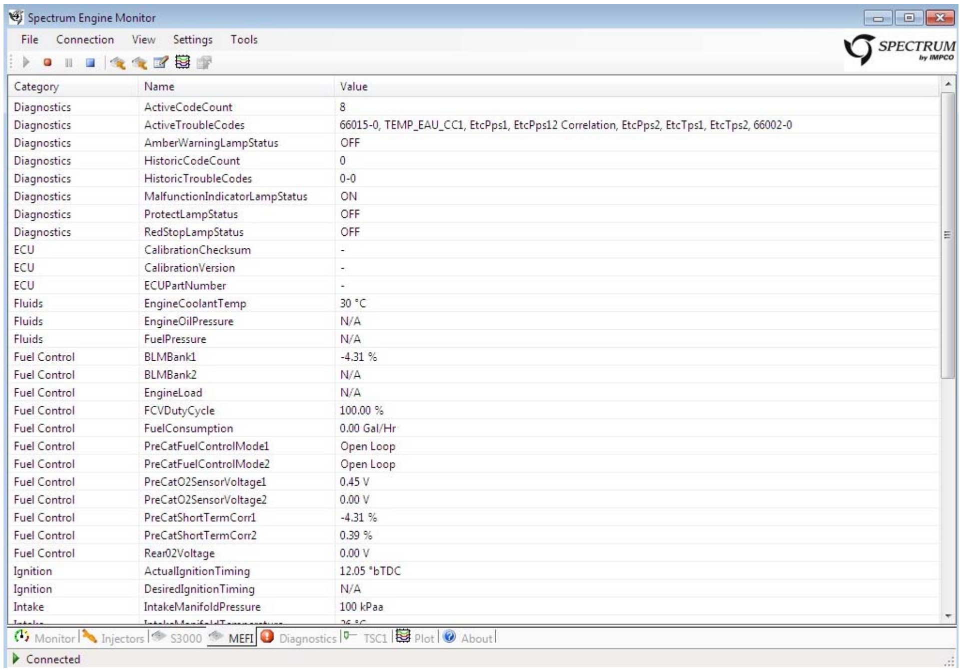
Pull down the **Settings** menu and click on **Connection Settings.**



The **Select CAN Device & Channel** dialog box will appear. Select the **Ifak** device, and then click the **OK** box.



Under the **Connection** drop down menu, select **Connect**



When connected, the live data stream appears in the **Value** column.


Spectrum Engine Monitor
File Connection View Settings Tools
SPECTRUM
Engine Speed
1796 rpm
Torque
18 %
Oxygen Sensor(s)
0.06 V
0.00 V
RO2 Voltage 0.00 V
RO2 correction 0 mV
Bank 1 Fuel Control
Feedback 14.8 %
BLM 11.4 %
Control Mode Closed Loop
FCV Duty Cycle 5.0 %
Bank 2 Fuel Control
Feedback 0.0 %
BLM 0.0 %
Control Mode
Injection Time 0.0 ms
Fuel & Spark
Fuel Pressure 1020.0 kPa
Fuel Usage 0.0 gal/hr
Air Flow 82.7 kg/h
Engine Load 0.0 %
Ignition Timing 18.6 °bTDC
Optimal Timing 0.0 °bTDC
Battery Voltage 13.8 V
Engine Mode N/A
Engine Torque 0.0 Nm
Diagnostics
MIL Clear Details...
Coolant Temperature
72 °C
Oil Pressure
1020 kPa
Air Temperature
41 °C
Manifold Pressure
32 kPa
Pedal Position Sensor
Pedal Position 0.0 %
Sensor 1 Sensor 2
Sensor Voltage 0.0 V 0.0 V
Throttle Position Sensor
Throttle Position 14.8 %
Sensor 1 Sensor 2
Sensor Voltage 1.1 V 3.9 V
IMPCO
ENGINE SYSTEMS
Monitor Injectors S3000 MEFI Diagnostics TSC1 Plot About
Connected to ECU
MEFI 6
6342801A 2011 5.7L MXR Engine
M6-09.02,5.7,001
start
Spectrum Engine Mon...
Document1 - Microsof...
9:55 AM

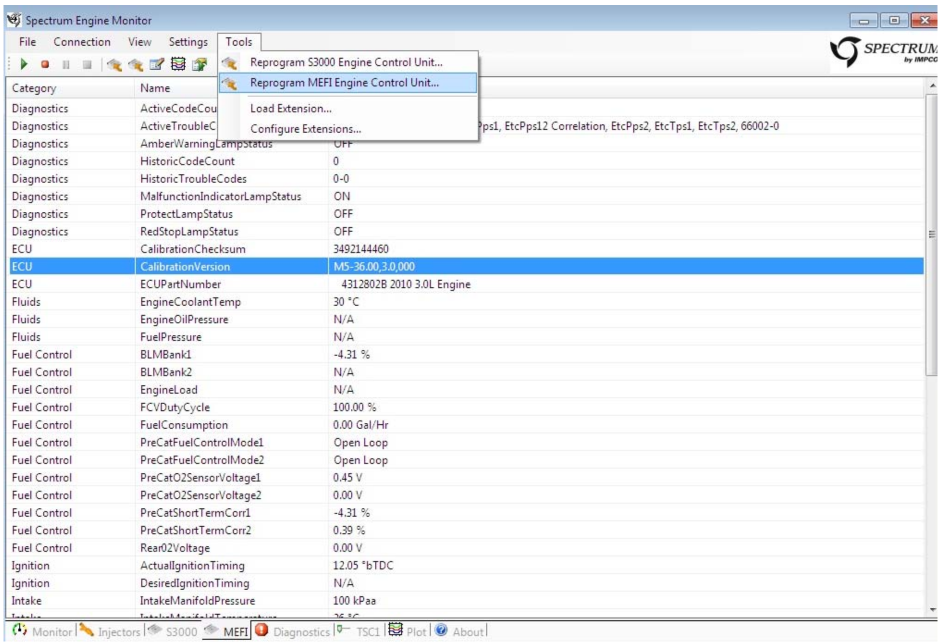
Using the Spectrum DST

The Spectrum IV DST is the next generation all CAN (Controller Area Network) enabled diagnostic tool. This is a new tool for emission year 2011. It is designed to be compatible for all 2011 Spectrum fuel systems that use both the MEFI (industrial) and S3000 (mobile) ECM applications. The DST operates on an expandable platform and its functions are planned to increase in the future. At this time the DST provides the basic functions required for the fuel and emission diagnostics for the MEFI industrial controller when used with the fuel and emissions service manual. The current functions are listed below:

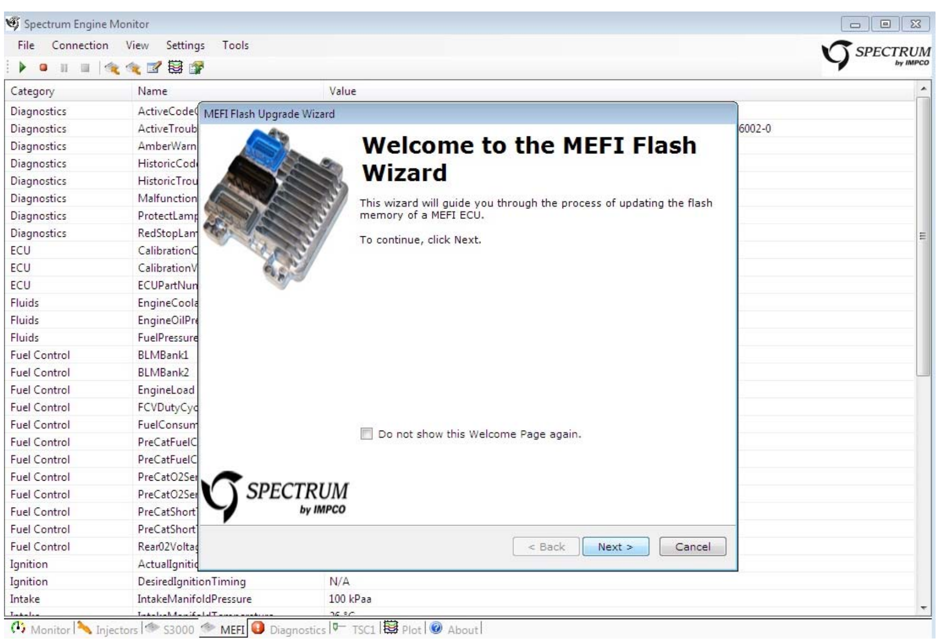
- Updating the ECM calibration using the .s37 calibration file.
- Provide graphical display interface for engine and sensors parameters
- Display and save DTC (Diagnostic Trouble Codes)
- Clear both active and historic DTCs.
- Provide data stream information from engine sensors and actuators
- Plot data.
- Record Data

Updating the ECM Calibration

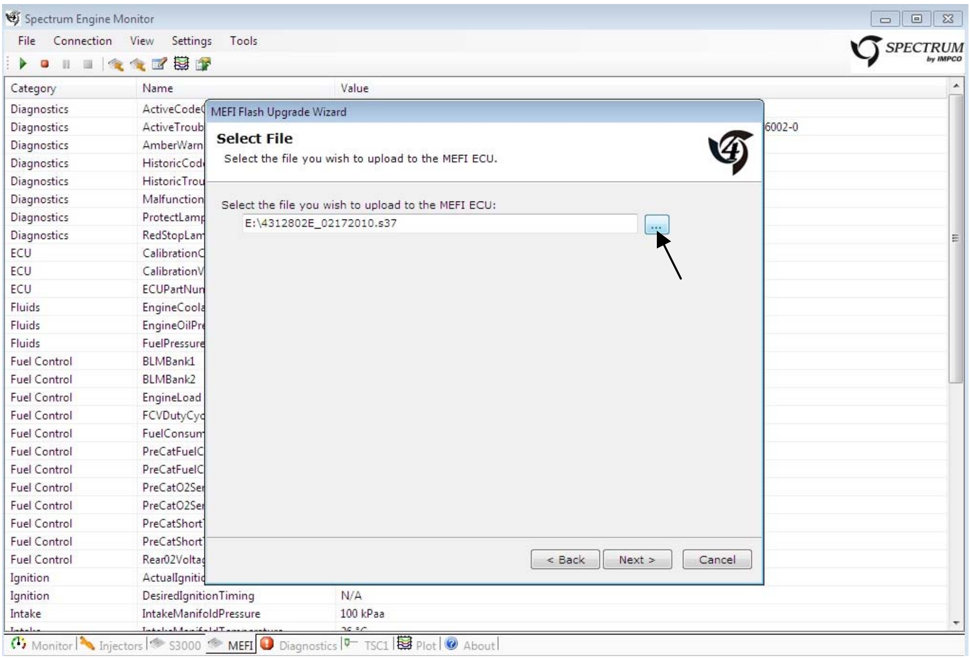
In field updates (or reflashing) are possible with the MEFI ECM using the DST. Always check first to be sure the ECM has been programmed with the latest calibration before attempting any diagnostic or service repair procedure. Calibration files are supplied in the .s37 file format. These files may be supplied to you by the OEM along with a password unique to that particular s.37 file. You will need the password to complete the re-programming procedure. Before re-programming the ECM, shut down any other programs running on your PC including wireless and e-mail programs. The PC must be dedicated to the re-programming process at this time. Be sure your PC battery is adequately charged. Failure to follow these instructions may render the ECM not usable in the field.



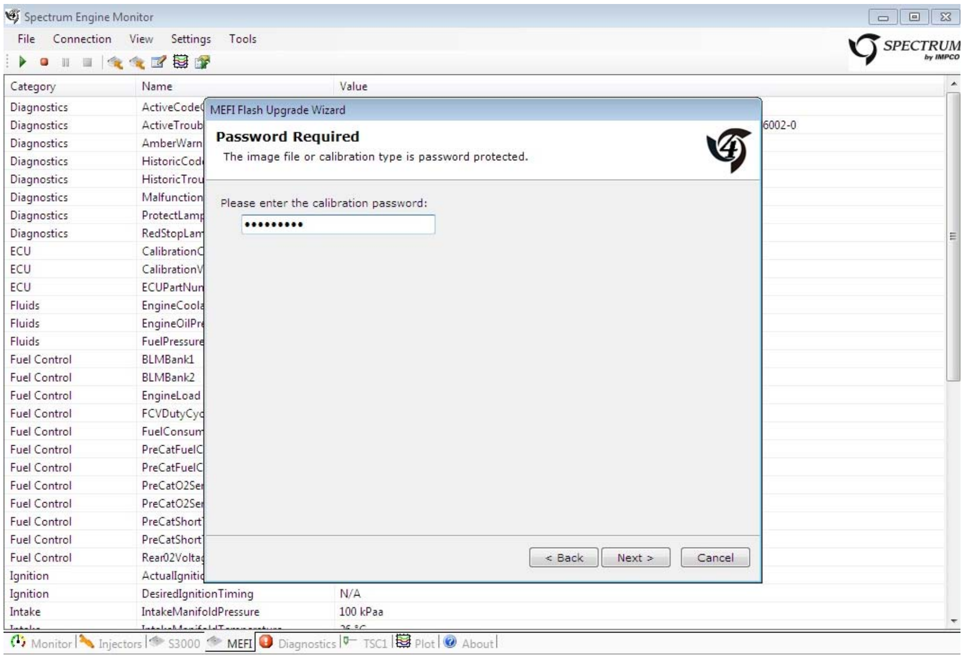
Under the **Tools** drop down menu, select **Reprogram MEFI Engine Control Unit**. Turn ignition power ON.



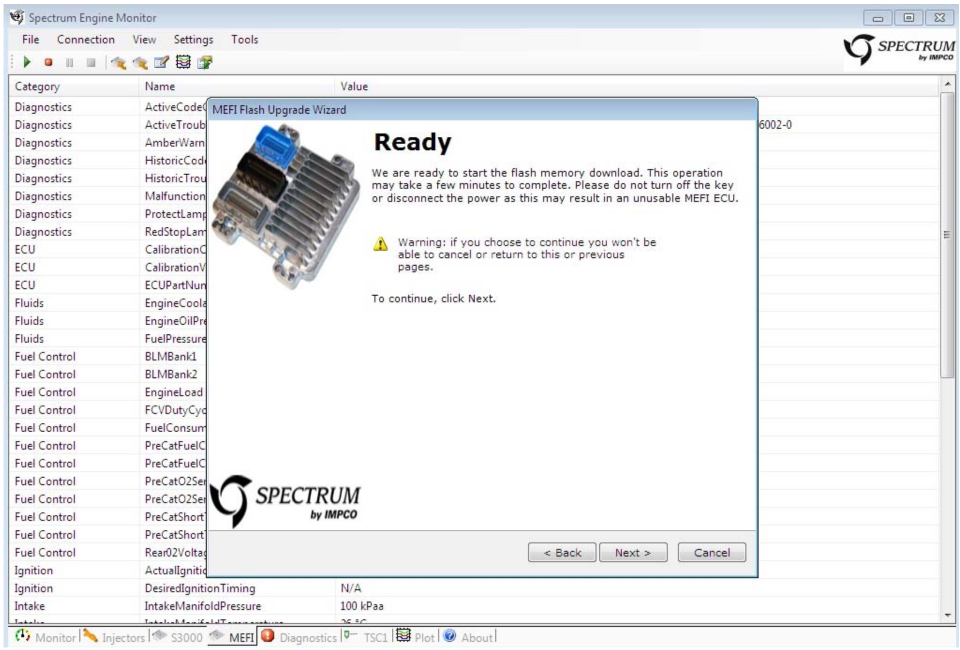
The **MEFI Flash Upgrade Wizard** dialog box will appear. Select the **Next** box.



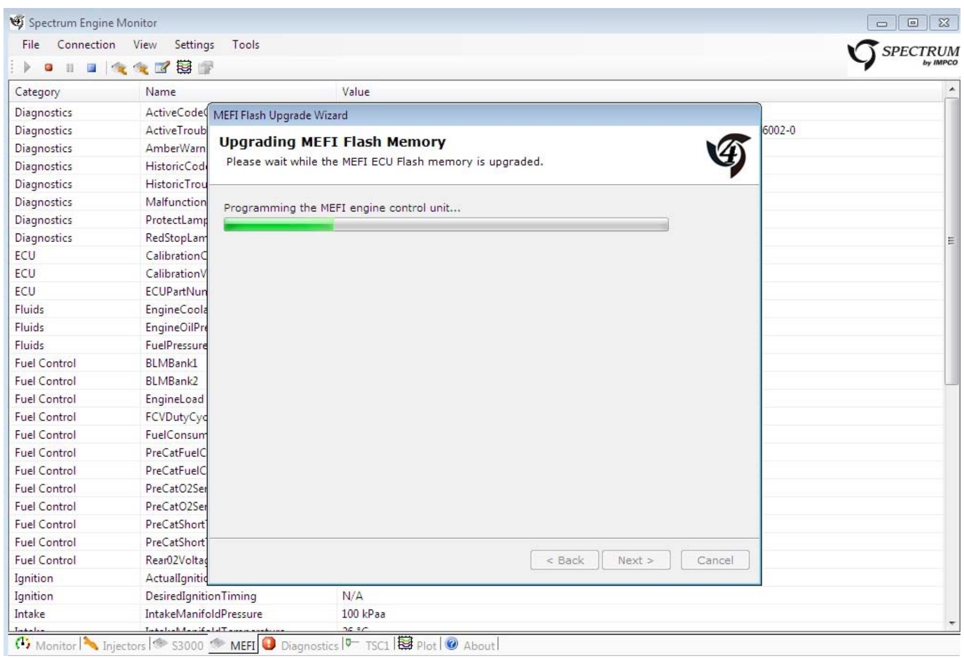
Use the **Browse** box to navigate to the location of the .s37 calibration file.



Enter the password that was supplied with the .s37 calibration file.



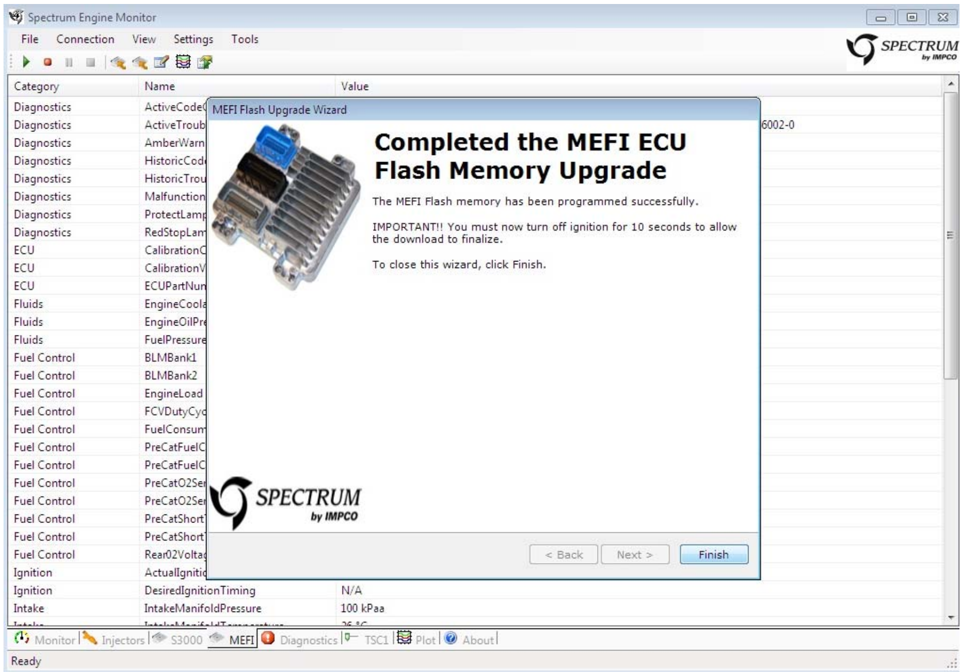
Select the **Next** box.



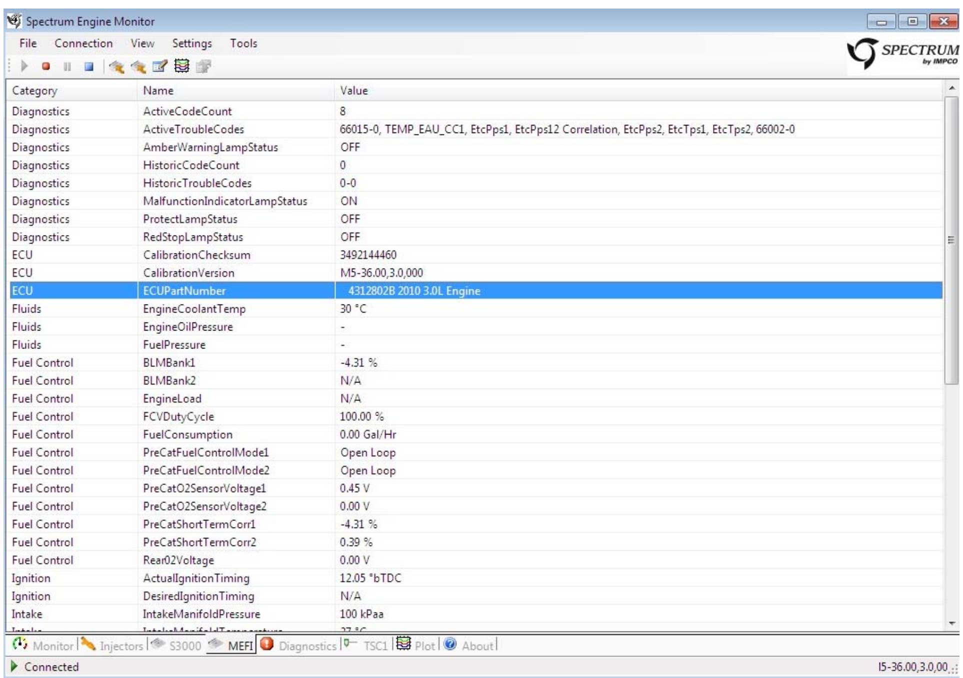
The progress bar shows the status updating. Please wait until you receive a message confirming the update is complete.

CAUTION

Any interruption during the re-programming process may render the ECM unusable in the field.



Turn the ignition power OFF. Wait 10 seconds and select **Finish**.

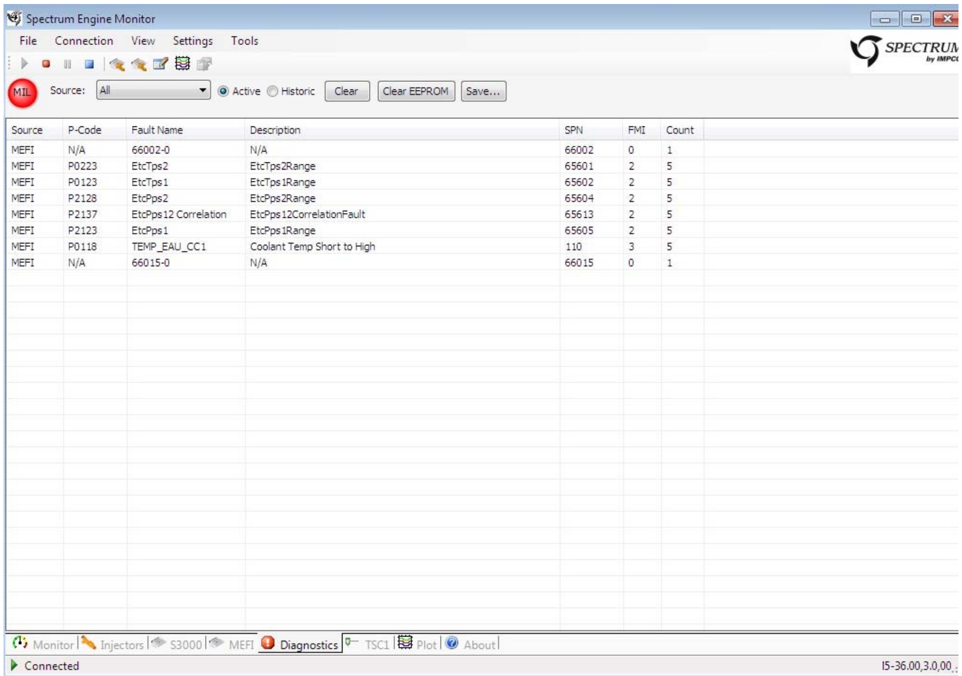


Turn the ignition ON. Verify the calibration updated with the new .s37 file number in the **ECU Part Number** data stream shown above. The reprogramming process is now complete.

Graphic Display Interface

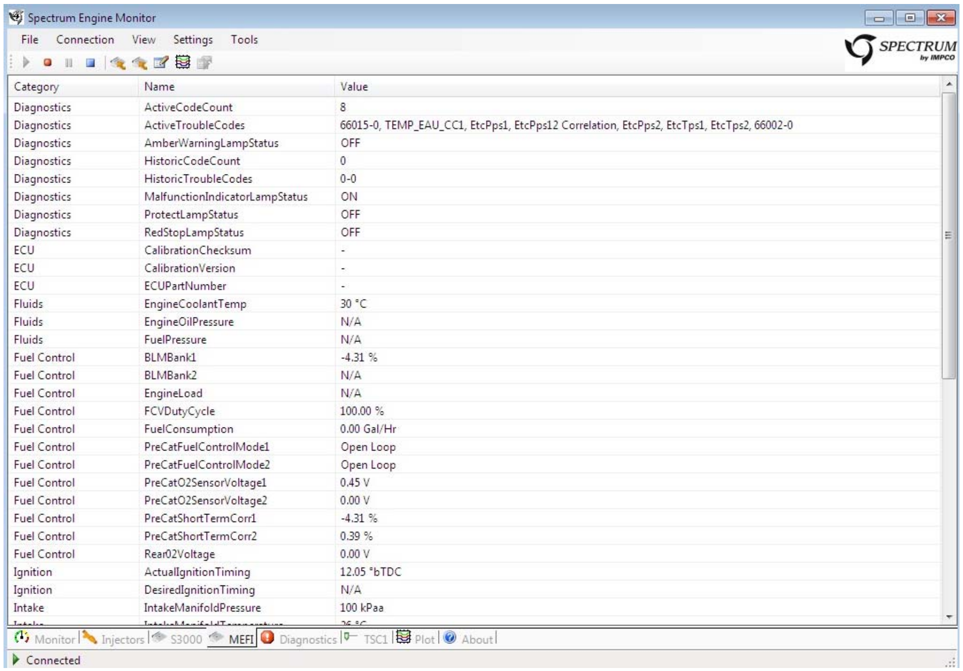
The Monitor page in the DST provides a graphical interface for important engine parameters. Graphics shown in gray are not available for the specific application the DST may be connected to as shown above. This function is controlled by the ECM calibration file and cannot be changed by the service technician.

Display DTC (Diagnostic Trouble Codes)



DTC codes can be read by clicking on the **Diagnostics** tab at the bottom of the monitor page. The source of the DTC stream can be set manually for the MEFI ECM or the S3000 ECM, or left in the default **All** position for auto detection of the DTC codes from either MEFI or the S3000 ECM. Codes that can be viewed are set in two categories, active and historic. Active codes are codes that are set and the fault that is causing the code to set is constant. Historic codes are codes that have set in the past, but the fault that caused them has been corrected such as with an intermittent problem. This function is selectable by choosing the **Active** or **Historic**, as shown in the above image. Codes can be cleared by clicking the **Clear** box. The DTC set code list may also be saved by clicking the **Save** box shown above. The file will be saved in a convenient HTML file compatible with Windows Internet Explorer and will provide a browse function to save the file to a location of choice for the service technician. Active codes are also displayed and can be cleared from the Monitor page.

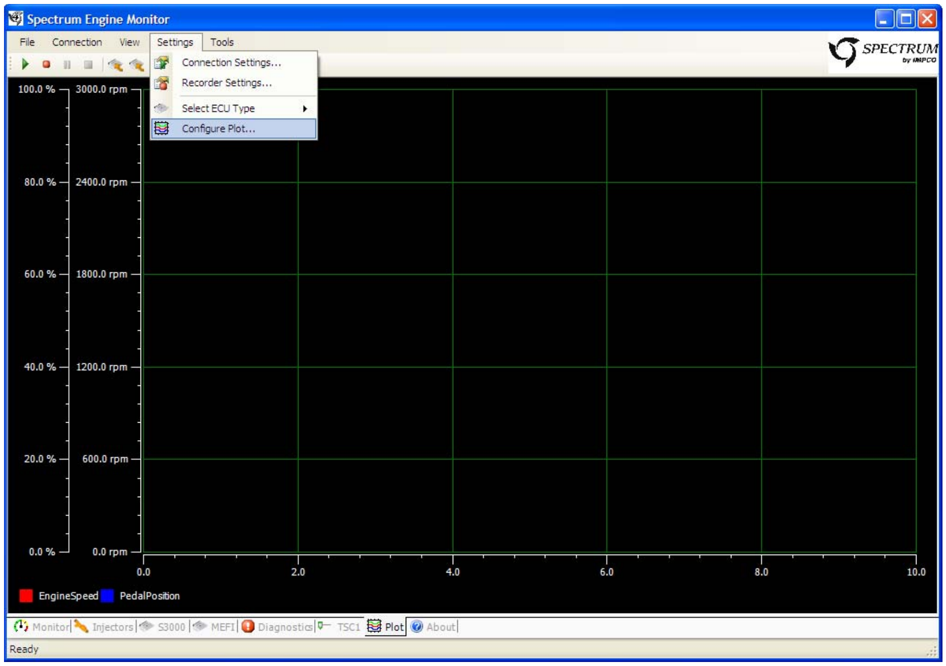
Data Stream:



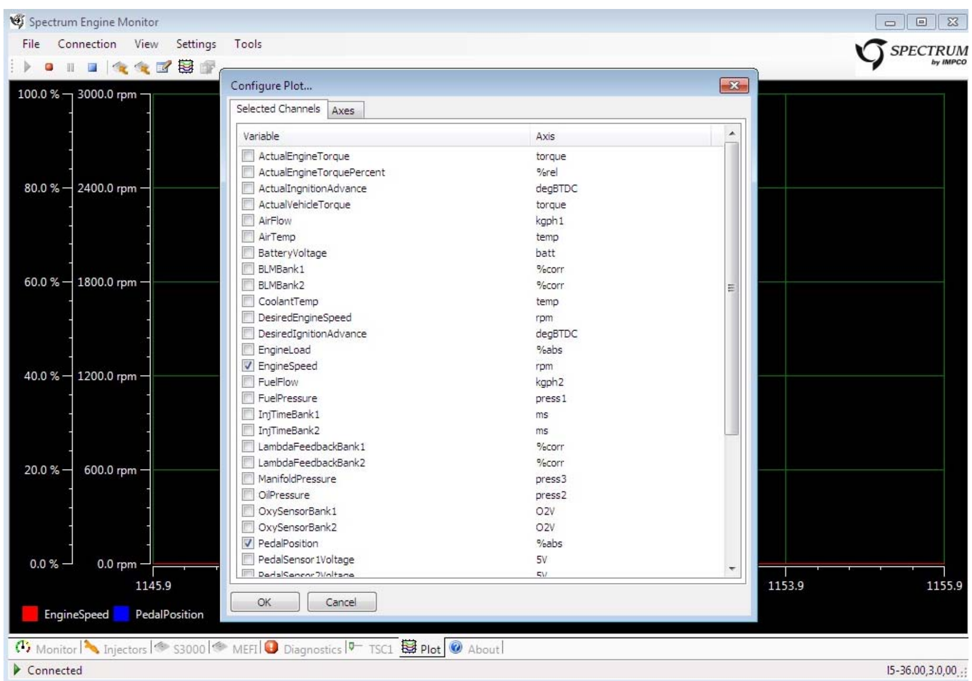
The fuel and emissions service manual will refer to the DST and asked that it be connected in the data stream mode. This simply means it is first connected and that data is shown on the MEFI data stream page as shown above. The data stream page can be accessed by selecting the **MEFI** tab shown at the lower left above.

Plot Data:

Data stream information may also be selected for a trace plot. This page is available by clicking the **Plot** tab at the lower page center as shown above.

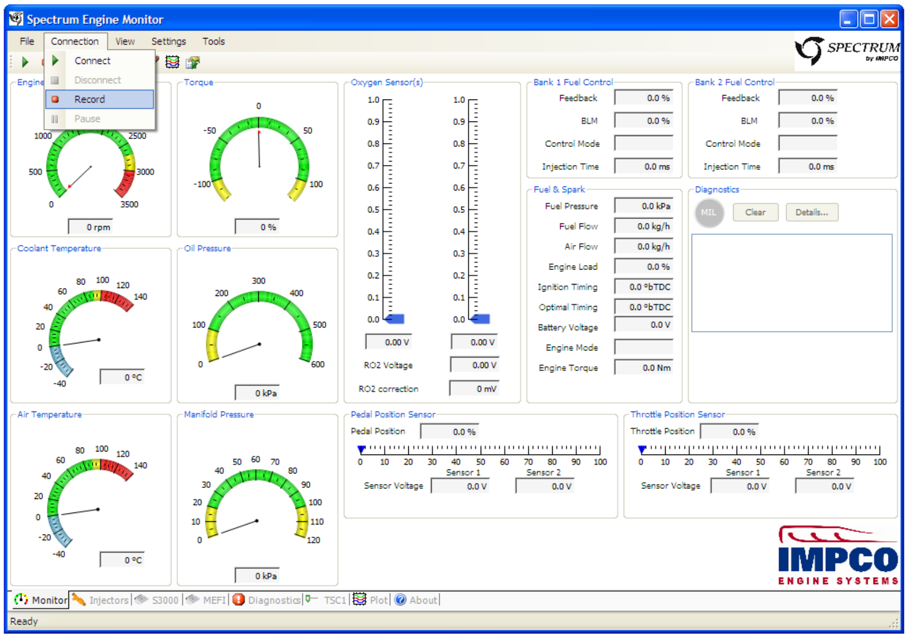


The custom parameters of the plot can be selected by clicking on the plot icon just below the **Settings** menu item at the top left of the page shown above.



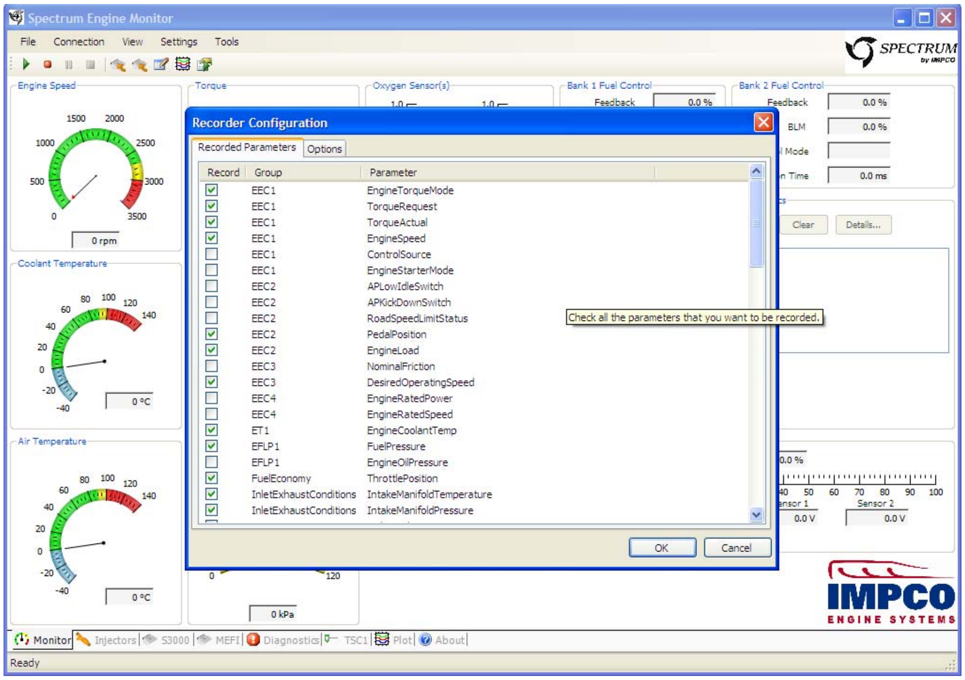
Check/uncheck channel as required. Axis scale and time extent can be adjusted from the Axes tab. To save the custom settings select **OK**.

Record Data:

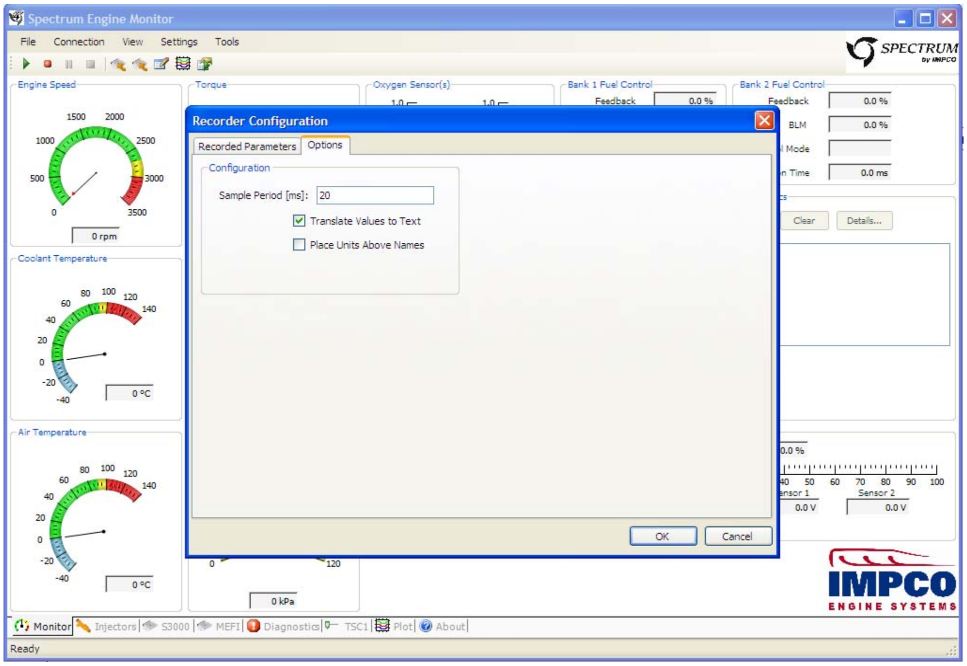


Data stream information may also recorded and saved to file for future analysis. This function is accessed from the **Connection** menu and is activated by clicking **Record,** click again to stop the recording and the save file. The data is saved as a .csv file at a location specified by the service technician. The recording can be interrupted at anytime by using **Pause**.

The custom parameters of the recording can be selected by accessing the **Settings** menu and selecting **Recorder Settings.**

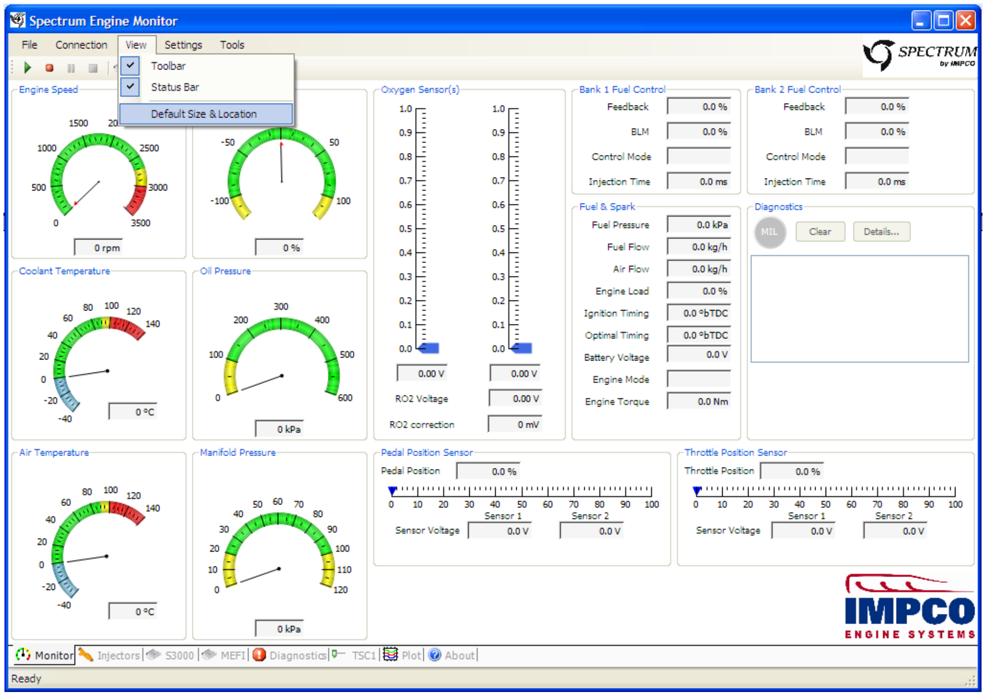


The **Recorder Configuration** windows opens, check/uncheck channels as required.

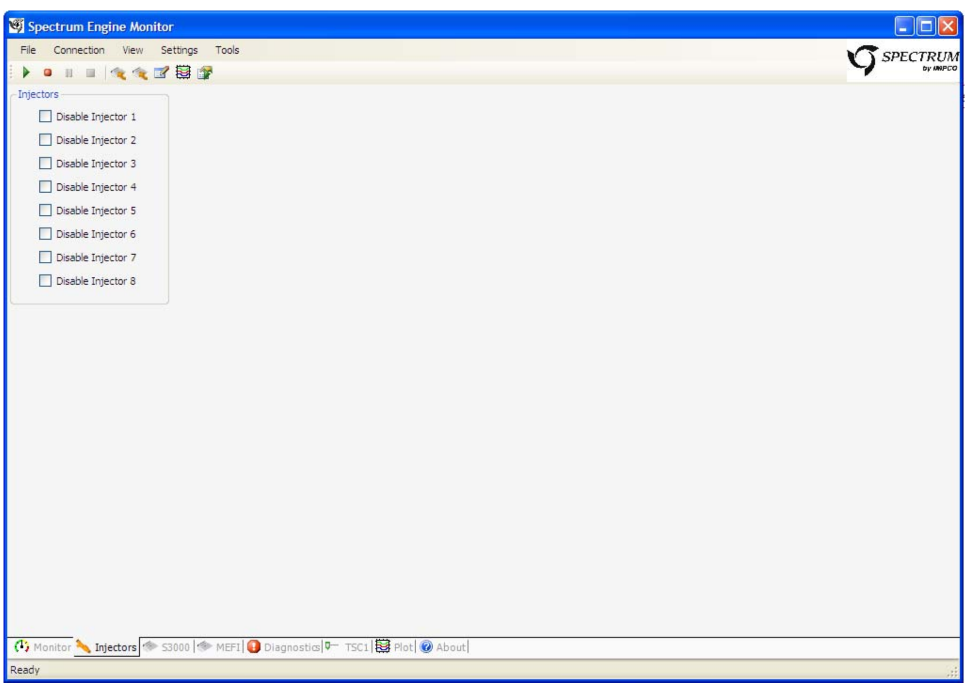


You can change the sample speed from the **Options** tab. To save select **OK.**

Useful Tips:



If the size or location of the DST is changed, for instance, accidentally maximized or resized the default can be restored from the **View** tab and selecting **Default Size & Location.**



Individual injectors can be disabled from the **Injectors** tab. A useful diagnostic tool when trying to identify which cylinder has a misfire. DO NOT RUN ENGINE FOR AN EXTENDED TIME WITH AN INJECTOR DISABLED.

Diagnosing Intermittent Problems

Intermittent fuel system problems can prove to be the most challenging to diagnose. It is of the upmost important when diagnosing intermittent problems to operate the engine system while monitoring with the DST and pressure gauge set. An example of this would be if the DST showed a lean fuel mixture at full load. One of the first things to look at would be the fuel pressure. The fuel pressure would need to be monitored while the engine is operating at full load, not at low or no load because the leaning effect does not occur until full load. Electrical problems should be treated in a similar same way. One excellent tool for finding intermittent electrical problems is the DST plot function. Set up the plot for the sensor code that sets. An example of this would be if an intermittent IAT code set, tag the IAT voltage and watch the plot. While watching the plot, agitate the electrical wire connection at the sensor and ECM connector. The resolution of the plot screen is such that you will be able to see any unstable voltages that you may not see with a standard DVOM.

Caution should be used when pressure washing the under hood of any electrical system. Avoid direct pressure spray on the system electrical connectors. The connectors are splash proof but if high pressure water or steam is sprayed directly at the connector moisture can become trapped behind the connector seal and cause serious system problems, many of them showing up as intermittent. Extra care must be taken when probing electrical pins and terminals. Do not bend or spread these terminals as this can also be a source of intermittent problems cause by improper handling of these low voltage connectors and terminals. When running electrical diagnostics avoid back probing the wire connectors as this may damage the wire seal. When running the continuity checks use a wire probe to only touch the wire terminal. Forcing the electrical probe into the terminal may cause the terminal to spread leading to permanent damage. More Intermittent diagnostic information can be found on the Fuel Symptom Diagnostics, Intermittent Diagnostic Charts.

Fuel System Checks

This system has OBD (Onboard Diagnostics) for many sensors, relays and monitors, but not all malfunctions have a DTC code available to alert the service technician to a problem. A good example of this would be the engine ignition system. If a spark plug, cap, rotor or wire fails a DTC code may not be set. The DST provides advanced diagnostic capabilities, but some items are still left to the basics of general engine mechanics. Following the recommended maintenance schedule is the best way to prevent this type of problem for which a DTC code does not exist. Many times the basics are overlooked and can be attributed to improper maintenance. Some general rules to follow are:

- Check to be sure the ECM is programmed with the latest calibration file
- Check general engine tune up items such as spark plugs, distributor cap and rotor, spark plug wires, air, and fuel filters if equipped with such.
- Check that the charging system is working correctly.
- Check block heaters, battery heaters, battery terminals and fuel supply systems for proper operation.

Fuel Symptom Diagnosis

Minimum and Maximum Recommended Inlet Pressure Specifications

Shown in inches of W.C. (water column) pressure.

The fuel system relies on fuel pressure to the engine systems low pressure regulator to deliver advertised power levels. Be sure the gas supply pressure is maintained to the fuel systems low pressure shutoff valve(s) as shown in the following pages.

Natural Gas maximum at engine OFF no load:	13.85” W.C.
Natural Gas minimum at engine ON full load:	6.0” W.C.
Propane Vapor maximum at engine OFF no load:	13.85” W.C.
Propane Vapor minimum at engine ON full load:	6.0” W.C.

Minimum Flow Specifications

This information may be required by the gas company or installing contractor to determine the line size and length to be sure enough fuel is supplied at the minimum pressure specifications:

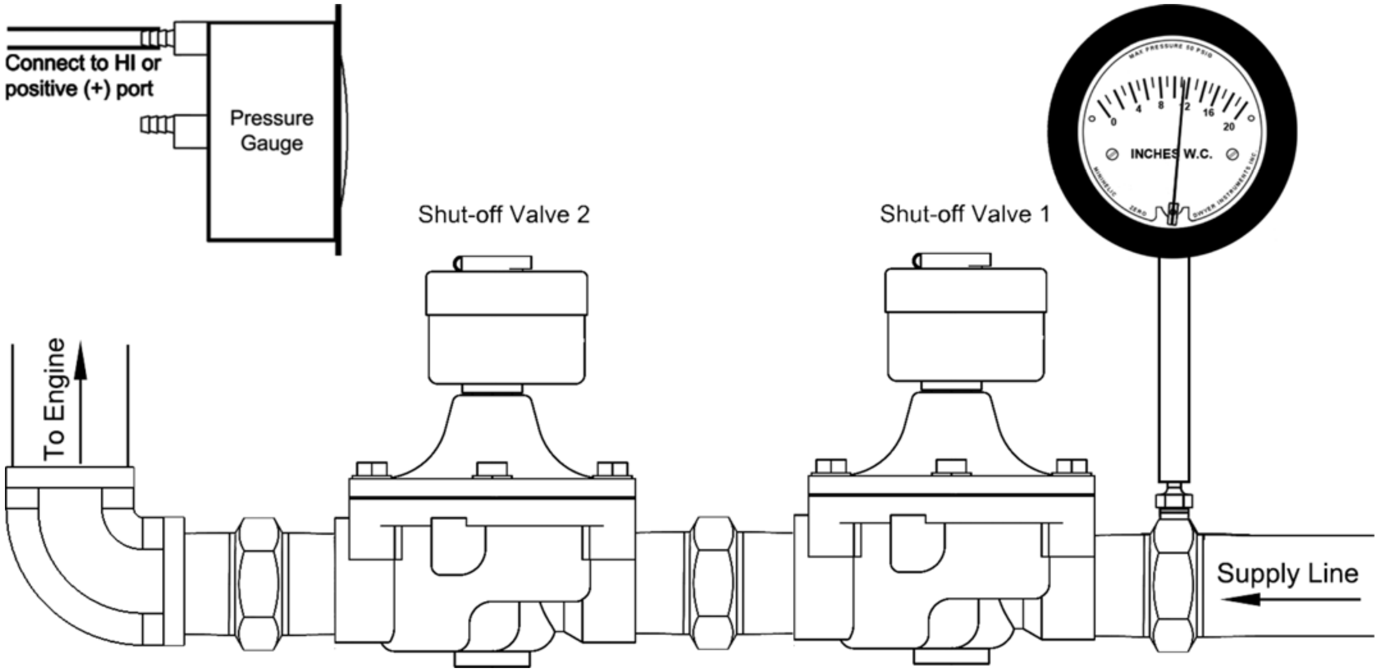
Minimum flow for Natural Gas:	1180 SCFH @ 6.0” W.C.
Minimum flow for Propane Vapor:	520 SCFH @ 6.0” W.C.

Maximum Fuel System Regulator Outlet Pressure

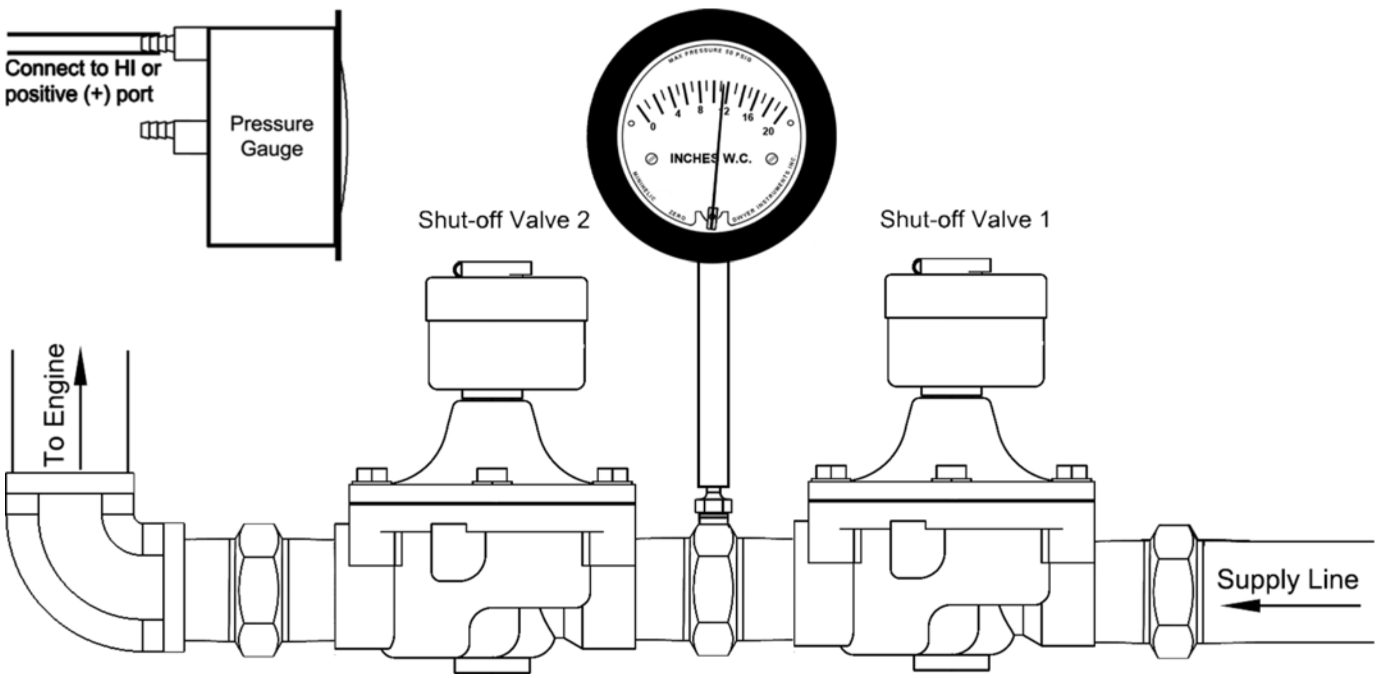
This system uses on a near zero fuel pressure regulator to supply fuel to the intake Mixer and throttle assembly.

Pressure readings taken from the regulator outlet port (see below) with the engine running should show negative pressure. Slightly positive pressures may only be observed during the engine cranking cycle to assist in cold engine starts. Once the engine warms and goes into closed loop fuel control the negative pressure should typically swing between -2.0” W.C. to -6.0” W.C. This is how the rich to lean closed loop control is achieved. By varying the fuel pressure high and low the mixture runs rich to lean transitioning approximately once per second crossing the point of stoichiometry for low exhaust emissions. Any negative pressure over -8.0 inches water indicates inadequate fuel supply to the Mixer causing a lean condition. A lean condition may cause low power output, increased engine temperature, hard starting, and induction backfire. This could be the fault of the fuel system low pressure regulator, but is most likely due to inadequate supply pressure to the fuel system low pressure regulator. Inversely, a constant positive pressure would create a rich condition causing excessive fuel consumption, low power output, increased exhaust temperatures, hard starting and exhaust system backfire. The following diagrams show how to correctly install the fuel pressure gauges to determine if such a problem may exist.

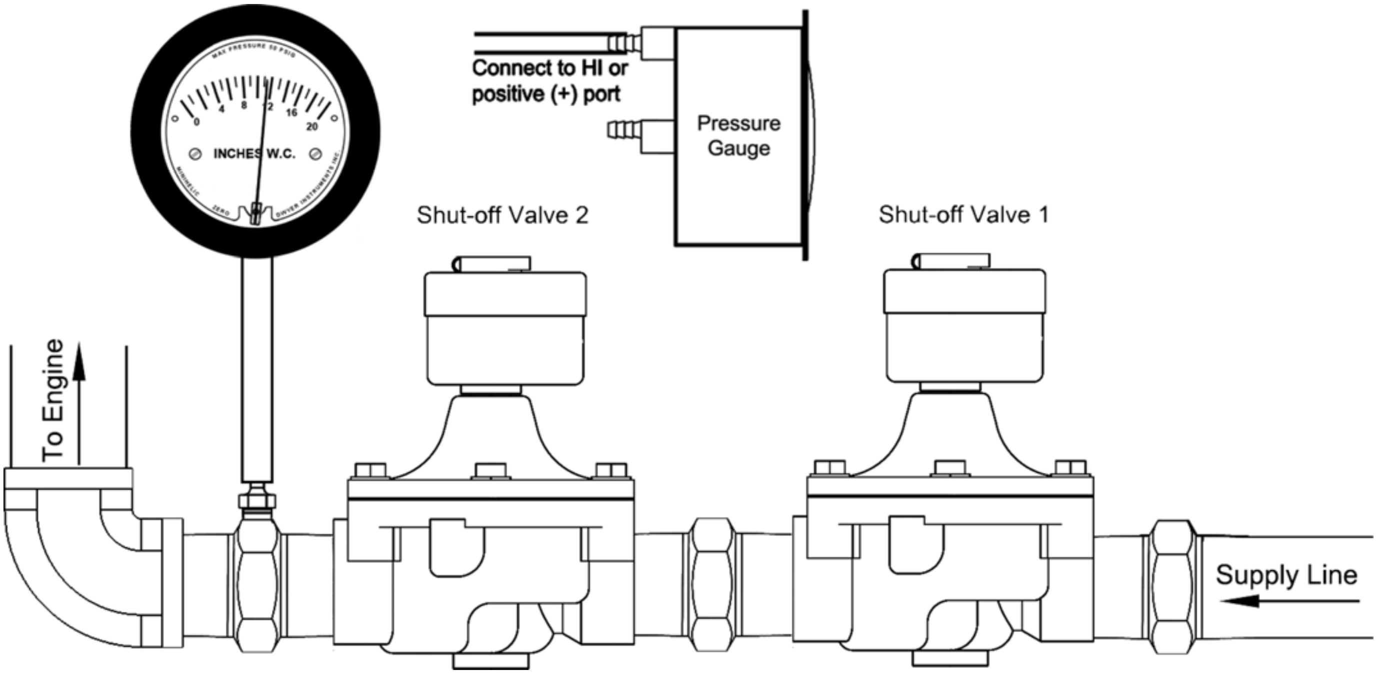
NOTE: Be sure to zero the gauge and/or calibrate it prior to testing, especially after carrying on a plane or using at altitude.



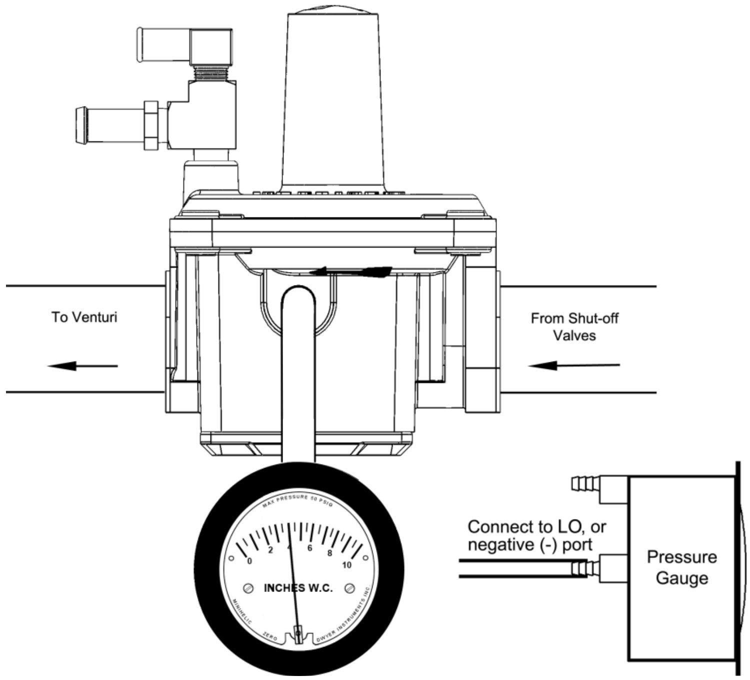
The above illustration shows the 0-20" W.C. gauge installed to measure the supply line fuel pressure (note that the actual lock-offs may differ from those pictured above)



The above illustration shows the 0-20" W.C. gauge installed to measure fuel pressure after the solenoid Shut-off Valve number 1.



The above illustration shows the 0-20" W.C. gauge installed to measure fuel pressure after the solenoid Shut-off Valve number 2 (note that the actual lock-offs may differ from those pictured above).



The above illustration shows the 0-10" W.C. gauge installed to measure the pressure at the regulator outlet.

Fuel System Diagnostic Chart

Use this chart if you were referred to the Fuel System Diagnostics from the DTC section, or have a problem with a running engine. For no start issues use the Symptom Diagnostic Charts shown in the manual.

Step	Action	Value(s)	Yes	No
1	• Turn the Fuel Supply valve on the gas supply line OFF. **CAUTION** Some residual gas pressure may be present. • Install the 0 to 20" water column gauge to the fuel pressure test port at the number one fuel solenoid inlet as shown in the Fuel System Diagnostic section of this manual. **NOTE:** Be sure to zero the gauge and/or calibrate it prior to testing, especially after carrying on a plane or using at altitude. Is the pressure gauge installed properly?		Go to Step (2)	Refer to the pressure gauge illustrated diagram in the Fuel System Diagnostic section of this manual.
2	Install the 0 to 10" water column gauge at the fuel system low pressure regulator outlet test port as shown in the Fuel System Diagnostic section of this manual. Is the pressure gauge installed properly?		Go to Step (3)	Refer to the pressure gauge illustrated diagram in the Fuel System Diagnostic section of this manual.
3	• Slowly turn the Fuel Supply Valve ON • Check the gauge hose and adapter fittings for any gas leakage Are the fittings and hoses secure and tight with no gas leakage?		Go to Step (4)	Correct the leakage problem before proceeding with this diagnostic chart.
4	Observe the 0 to 20" water column gauge installed at the fuel shut off solenoid inlet test port. Is the pressure between +6.0 and +13.85 inches water column pressure?		Go to Step (5)	Correct the improper gas supply pressure. Notify the gas utility company or authorized contactor for assistance.

Step	Action	Value(s)	Yes	No
5	• Start the engine • Run the engine to full operating temperature. If you were directed to this chart from the DTC section run the engine at the same load point where the DTC code was set, if known. Otherwise run the engine to full load. • Observe the 0 to 10" water column gauge. Does the gauge show a pressure reading between 0 and -8.0" water column pressure?		Go to Step (6)	Go to Step (8)
6	• Observe the 0 to 20" water column gauge Does the gauge show a pressure between +6.0 to +13.85 inches water column pressure?		Go to Step (7)	Correct the improper gas supply pressure or low flow problem. Notify the gas utility company or authorized contactor for assistance.
7	Observe the 0 to 10" water column gauge Does the gauge reading swing between 0 and -8.0 inches water column pressure?		Fuel System OK	Go to OBD System Check

Step	Action	Value(s)	Yes	No
8	• Turn the Fuel Supply valve on the gas supply line OFF **CAUTION** Some residual gas pressure may be present. • Remove the 0 to 20" water column gauge from the number one fuel shutoff solenoid inlet pressure test port. • Re-install the test port plug using the recom-mended Loctite thread sealant #567 Is the test port plug securely installed using pipe thread sealant?		Go to Step (9)	-
9	• Install the 0 to 20" water column gauge to the fuel pressure test port between the number one fuel lock solenoid outlet and the number two fuel lock solenoid inlet as shown in the Fuel System Diagnostic section of this manual. • Slowly turn the Fuel Supply valve ON • Check the gauge hose and adapter fittings for any gas leakage, including the previously re-installed test port Are the fittings and hoses secure and tight with no gas leakage?		Go to Step (10)	-
10	• Start the engine. If you were directed to this chart from the DTC section run the engine at the same load point where the DTC code was set, if known. Otherwise run the engine to full load. • Observe the 0 to 20" water column gauge. Does the gauge show a pressure between +6.0 to +13.85 inches water column pressure?		Go to Step (12)	Go to Step (11)
11	• Turn the Fuel Supply Valve on the gas supply line OFF. • Replace the number one fuel lock solenoid Is the replacement complete?		Go to Step (5)	-

Step	Action	Value(s)	Yes	No
12	• Turn the Fuel Supply valve on the gas supply line OFF **CAUTION** Some residual gas pressure may be present. • Remove the 0 to 20” water column gauge between the number one and number two fuel shutoff solenoids. • Re-install the test port plug using the recommended Loctite thread sealant #567 Is the test port plug securely installed using pipe thread sealant?		Go to Step (13)	-
13	• Install the 0 to 20” water column gauge to the fuel pressure test port at the outlet of the number two fuel lock solenoid as shown in the Fuel System Diagnostic section of this manual. • Slowly turn the Fuel Supply valve ON • Check the gauge hose and adapter fittings for any gas leakage, including the previously re-installed test port Are the fittings and hoses secure and tight with no gas leakage?		Go to Step (14)	-
14	• Start the engine. If you were directed to this chart from the DTC section run the engine at the same load point where the DTC code was set, if known. Otherwise run the engine to full load. • Observe the 0 to 20” water column gauge Does the gauge show a pressure between +6.0 to +13.85 inches water column?		Go to Step (16)	Go to Step (15)
15	• Turn the Fuel Supply valve on the gas supply line OFF. • Replace the number two fuel lock solenoid Is the replacement complete?		Go to Step (5)	-
16	Replace the fuel system low pressure regulator. Is the replacement complete?		Go to Step (5)	-

Fuel Symptom Diagnostics

FUEL SYMPTOM DIAGNOSTICS

Checks	Action
Before Using This Section	Before using this section, you should have performed On Board Diagnostic (OBD) Check and determined that: 1. The ECM and MIL are operating correctly. 2. There are no Diagnostic Trouble Codes (DTCs) stored, or a DTC exists but without a MIL. Several of the following symptom procedures call for a careful visual and physical check. These checks are very important as they can lead to prompt diagnosis and correction of a problem.
Fuel System Check	1. Verify the customer complaint. 2. Locate the correct symptom table. 3. Check the items indicated under that symptom. 4. Operate the engine under the conditions the symptom occurs. Verify HEGO switching between lean and rich (cycling of voltage). **IMPORTANT! Normal HEGO switching indicates the fuel system is in closed loop and operating correctly at that time.** 5. Take a data snapshot using the DST under the condition that the symptom occurs to review at a later time.
Visual and Physical Checks	• Check all ECM system fuses and circuit breakers. • Check the ECM ground for being clean, tight and in its proper location. • Check the vacuum hoses for splits, kinks and proper connections. • Check thoroughly for any type of leak or restriction. • Check for air leaks at all the mounting areas of the intake manifold sealing surfaces. • Check for proper installation and leakage around the Regulator, Mixer and Throttle body. Check the ignition wires for the following conditions: • Cracking • Hardening • Proper routing • Carbon tracking • Check the wiring for the following items: proper connections, pinches or cuts. • The following symptom tables contain groups of possible causes for each symptom. The order of these procedures is not important. If the DST readings do not indicate a problem, then proceed in a logical order, easiest to check or most likely to cause the problem.

INTERMITTENT

<table>
<tr><th>Checks</th><th>Action</th></tr>
<tr><td colspan="2">DEFINITION: The problem may or may not turn ON the (MIL) or store a Diagnostic Trouble Code (DTC).</td></tr>
<tr><td>Preliminary Checks</td><td>Do not use the DTC table if a fault is an intermittent, the use of the DTC tables with this condition may result in the replacement of good parts.</td></tr>
<tr><td>Faulty Electrical Connections or Wiring</td><td>Faulty electrical connections or wiring can cause most intermittent problems. Check the suspected circuit for the following conditions:

• Faulty fuse or circuit breaker, connectors poorly mated, terminals not fully seated in the connector (backed out). Terminals not properly formed or damaged.
• Wire terminals poorly connected.
• Terminal tension is insufficient.
• Carefully remove all the connector terminals in the problem circuit in order to ensure the proper contact tension.
• If necessary, replace all the connector terminals in the problem circuit in order to ensure the proper contact tension (except those noted as “Not Serviceable”). See section Wiring Schematics.
• Checking for poor terminal to wire connections requires removing the terminal from the connector body.</td></tr>
<tr><td>Operational Test</td><td>If a visual and physical check does not locate the cause of the problem, operate the engine with the DST connected. When the problem occurs, an abnormal voltage or scan reading indicates a problem circuit.</td></tr>
<tr><td>Intermittent MIL Illumination</td><td>The following components can cause intermittent MIL and no DTC(s):

• A defective relay.
• Switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating.
• The improper installation of add on electrical devices, such as lights, 2-way radios, electric motors, etc.
• The ignition secondary voltage shorted to a ground.
• The MIL circuit or the Diagnostic Test Terminal intermittently shorted to ground.
• The MIL wire grounds.</td></tr>
<tr><td>Loss of DTC Memory</td><td>To check for the loss of the DTC Memory:

1. Disconnect the TMAP sensor.
2. Run engine under no load until the MIL illuminates.
3. The ECM should store a TMAP DTC which should remain in the memory when the ignition is turned OFF. If the TMAP DTC does not store and remain, the ECM is faulty.</td></tr>
</table>

NO START

Checks	Action
DEFINITION: *The engine cranks OK but does not start.*	
Preliminary Checks	None
ECM Checks	Use the DST to : • Check for proper communication with both the ECM • Check all system fuses engine fuse holder. Refer to *Engine Controls Schematics.* • Check battery power, ignition power and ground circuits to the ECM. Refer to *Engine Control Schematics.* Verify voltage and/or continuity for each.
Sensor Checks	• Check the TMAP sensor. • Check the cam/crank sensors for output (rpm). This can be verified by an RPM signal on the DST.
Fuel System Checks	**Important**: A closed Gas supply valve will create a no start condition. • Verify proper operation of the Shut-off solenoid Valves. • Check for air intake system leakage around the Regulator, Mixer and throttle body. • Check the fuel system pressures. • Refer to the *Fuel System Diagnosis*.
Ignition System Checks	Note: Natural Gas and Propane require higher secondary ignition system voltages for the equivalent gasoline operating conditions. 1. Check for the proper ignition voltage output with *J 26792* or the equivalent. 2. Verify that the spark plugs are correct. Check the spark plugs for the following conditions: • Wet plugs (Oil Fouling) • Cracks. • Wear. • Improper gap. • Burned electrodes. • Heavy deposits. • Check for bare or shorted ignition wires. • Check for loose ignition coil connections at the coil.

Checks	Action
Engine Mechanical Checks	Check for the following: • Manifold vacuum leaks. • Mixer vacuum leaks. • Engine Vacuum leaks. • Improper valve timing. • Low compression. • Improper valve clearance. • Worn rocker arms. • Broken or weak valve springs. • Worn camshaft lobes.
Exhaust System Checks	Check the exhaust system for a possible restriction: • Inspect the exhaust system for damaged or collapsed pipes. • Inspect the muffler for signs of heat distress or for possible internal failure.

HARD START

<table>
<tr><th>Checks</th><th>Action</th></tr>
<tr><td colspan="2">DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.</td></tr>
<tr><td>Preliminary Checks</td><td>Make sure the engine’s operator is using the correct starting procedure.</td></tr>
<tr><td>Sensor Checks</td><td>Check the Engine Coolant Temperature sensor with the DST. Compare the engine coolant temperature with the ambient air temperature on a cold engine. If the coolant temperature reading is more than 10 degrees greater or less than the ambient air temperature on a cold engine, check for high resistance in the coolant sensor circuit. Check the cam/crank sensors.
Check the electronic throttle connections.</td></tr>
<tr><td>Fuel System Checks</td><td>Important: A partially closed fuel supply valve will create an extended crank OR no start condition.

Check Mixer assembly for proper installation and leakage.
Verify proper operation of the Shut-off solenoid Valves.
Verify proper operation of the system low pressure Regulator.
Check for air intake system leakage between the Mixer, Throttle Body and Air Filter Assembly. Check the fuel system pressures. Refer to the Fuel System Diagnosis.</td></tr>
<tr><td>Ignition System Checks</td><td>Note: Natural Gas and Propane require higher secondary ignition system voltages for the equivalent gasoline operating conditions.
Check for the proper ignition voltage output with J 26792 tool or the equivalent.
Verify that the spark plugs are the correct type and properly gapped.
Check the spark plugs for the following conditions:
Wet plugs (oil fouling).
Cracks.
Wear.
Burned electrodes.
Heavy deposits.
Check for bare or shorted ignition wires.
Check for moisture in the distributor cap.
Check for loose ignition coil connections.
Important:
If the engine starts but then immediately stalls, check the cam/crank sensor.
Check for improper gap, debris or faulty connections.</td></tr>
</table>

Checks	Action
Engine Mechanical Checks	Check for the following: • Engine vacuum leaks • Manifold vacuum leaks. • Mixer Vacuum Leaks • Improper valve timing • Low compression • Improper valve clearance. • Worn rocker arms • Broken or weak valve springs • Worn camshaft lobes.
Exhaust System Checks	Check the exhaust system for a possible restriction: • Inspect the exhaust system for damaged or collapsed pipes. • Inspect the muffler for signs of heat distress or for possible internal failure.

CUTS OUT, MISSES

Checks	Action
***DEFINITION**: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases, but normally felt below 1500 rpm. The exhaust has a steady spitting sound at low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.*	
Preliminary Checks	None
Ignition System Checks	1. Start the engine. 2. Check for proper ignition output voltage with spark tester J 26792. 3. Check for a cylinder misfire. 4. Verify that the spark plugs are the correct type and properly gapped. Remove the spark plugs and check for the following conditions: • Insulation cracks. • Wear. • Improper gap. • Burned electrodes. • Heavy deposits. Visually/Physically inspect the secondary ignition for the following: • Ignition wires for arcing and proper routing. • Cross-firing. • Ignition coils for cracks or carbon tracking.
Engine Mechanical Checks	Perform a cylinder compression check. Check the engine for the following: • Improper valve timing. • Improper valve clearance. • Worn rocker arms. • Worn camshaft lobes. • Broken or weak valve springs. • Check the intake and exhaust manifold passages for casting flash.
Fuel System Checks	Check the fuel system: • Plugged fuel filter (if equipped). • Low fuel pressure, etc. Refer to *Fuel System Diagnosis*. • Check the condition of the wiring to the Shut-off Valves.
Additional Check	Check for Electromagnetic Interference (EMI), which may cause a misfire condition. Using the DST, monitor the engine rpm and note sudden increases in rpm displayed on the scan tool but with little change in the actual engine rpm. If this condition exists, EMI may be present. Check the routing of the secondary wires and the ground circuit.

HESITATION, SAG, STUMBLE

Checks	Action
DEFINITION: *The engine has a momentary lack of response when accelerating the engine. The condition can occur at any engine speed. The condition may cause the engine to stall if it's severe enough.*	
Preliminary Checks	None.
Fuel System Checks	• Check the fuel pressure. Refer to *Fuel System Diagnosis*. • Check for low fuel pressure during a moderate or full throttle acceleration. If the fuel pressure drops below specification, there is possibly a faulty low pressure regulator or a restriction in the fuel system. • Check the TMAP sensor response and accuracy. • Check Shut-Off electrical connections. • Check the Regulator, Mixer and Throttle body for proper installation and leakage.
Ignition System Checks	Note: Natural Gas and Propane require higher secondary ignition system voltages for the equivalent gasoline operating conditions. • Check for the proper ignition voltage output with *J 26792* or the equivalent. Verify that the spark plugs are the correct type and properly gapped. • Check for faulty spark plug wires. • Check for oil fouled spark plugs.
Additional Check	• Check for manifold vacuum or air induction system leaks. • Check the alternator output voltage.

BACKFIRE

<table>
<tr><th>Checks</th><th>Action</th></tr>
<tr><td colspan="2">DEFINITION: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.</td></tr>
<tr><td>Preliminary Check</td><td>None.</td></tr>
<tr><td>Ignition System Checks</td><td>Note: Natural Gas and Propane require higher secondary ignition system voltages for the equivalent gasoline operating conditions.

• Check for the proper ignition coil output voltage using the spark tester J26792 or the equivalent.
• Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires.
• Check the connection at ignition coil.
• Check for deteriorated spark plug wire insulation.

Remove the plugs and inspect them for the following conditions:

• Wet plugs (oil fouling).
• Cracks.
• Wear.
• Improper gap.
• Burned electrodes.
• Heavy deposits.</td></tr>
<tr><td>Engine Mechanical Check</td><td>Check the engine for the following:

• Improper valve timing.
• Engine compression.
• Manifold vacuum leaks.
• Intake manifold gaskets.
• Sticking or leaking valves.
• Exhaust system leakage.</td></tr>
<tr><td>Fuel System Checks</td><td>Perform a fuel system diagnosis. Refer to Fuel System Diagnosis.</td></tr>
</table>

LACK OF POWER, SLUGGISHNESS, OR SPONGINESS

<table>
<tr><th>Checks</th><th>Action</th></tr>
<tr><td colspan="2">DEFINITION: The engine delivers less than expected power. There is little or no increase in speed when throttling the engine.</td></tr>
<tr><td>Preliminary Checks</td><td>• Refer to the Fuel system OBD System Check.
• Compare the customer’s engine with a similar unit to verify customer has an actual problem. Do not compare the power output of the engine operating on Natural Gas and Propane to one operating on gasoline as the fuels do have different performance characteristics.
• Remove the air filter and check for dirt or restriction.</td></tr>
<tr><td>Fuel System Checks</td><td>• Check for contaminated fuel, or improper fuel pressure. Refer to Fuel System Diagnosis.
• Check for the proper ignition output voltage with the spark tester J 26792 or the equivalent.
• Check the Regulator, Mixer and Throttle body for proper installation and leakage. Check all air inlet ducts for condition and proper installation.
• Check for fuel leaks in supply lines.
• Verify that the Fuel Supply Valve on the supply line is open.</td></tr>
<tr><td>Sensor Checks</td><td>• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the TMAP sensor.</td></tr>
<tr><td>Exhaust System Checks</td><td>Check the exhaust system for a possible restriction:

• Inspect the exhaust system for damaged or collapsed pipes.
• Inspect the muffler for signs of heat distress or for possible internal failure.</td></tr>
<tr><td>Engine Mechanical Check</td><td>Check the engine for the following:

• Engine compression.
• Valve timing.
• Improper or worn camshaft.
• Refer to Engine Mechanical in the Service Manual.</td></tr>
<tr><td>Additional Check</td><td>• Check the ECM grounds for being clean, tight, and in their proper locations.
• Check the alternator output voltage.

If all procedures have been completed and no malfunction has been found, review and inspect the following items:

• Visually and physically, inspect all electrical connections within the suspected circuit and/or systems.
• Check the DST data.</td></tr>
</table>

POOR FUEL ECONOMY

Checks	Action
DEFINITION: *Fuel economy, as measured by refueling records, is noticeably lower than expected. Also, the economy is noticeably lower than it was on this engine at one time, as previously shown by refueling records.*	
Preliminary Checks	• Check the air cleaner element (filter) for dirt or being plugged. • Visually check the vacuum hoses for splits, kinks, and proper connections.
Fuel System Checks	• Check the Regulator fuel pressure. Refer to *Fuel System Diagnosis*. • Check the fuel system for leakage.
Sensor Checks	• Check the TMAP sensor.
Ignition System Checks	Verify that the spark plugs are the correct type and properly gapped. Remove the plugs and inspect them for the following conditions: • Wet plugs (oil fouling). • Cracks. • Wear. • Improper gap. • Burned electrodes. • Heavy deposits. Check the ignition wires for the following items: • Cracking. • Hardness. • Proper connections.
Cooling System Checks	Check the engine thermostat to see if it is stuck open or for the wrong heat range.

ROUGH, UNSTABLE, OR INCORRECT ENGINE SPEED, STALLING

<table>
<tr><th>Checks</th><th>Action</th></tr>
<tr><td colspan="2">DEFINITION: The engine runs unevenly at under no load. If severe enough, the engine may shake. The engine speed may vary in rpm. Either condition may be severe enough to stall the engine.</td></tr>
<tr><td>Preliminary Check</td><td>None.</td></tr>
<tr><td>Sensor Checks</td><td>Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance:

• Check for silicone contamination from fuel or improperly used sealant. If contaminated, the sensor may have a white powdery coating result in a high but false signal voltage (rich exhaust indication). The ECM will reduce the amount of fuel delivered to the engine causing a severe performance problem.

Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.</td></tr>
<tr><td>Fuel System Checks</td><td>• Check for rich or lean symptom that causes the condition.
• Run the engine at the speed of the complaint.
• Monitoring the oxygen sensor will help identify the problem.
• Verify proper operation of the Regulator.
• Perform a cylinder compression test. Refer to Engine Mechanical in the Service Manual.
• Check the Regulator fuel pressure. Refer to the Fuel System Diagnosis.
• Check the Regulator, Mixer and Throttle body for proper installation and leakage.</td></tr>
<tr><td>Ignition System Checks</td><td>• Check for the proper ignition output voltage using the spark tester J26792 or the equivalent.
• Verify that the spark plugs are the correct type and properly gapped.

Remove the plugs and inspect them for the following conditions:

• Wet plugs (oil fouling).
• Cracks.
• Wear.
• Improper gap.
• Burned electrodes.
• Blistered insulators.
• Heavy deposits.

Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires.</td></tr>
<tr><td>Additional Checks</td><td>• Check for vacuum leaks. Vacuum leaks can cause poor engine performance.
• Check the ECM grounds for being clean, tight, and in their proper locations. Check the battery cables and ground straps. They should be clean and secure. Erratic voltage may cause all sensor readings to be skewed resulting in poor engine performance.</td></tr>
</table>

Checks	Action
Engine Mechanical Check	Check the engine for: • Broken motor mounts. • Improper valve timing. • Low compression. • Improper valve clearance. • Worn rocker arms. • Broken or weak valve springs. • Worn camshaft lobes.

SURGES/CHUGGLES

Checks	Action
DEFINITION: *The engine has a power variation under a steady throttle. The engine feels as if it speeds up and slows down with no change to the throttle.*	
Preliminary Checks	None.
Sensor Checks	Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance.
Fuel System Checks	• Check for Rich or Lean symptom that causes the condition. • Run the engine at the speed of the complaint. Monitoring the oxygen sensor will help identify the problem. • Check the fuel pressure while the condition exists. Refer to *Fuel System Diagnosis.* • Verify proper fuel control Shut-off Valve operation. • Verify that the Fuel Supply Valve on the Gas Supply line is fully open.
Ignition System Checks	• Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. • Verify that the spark plugs are the correct type and properly gapped. Remove the plugs and inspect them for the following conditions: • Wet plugs (oil fouling). • Cracks. • Wear. • Improper gap. • Burned electrodes. • Heavy deposits. Check the Crankshaft Position (CKP) sensor.
Additional Check	• Check the ECM grounds for being clean, tight, and in their proper locations. • Check the alternator output voltage. • Check the vacuum hoses for kinks or leaks.

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS
RESULTS OF INCORRECT OPERATION

A plugged positive crankcase ventilation (PCV) orifice or hose may cause the following conditions:

- Rough or unstable engine speed
- Stalling
- Oil leaks
- Oil in the air cleaner
- Sludge in the engine

A leaking PCV orifice or hose may cause the following problems:

- Rough or unstable engine speed.
- Stalling

Functional check:

Any blow-by in excess of the system capacity, from a badly worn engine, sustained heavy load, etc., is exhausted into the air cleaner and is drawn back into the engine.

Proper operation of the crankcase ventilation system depends on a sealed engine. If irregular oil flow or dilution is noted and the crankcase ventilation system is functioning properly, check the engine for another possible cause. Correct any of these problems first.

If an engine is running rough, inspect for a clogged PCV orifice, a dirty vent filter, air cleaner element, or plugged hose. Replace any faulty items found. Use the following procedure:

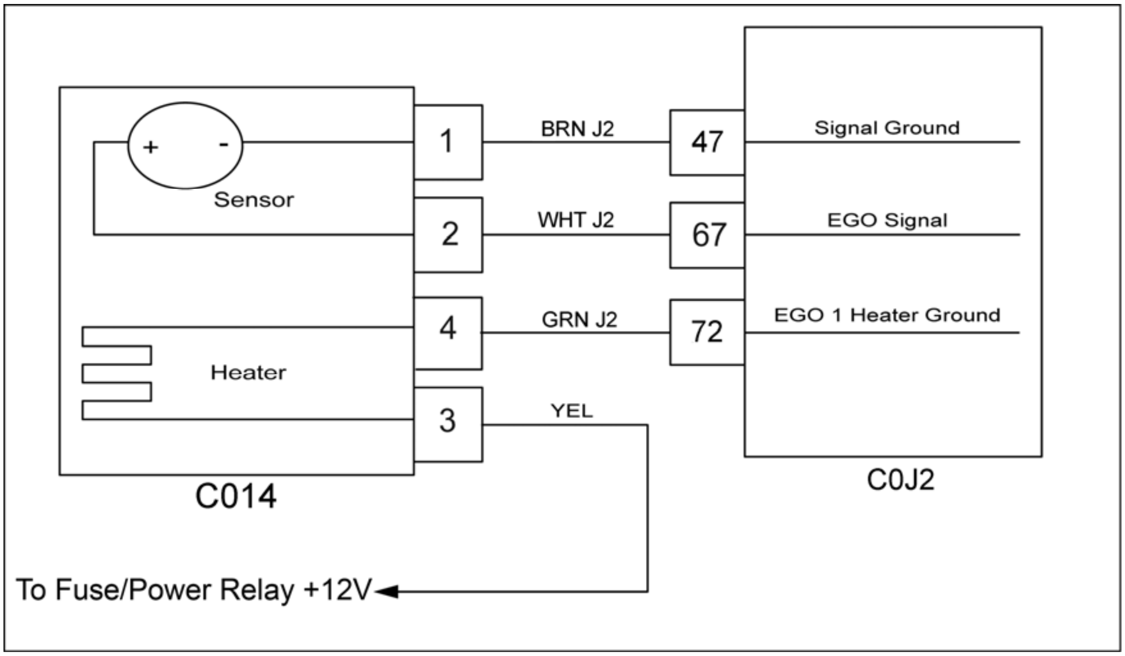
- Remove the PCV hose (positive side) from the rocker arm cover.
- Operate the engine at no load.
- Place your thumb over the end of the hose in order to check for vacuum. If there is no vacuum at the hose end, inspect for the following items:

  - Plugged hoses
  - The manifold vacuum port

- Turn the engine OFF.
- Inspect the PCV orifice in the valve cover for debris or blockage.

Diagnostic Trouble Codes (DTCs)

DTC P0031 Oxygen Sensor Heater Short Low/Open



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition-Ignition ON
- Fault Condition-Less than 30mv
- MIL-On

Circuit Description

The EGO sensor (Exhaust Gas Oxygen) sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The EGO sensor uses an internal heating element to keep the sensor active. This fault will set if the ECM detects a short low or open in the HEGO heater element or control circuit.

Diagnostic Aid

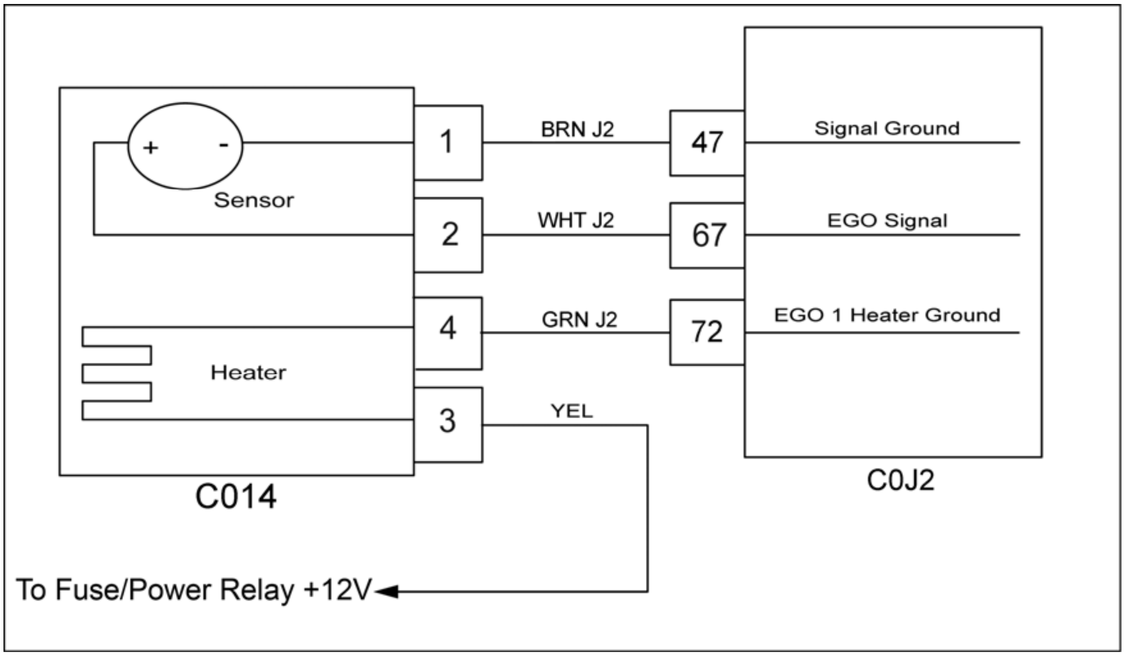
SPN 66019
FMI 5

DTC P0031 Oxygen Sensor Heater Short Low/Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition OFF • Disconnect HEGO connector C014 • Ignition ON • Using a DVOM check for voltage between EGO connector pins 3 and 4 Does the DVOM show voltage?	System Battery Voltage	Go to Step (8)	Go To Step (3)
3	• Ignition ON • Using a DVOM check for voltage between HEGO connector pin 3 and engine ground Do you have voltage?	System Battery Voltage	Repair open HEGO heater supply circuit from power relay. See wire harness repair.	Go to Step (4)
4	• Using a DVOM check for voltage between HEGO connector pin 4 and battery positive • Ignition ON Do you have voltage?		Repair open HEGO ground circuit. See wire harness repair.	Go to Step (5)
5	• Ignition OFF • Disconnect connector C0J2 • Using a DVOM check for continuity between connector pin 72 and HEGO connector pin 4 Does the DVOM show continuity?		Go to Step (6)	Repair the open HEGO heater ground. See wire harness repair.
6	• Ignition ON • Using a DVOM check for voltage between HEGO connector pin 4 and battery positive Does the DVOM show voltage?		Repair the HEGO heater ground shorted to voltage. See wire harness Repair.	Go to Step (7)
7	• Replace ECM Is the replacement complete?		Go to Step (10)	-

Step	Action	Value(s)	Yes	No
8	Using a DVOM measure the resistance of the HEGO heater (sensor side) between pins 3 and 4. Does the DVOM show a resistance value greater than 25 Ohms?	Greater than 25 Ohms	Go to Step (9)	Go to Step (5)
9	Replace the HEGO sensor Is the replacement complete?		Go to Step (10)	-
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0031 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0032 Oxygen Sensor Heater Short High



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition-Ignition ON
- Fault Condition-Greater than system voltage for five seconds
- MIL-On

Circuit Description

The EGO sensor (Exhaust Gas Oxygen) sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The EGO sensor uses an internal heating element to keep the sensor active. This fault will set if the ECM detects a short high in the HEGO heater element or control circuit.

Diagnostic Aid

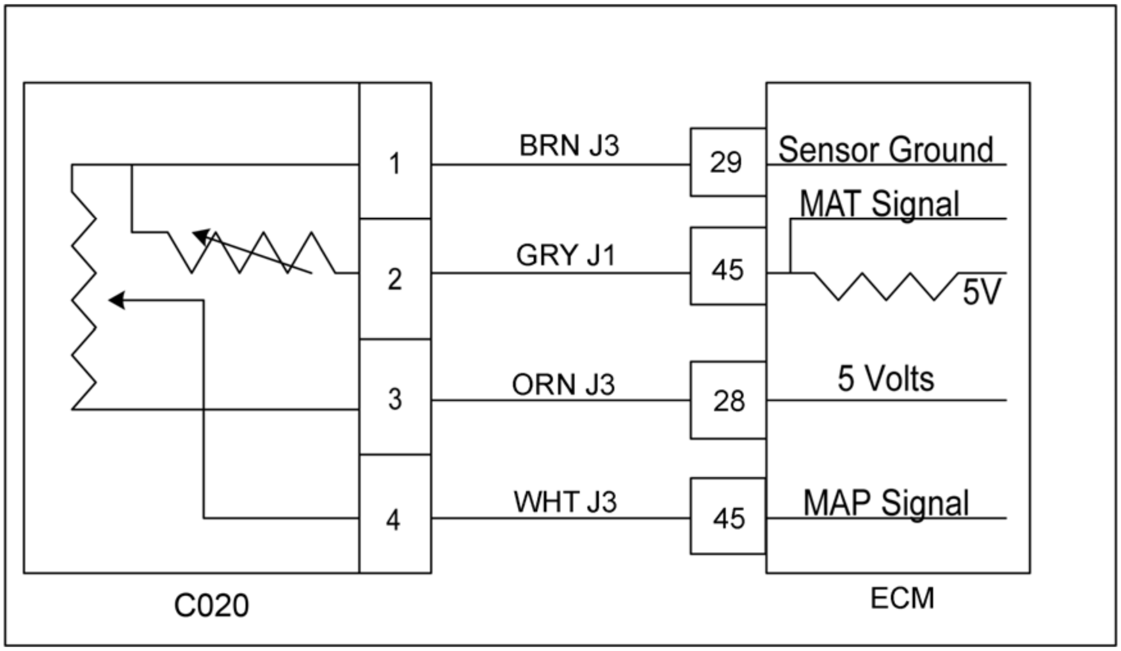
SPN 66019
FMI 3

DTC P0032 Oxygen Sensor Heater Short High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition OFF • Disconnect HEGO connector C014 • Ignition ON • Using a DVOM check for voltage between EGO connector pins 3 and 4 Does the DVOM show voltage?	System Battery Voltage	Go to Step (8)	Go To Step (3)
3	• Ignition ON • Using a DVOM check for voltage between HEGO connector pin 3 and engine ground Do you have voltage?	System Battery Voltage	Repair open HEGO heater supply circuit from power relay. See wire harness repair.	Go to Step (4)
4	• Using a DVOM check for voltage between HEGO connector pin 4 and battery positive • Ignition ON Do you have voltage?		Repair open HEGO ground circuit. See wire harness repair.	Go to Step (5)
5	• Ignition OFF • Disconnect ECM connector C0J2 • Using a DVOM check for continuity between ECM connector pin 72 and HEGO connector pin 4 Does the DVOM show continuity?		Go to Step (6)	Repair the open HEGO heater ground. See wire harness repair.
6	• Ignition ON • Using a DVOM check for voltage between HEGO connector pin 4 and battery positive Does the DVOM show voltage?		Repair the HEGO heater ground shorted to voltage. See wire harness Repair.	Go to Step (7)
7	Replace ECM Is the replacement complete?		Go to Step (10)	-

Step	Action	Value(s)	Yes	No
8	• Using a DVOM measure the resistance of the HEGO heater (sensor side) between pins 3 and 4 (the two white wires). Does the DVOM show a resistance value of less than 5 Ohms?	Greater than 5 Ohms	Go to Step (9)	Go to Step (5)
9	Replace the HEGO sensor Is the replacement complete?		Go to Step (10)	-
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0032 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0105 MAP Sensor Skewed Low



Conditions for Setting the DTC

- MAP Sensor
- Check Condition-Engine running
- Fault Condition-MAP less than 10 Kpa, RPM less than 2800 and TPS greater than 10%.
- MIL-On during active fault

Circuit Description

The MAP (Manifold Absolute Pressure) sensor is a pressure transducer connected to the intake manifold. It is used to measure the manifold pressure. This system incorporates a TMAP (Temperature Manifold Absolute Pressure) sensor that also measures temperature in the intake manifold prior to induction. This diagnostic indicates a possible problem in the MAP portion of the sensor. The pressure and temperature readings are used in conjunction with other inputs to estimate the airflow requirement of the engine. This fault will set if the MAP value is excessively skewed low.

Diagnostic Aid

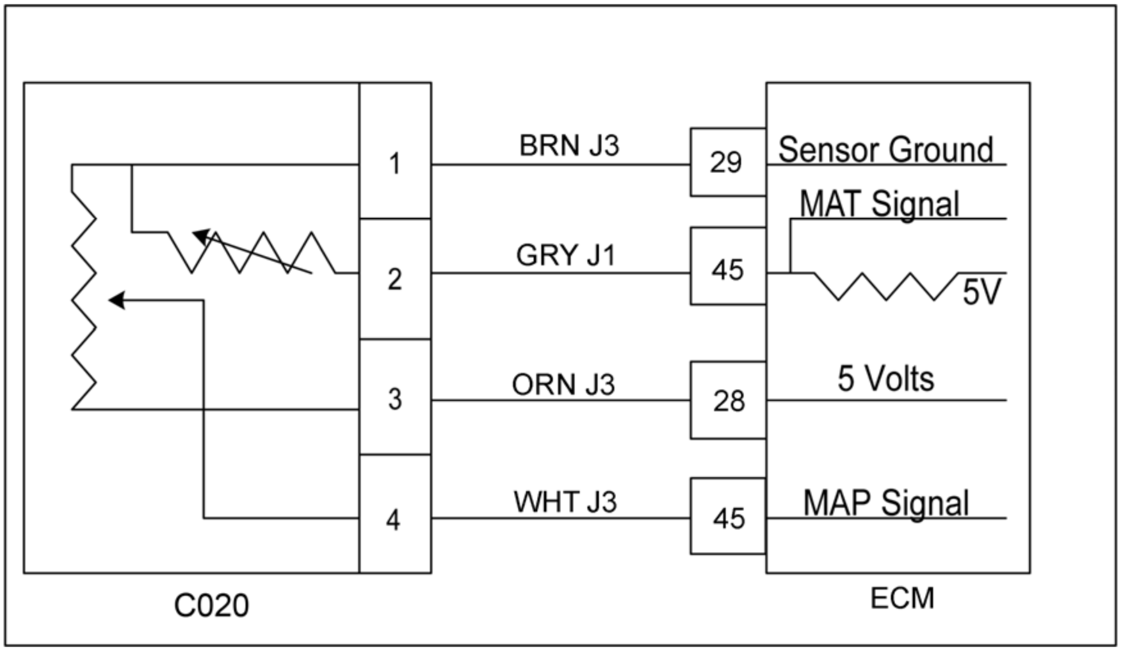
SPN 106
FMI 1
MAP sensors are known to drift or “skew” with age. Small vacuum leaks may also cause this code to set. Check the intake manifold and MAP sensor vacuum seal for leakage before using this diagnostic chart.

DTC P0105 MAP Sensor Skewed Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON, Engine OFF • DST (Diagnostic Scan Tool) connected in the data stream mode. • Clear DTC P0105 • Ignition OFF • Ignition ON Does DTC P0105 re-set?		Go to Step (3)	Intermittent problem Go to Intermit-tent section
3	• Ignition OFF • Disconnect ECM connector C0J3 • Disconnect TMAP connector C020 • Using a DVOM check for continuity between TMAP connector pin1 and ECM connector pin 29 Do you have continuity between them?		Go to Step (4)	Repair the open ground circuit as ne-cessary. Refer to Wiring Re-pairs in Engine Elec-trical.
4	• Using a DVOM check for continuity between TMAP connector pins 3 and 4 Do you have continuity between them?		Repair the shorted signal to 5 volt circuit as necessary. Refer to Wiring Repairs in En-gine Electrical.	Go to Step (5)
5	• Using a DVOM check for continuity between TMAP connector pin 4 and battery positive Do you have continuity between them?		Repair the shorted signal to battery vol-tage circuit as necessary. Refer to Wiring Repairs in En-gine Electrical.	Go to Step (6)
6	• Inspect the throttle connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the cir-cuit as necessary. Refer to Wiring Repairs in En-gine Electrical.	Go to Step (7)
7	• Replace the TMAP sensor Is the replacement complete?		Go to Step (9)	-
8	• Replace the ECM Is the replacement complete?		Go to Step (10)	-

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate to full operating temperature • Observe the MIL • Observe engine performance. Does the engine operate normally with no stored codes?		System OK	Go to Step (8)
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate to full operating temperature • Observe the MIL • Observe engine performance. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0106 MAP Sensor Skewed High



Conditions for Setting the DTC

- MAP Sensor
- Check Condition-Engine running
- Fault Condition-MAP above 99 Kpa with rpm greater than 1000 with TPS less than 87%.
- MIL-On during active fault

Circuit Description

The MAP (Manifold Absolute Pressure) sensor is a pressure transducer connected to the intake manifold. It is used to measure the manifold pressure. This system incorporates a TMAP (Temperature Manifold Absolute Pressure) sensor that also measures temperature in the intake manifold prior to induction. This diagnostic indicates a possible problem in the MAP portion of the sensor. The pressure and temperature readings are used in conjunction with other inputs to estimate the airflow requirement of the engine. This fault will set if the MAP value is excessively skewed high.

Diagnostic Aid

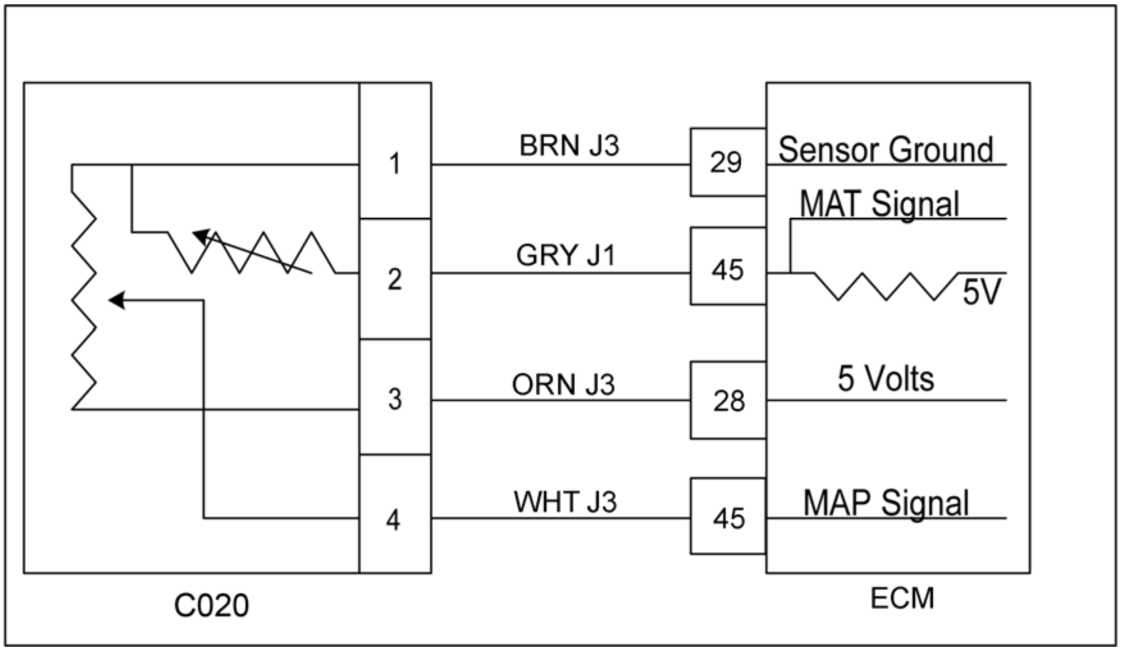
SPN 106
FMI 0
MAP sensors are known to drift or “skew” with age. Small vacuum leaks may also cause this code to set. Check the intake manifold and MAP sensor vacuum seal for leakage before using this diagnostic chart.

DTC P0106 MAP Sensor Skewed High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON, Engine OFF • DST (Diagnostic Scan Tool) connected in the data stream mode. • Clear DTC P0106 • Ignition OFF • Ignition ON Does DTC P0106 re-set?		Go to Step (3)	Intermittent problem Go to Intermit-tent section
3	• Ignition OFF • Disconnect ECM connector C0J3 • Disconnect TMAP connector C020 • Using a DVOM check for continuity between TMAP connector pin1 and ECM connector pin 29 Do you have continuity between them?		Go to Step (4)	Repair the open ground circuit as ne-cessary. Refer to Wiring Re-pairs in Engine Elec-trical.
4	• Using a DVOM check for continuity between TMAP connector pins 3 and 4 Do you have continuity between them?		Repair the shorted signal to 5 volt circuit as necessary. Refer to Wiring Repairs in En-gine Electrical.	Go to Step (5)
5	• Using a DVOM check for continuity between TMAP connector pin 4 and battery positive Do you have continuity between them?		Repair the shorted signal to battery vol-tage circuit as necessary. Refer to Wiring Repairs in En-gine Electrical.	Go to Step (6)
6	• Inspect the throttle connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the cir-cuit as necessary. Refer to Wiring Repairs in En-gine Electrical.	Go to Step (7)
7	• Replace the TMAP sensor Is the replacement complete?		Go to Step (9)	-
8	• Replace the ECM Is the replacement complete?		Go to Step (10)	-

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate to full operating temperature • Observe the MIL • Observe engine performance. Does the engine operate normally with no stored codes?		System OK	Go to Step (8)
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate to full operating temperature • Observe the MIL • Observe engine performance. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0107-TMAP Low Voltage



Conditions for Setting the DTC

- MAP Sensor
- Check Condition-Engine cranking or running
- Fault Condition-MAP less than 0.25 volts
- MIL-ON

Circuit Description

The MAP (Manifold Absolute Pressure) sensor is a pressure transducer connected to the intake manifold. It is used to measure the manifold pressure. This system incorporates a TMAP (Temperature Manifold Absolute Pressure) sensor that also measures temperature in the intake manifold prior to induction. This diagnostic indicates a possible problem in the MAP portion of the sensor. The pressure and temperature readings are used in conjunction with other inputs to estimate the airflow requirement of the engine. This fault will set if the MAP voltage is less than 0.25 volts

Diagnostic Aid

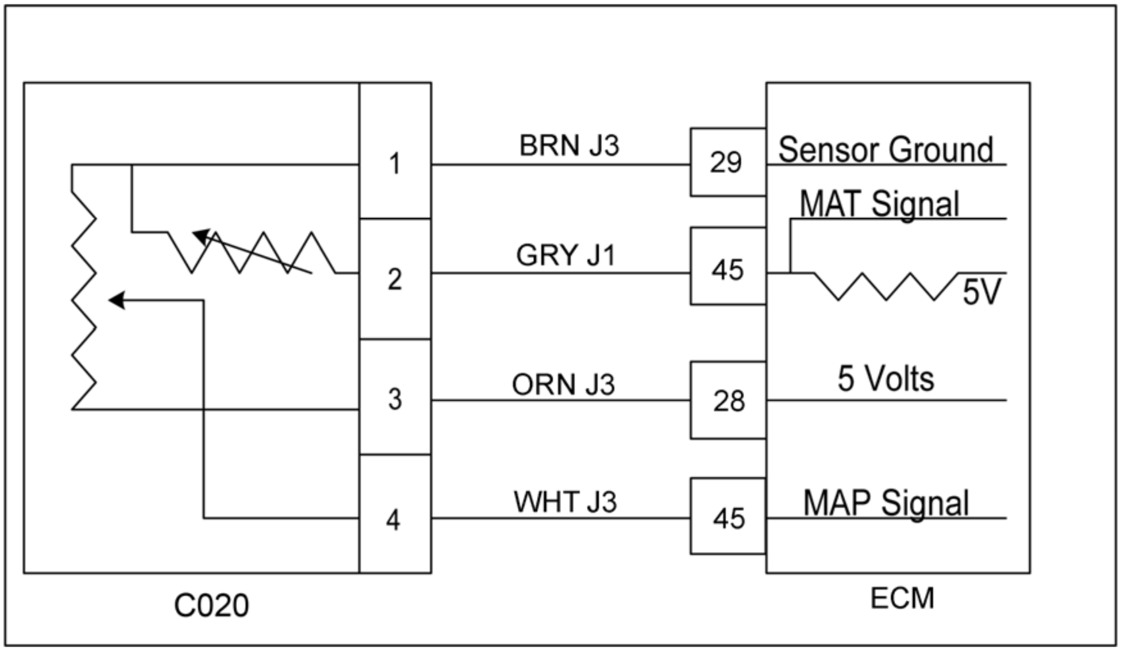
SPN 106
FMI 4

DTC P0107 TMAP Low Voltage

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON, Engine OFF • DST (Diagnostic Scan Tool) connected in the data stream mode. • Clear DTC P0107 • Ignition OFF • Ignition ON Does DTC P0107 re-set?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect ECM connector C0J3 • Disconnect the TMAP sensor connector C020 • Using a DVOM check for continuity between ECM connector pin 29 and TMAP connector pin 1 Does the DVOM show continuity?		Go to Step (4)	Repair the open sensor ground circuit as necessary. Refer to Wiring Repairs.
4	Using a DVOM check for continuity between C0J3 pin 28 and TMAP connector pin 3 Does the DVOM show continuity?		Go to Step (5)	Repair the open circuit as necessary. Refer to Wiring Repairs.
5	Using a DVOM check for continuity between C0J3 pin 45 and TMAP connector pin 4 Does the DVOM show continuity?		Go to Step (6)	Repair the open 5 volt circuit as necessary. Refer to Wiring Repairs.
6	Using a DVOM check for continuity between TMAP connector pin 4 and engine ground Does the DVOM show continuity?		Repair the shorted signal circuit as necessary. Refer to Wiring Repairs.	Go to Step (7)
7	Using a DVOM check for continuity between TMAP connector pin 3 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt signal circuit shorted to ground as necessary. Refer to Wiring Repairs.	Go to Step (8)

Step	Action	Value(s)	Yes	No
8	Replace the TMAP sensor Is the replacement complete?		Go to Step (9)	-
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. Does the engine operate normally with no stored codes?		System OK	Go to Step (10)
10	Replace the ECM Is the replacement complete?		Go to Step (11)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the Ignition to full operating temperature • Observe the MIL • Observe engine performance. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0108-MAP Sensor High



Conditions for Setting the DTC

- MAP Sensor
- Check Condition-Ignition ON
- Fault Condition-MAP sensor voltage exceeds 4.84 volts
- MIL-On during active fault

Circuit Description

The MAP (Manifold Absolute Pressure) sensor is a pressure transducer connected to the intake manifold. It is used to measure the manifold pressure. This system incorporates a TMAP (Temperature Manifold Absolute Pressure) sensor that also measures temperature in the intake manifold prior to induction. This diagnostic indicates a possible problem in the MAP portion of the sensor. The pressure and temperature readings are used in conjunction with other inputs to estimate the airflow requirement of the engine. This fault will set if the MAP voltage is greater than 4.84 volts.

Diagnostic Aid

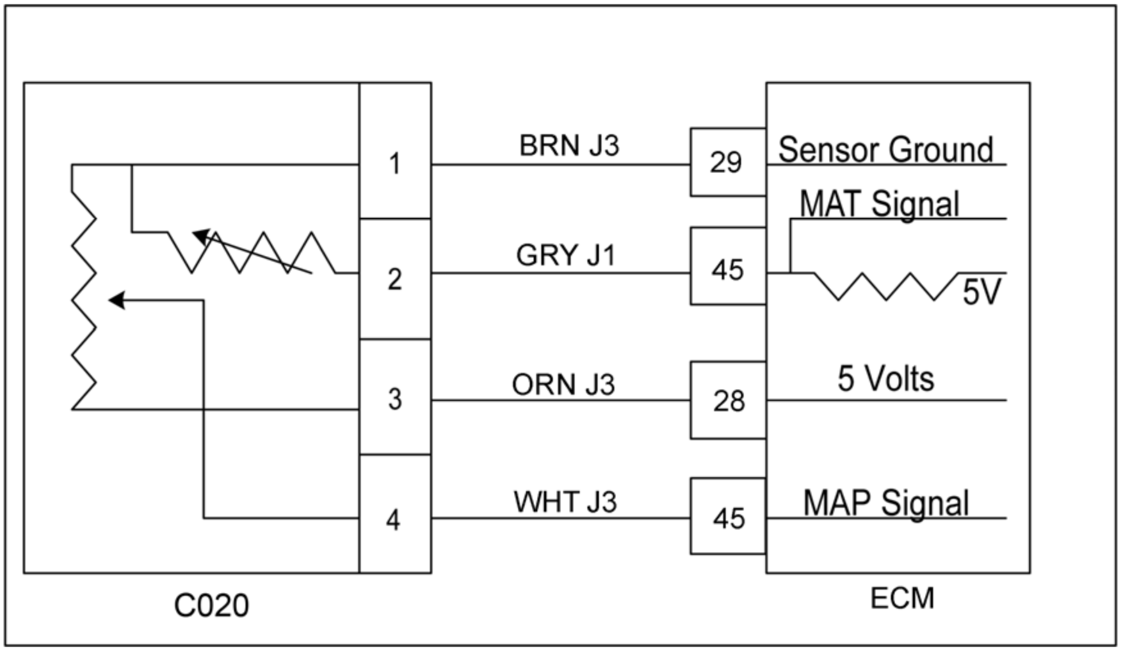
SPN 106
FMI 3

DTC P0108 TMAP Sensor High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON, Engine OFF • DST (Diagnostic Scan Tool) connected in the data stream mode. • Clear DTC P0108 • Ignition OFF • Ignition ON Does DTC P0108 re-set?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect connector C0J3 • Disconnect TMAP connector C020 • Using a DVOM check for continuity between TMAP connector pin1 and C0J3 connector pin 29 Do you have continuity between them?		Go to Step (4)	Repair the open ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	Using a DVOM check for continuity between TMAP connector pins 3 and 4 Do you have continuity between them?		Repair the shorted signal to 5 volt circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (5)
5	Using a DVOM check for continuity between TMAP connector pin 4 and battery positive Do you have continuity between them?		Repair the shorted signal to battery voltage circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	Inspect the throttle connector terminals for damage, corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	Replace the TMAP sensor Is the replacement complete?		Go to Step (9)	-

Step	Action	Value(s)	Yes	No
8	Replace the ECM Is the replacement complete?		Go to Step (10)	-
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. Does the engine operate normally with no stored codes?		System OK	Go to Step (8)
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0111 MAT Sensor High



Conditions for Setting the DTC

- Manifold Air Temperature
- Check Condition-Ignition ON
- Fault Condition-MAT Sensor temp is greater than 194.9°F (90.5°C) for 60 seconds
- MIL-On during active fault

Circuit Description

The MAT (Manifold Air Temperature) sensor is located in the intake air stream of the engine. A temperature sensitive resistor is used in the MAT to monitor the intake air temperature. The MAT value along with other sensors is used by the ECM to calculate the engines airflow requirement. This fault will set if the MAT Sensor temp is greater than 194.9°F (90.5°C) and deactivate once the temp drops to 158.5°F (70.25°C).

Diagnostic Aid

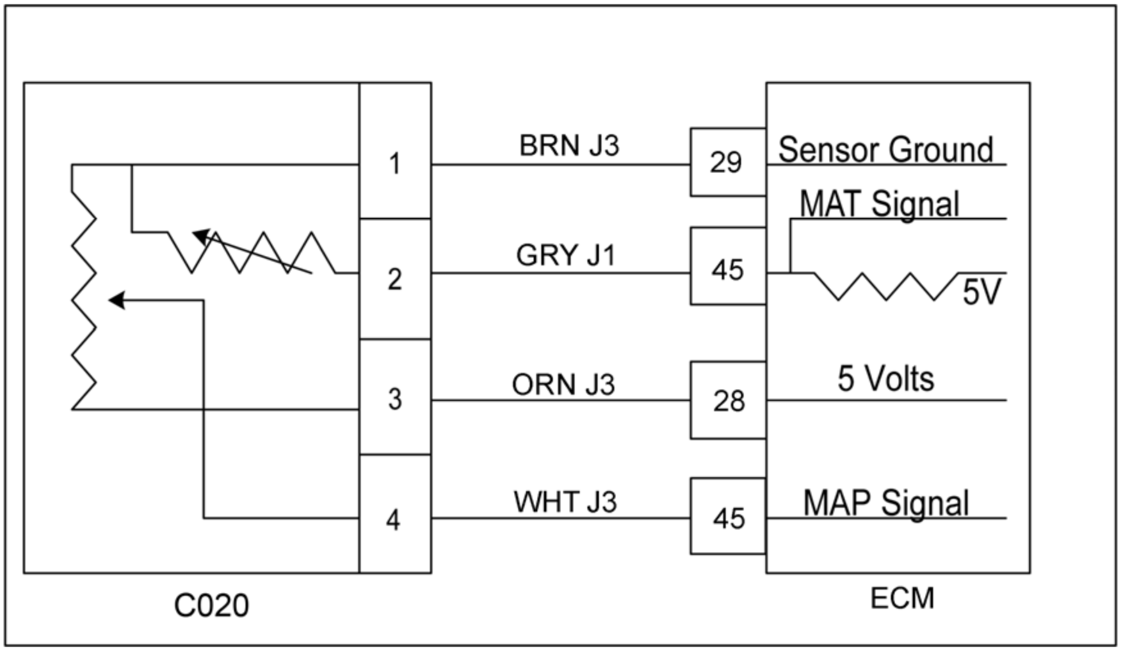
SPN 105
FMI 15
Detects a continuous short low in the circuit or sensor device.

DTC P0111 MAT Sensor Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected In System Data Mode Does DST display MAT temperature locked at 40 degrees.?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect the TMAP sensor connector C020 and jump pins 1 and 2 together • Ignition ON Does the DST display MAT temperature greater than 130 degrees C.?		Go to Step (5)	Go to Step (4)
4	• Disconnect connectors C0J1 and C0J3 • Using a DVOM check for continuity between TMAP sensor connector pin 1 and C0J3 connector pin 29 Does the DVOM show continuity?		Go to Step (6)	Repair the open ground circuit as necessary. Refer to Wire Harness Repair section.
5	Replace the TMAP sensor. Is the replacement complete?		Go to Step (10)	–
6	Using a DVOM check for continuity between TMAP connector pin 2 and C0J1 pin 45 Does the DVOM show continuity?		Go to Step (7)	Repair the open signal circuit as necessary. Refer to Wire Harness Repair Section
7	Using a DVOM check for continuity between TMAP connector pin 2 and engine ground Does the DVOM show continuity?		Repair the shorted signal to ground circuit as necessary. Refer to Wire Harness Repair Section.	Go to Step (8)

Step	Action	Value(s)	Yes	No
8	Inspect TMAP connector pins 1 and 2, and pins C0J3 pin 29 and C0J1 pin 45 for damage corrosion or contamination. Did you find a problem?		Repair the damaged electrical connector. Refer to Wire Harness Repair Section	Go to Step (9)
9	Replace the ECM Is the replacement complete?		Go to Step (10)	-
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and operate the engine to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0111 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0112 MAT Sensor Low



Conditions for Setting the DTC

- Manifold Air Temperature
- Check Condition-Ignition ON
- Fault Condition-MAT Sensor Voltage less than 100mv for 10 seconds
- MIL-On during active fault

Circuit Description

The MAT (Manifold Air Temperature) sensor is located in the intake air stream of the engine. A temperature sensitive resistor is used in the MAT to monitor the intake air temperature. The MAT value along with other sensors is used by the ECM to calculate the engines airflow requirement. This fault will set if the MAT signal voltage is less than 100mv.

Diagnostic Aid

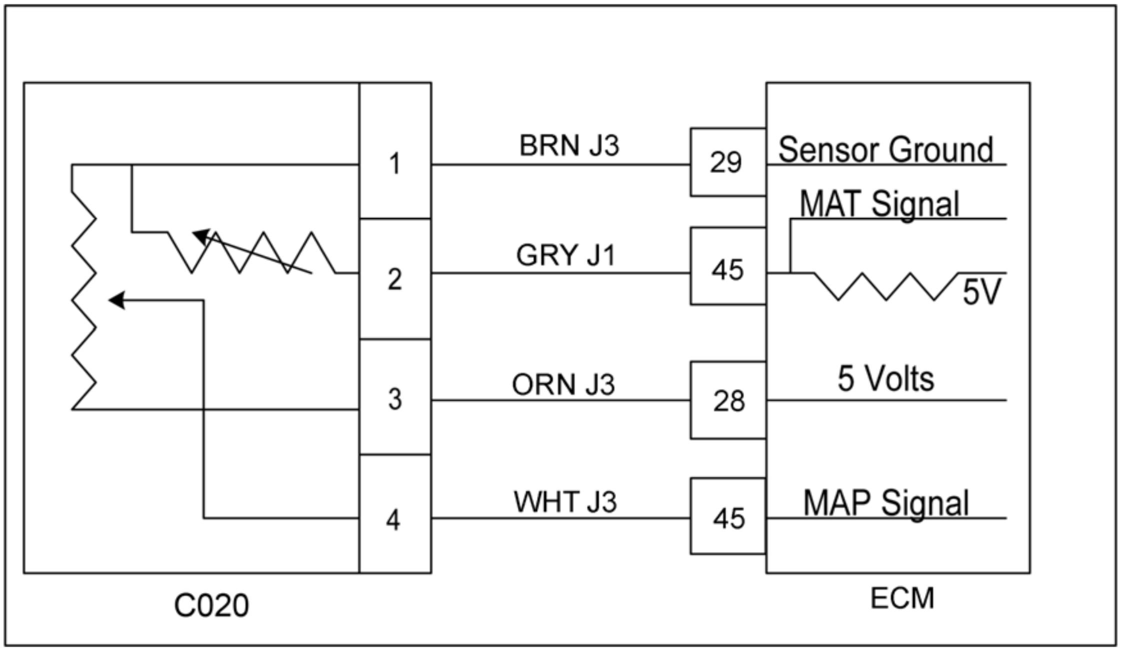
SPN 105
FMI 4
Detects a continuous short low in the circuit or sensor device.

DTC P0112 MAT Sensor Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected In System Data Mode Does DST display MAT temperature locked at 40 degrees C.?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect the TMAP sensor connector C020 and jump pins 1 and 2 together • Ignition ON Does the DST display MAT temperature greater than 130 degrees C.?		Go to Step (5)	Go to Step (4)
4	• Disconnect connector C0J3 • Using a DVOM check for continuity between TMAP sensor connector pin 1 and C0J3 pin 29 Does the DVOM show continuity?		Go to Step (6)	Repair the open ground circuit as necessary. Refer to Wire Harness Repair section.
5	Replace the TMAP sensor. Is the replacement complete?		Go to Step (10)	–
6	Using a DVOM check for continuity between TMAP connector pin 2 and C0J3 pin 45. Does the DVOM show continuity?		Go to Step (7)	Repair the open signal circuit as necessary. Refer to Wire Harness Repair Section
7	Using a DVOM check for continuity between TMAP connector pin 2 and engine ground Does the DVOM show continuity?		Repair the shorted signal to ground circuit as necessary. Refer to Wire Harness Repair Section.	Go to Step (8)

Step	Action	Value(s)	Yes	No
8	Inspect TMAP connector pins 1 and 2, and C0J1 pin 45 and C0J3 pin 29 for damage corrosion or contamination. Did you find a problem?		Repair the damaged electrical connector. Refer to Wire Harness Re-pair Section	Go to Step (9)
9	Replace the ECM Is the replacement complete?		Go to Step (10)	-
10	• Remove all test equipment except the DST. • Connect any disconnected components, fus-es, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and operate the engine to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test pa-rameters of DTC P0112 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0113 MAT Sensor High



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Ignition ON
- Fault Condition-MAT Sensor Voltage greater than 4.70 volts
- MIL-On during active fault

Circuit Description

The MAT (Manifold Air Temperature) sensor is located in the intake air stream of the engine. A temperature sensitive resistor is used in the MAT to monitor the intake air temperature. The MAT value along with other sensors is used by the ECM to calculate the engines airflow requirement. This fault will set if the MAT signal voltage is greater than 4.70 volts.

Diagnostic Aid

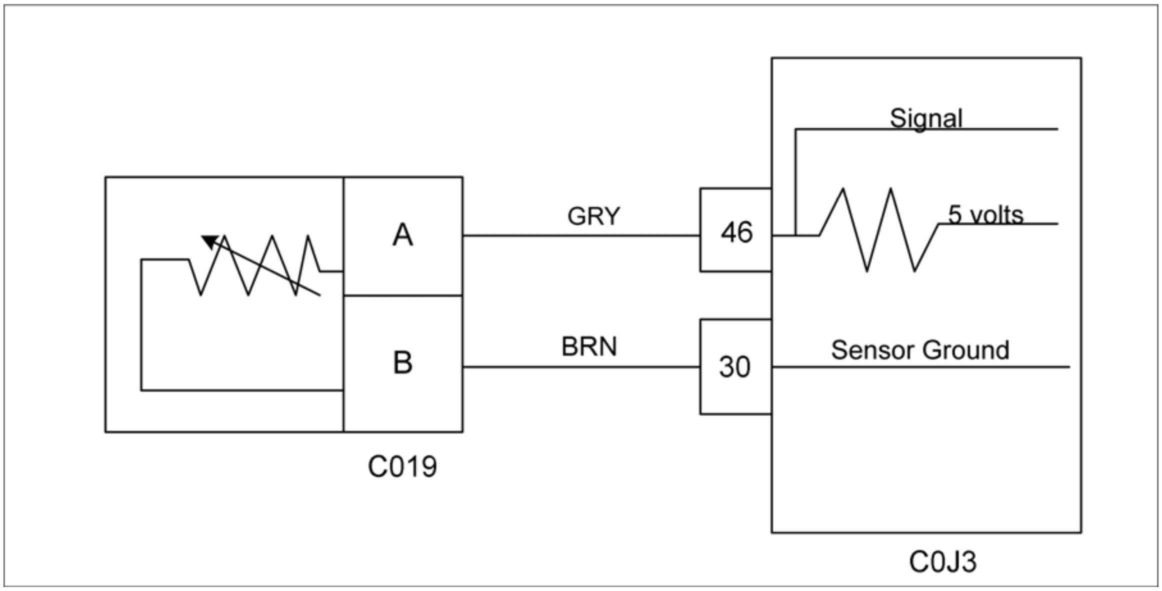
SPN 105
FMI 3
Detects a continuous short high in the circuit or sensor device.

DTC P0113 MAT Sensor High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAT temperature locked at 40 degrees C.?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect the TMAP sensor connector C020 and jump pins 1 and 2 together • Ignition ON Does the DST display MAT temperature greater than 130 degrees C?		Go to Step (5)	Go to Step (4)
4	• Disconnect C0J1 • Using a DVOM check for continuity between TMAP sensor connector pin 1 and C0J3 connector pin 29 Does the DVOM show continuity?		Go to Step (6)	Repair the open ground circuit as necessary. Refer to Wire Harness Repair section.
5	Replace the TMAP sensor. Is the replacement complete?		Go to Step (10)	–
6	Using a DVOM check for continuity between TMAP connector pin 2 and C0J1 pin 45. Does the DVOM show continuity?		Go to Step (7)	Repair the open signal circuit as necessary. Refer to Wire Harness Repair Section
7	• Ignition ON • Using a DVOM check for voltage between TMAP connector pin 2 and engine ground Does the DVOM show voltage?		Repair the shorted to voltage signal circuit as necessary. Refer to Wire Harness Repair Section.	Go to Step (8)

Step	Action	Value(s)	Yes	No
8	• Inspect TMAP connector pins 1 and 2, and C0J1 pin 45 and C0J3 pin 29 for damage corrosion or contamination. Did you find a problem?		Repair the damaged electrical connector. Refer to Wire Harness Repair Section	Go to Step (9)
9	Replace the ECM Is the replacement complete?		Go to Step (10)	-
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and operate the engine to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0113 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0116-ECT Low Voltage



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Ignition ON
- Fault Condition-ECT temp greater than 220.6°F (104.75°C) for 10 seconds
- MIL-On during active fault

Temp (deg F)	Ohms
242.4	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-6.2	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant passage. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm. This fault will set if the temperature is greater than 220.6°F (104.75°C) anytime the engine is running, creating the limp home mode reducing the RPMs. The ECM will use a default value for the ECT sensor in the event of this fault. The fault will deactivate once the temperature drops to 203°F (95°C)

Diagnostic Aid

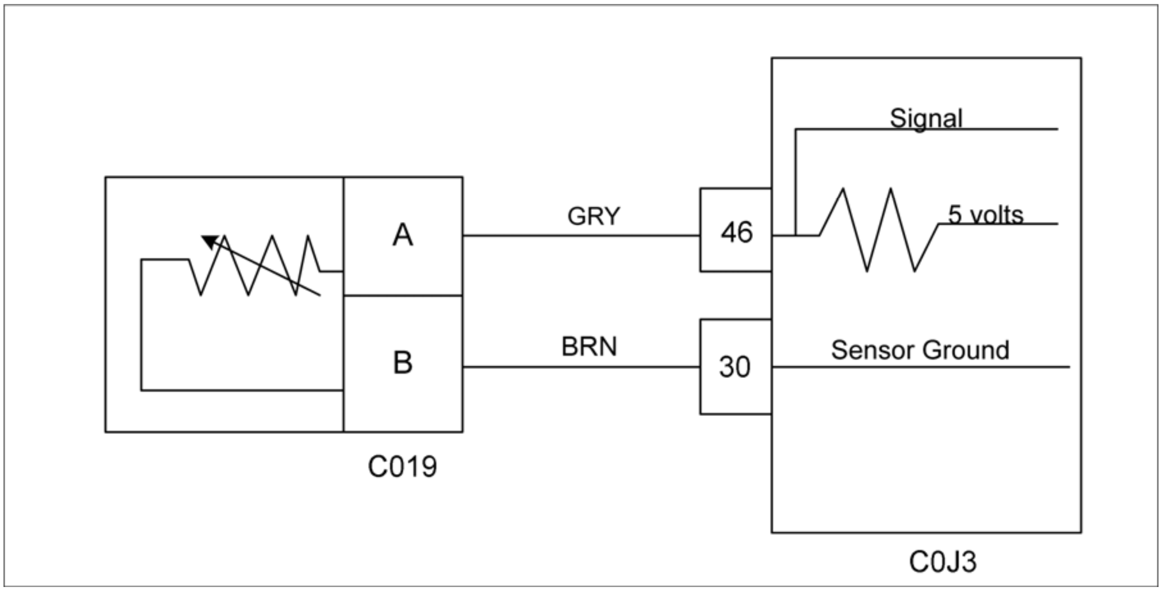
SPN 110
FMI 15

DTC P0116-ECT Low Voltage

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display ECT (Engine Coolant Temperature) fixed at 30 degrees C?		Go to Step (4)	Go to Step (3)
3	• Disconnect the ECT sensor connector C019 and Jump terminals A and B together • Ignition ON Does the DST display ECT temperature fixed at 30 degrees C?		Go to Step (4)	Go to Step (6)
4	• Ignition OFF • Disconnect ECT sensor connector • Using a DVOM check the resistance between the two terminals of the ECT sensor and compare the resistance reading to the chart Does the resistance value agree with the chart?	See resistance chart vs. temperature in the DTC P0116 circuit description	Go to Step (6)	Go to Step (5)
5	Replace ECT sensor Is the replacement complete?		Go to Step (10)	-
6	• Ignition OFF • Disconnect connector C0J3 • Using a DVOM check for continuity between ECT connector pin B and C0J3 connector pin 30 Does the DVOM show continuity?		Go to Step (7)	Repair the open sensor ground circuit. See Wire Harness repair Section.
7	Using a DVOM check for continuity between ECT connector pin A and C0J3 connector pin 46 Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor signal circuit. See Wire Harness repair Section.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between ECT connector pin A and engine ground. Does the DVOM show continuity?		Repair the sensor signal short to ground. See Wire Harness Repair Section.	Go to Step (9)
9	Replace the ECM Is the replacement complete?		Go to Step (10)	-
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and operate the Genset to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0116 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0117-ECT Low Voltage



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Ignition ON
- Fault Condition-ECT sensor voltage less than 0.36 volts
- MIL-On during active fault

Temp (deg F)	Ohms
242.4	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-6.2	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant passage. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm. This fault will set if the signal voltage is less than 0.36 volts anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

Diagnostic Aid

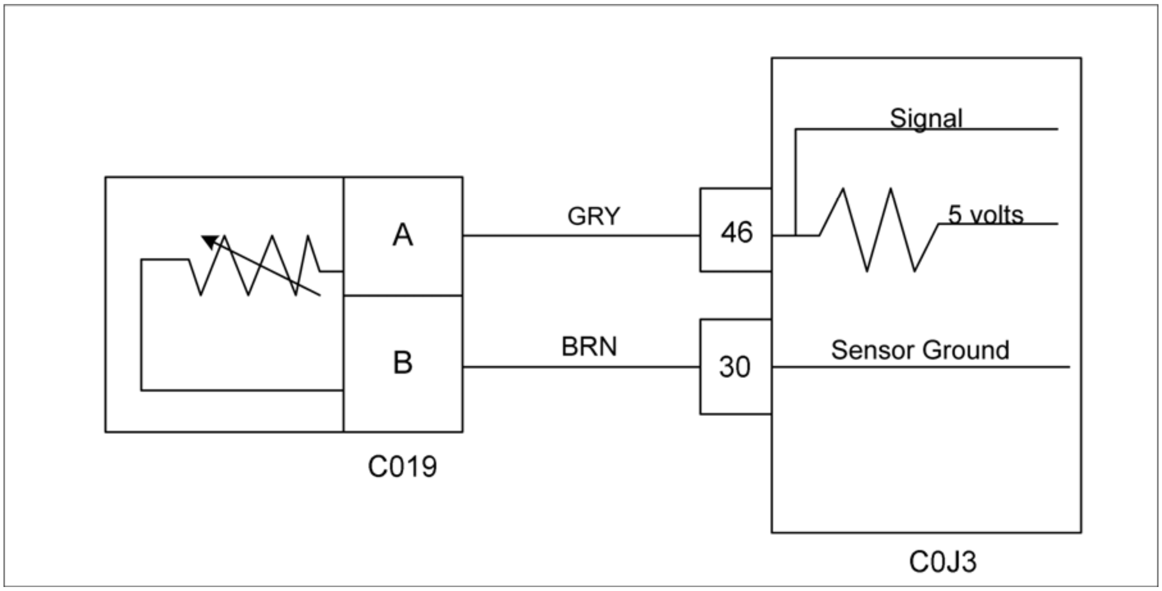
SPN 110
FMI 4

DTC P0117-ECT Low Voltage

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display ECT (Engine Coolant Temperature) fixed at 30 degrees C?		Go to Step (4)	Go to Step (3)
3	• Disconnect the ECT sensor connector C019 and Jump terminals A and B together • Ignition ON Does the DST display ECT temperature fixed at 30 degrees C?		Go to Step (4)	Go to Step (6)
4	• Ignition OFF • Disconnect ECT sensor connector • Using a DVOM check the resistance between the two terminals of the ECT sensor and compare the resistance reading to the chart Does the resistance value agree with the chart?	See resistance chart vs. temperature in the DTC P0117 circuit description	Go to Step (6)	Go to Step (5)
5	Replace ECT sensor Is the replacement complete?		Go to Step (10)	-
6	• Ignition OFF • Disconnect connector J3 • Using a DVOM check for continuity between ECT connector pin B and C0J3 connector pin 30 Does the DVOM show continuity?		Go to Step (7)	Repair the open sensor ground circuit. See Wire Harness repair Section.
7	Using a DVOM check for continuity between ECT connector pin A and C0J3 connector pin 46 Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor signal circuit. See Wire Harness repair Section.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between ECT connector pin A and engine ground. Does the DVOM show continuity?		Repair the sensor signal short to ground. See Wire Harness Repair Section.	Go to Step (9)
9	Replace the ECM Is the replacement complete?		Go to Step (10)	-
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and operate the Genset to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0117 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0118 ECT Voltage High



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Ignition ON
- Fault Condition-ECT sensor voltage exceeds 4.70 volts
- MIL-On during active fault

Temp (deg F)	Ohms
242.4	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-6.2	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant passage. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm. This fault will set if the signal voltage is greater than 4.70 volts anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

Diagnostic Aid

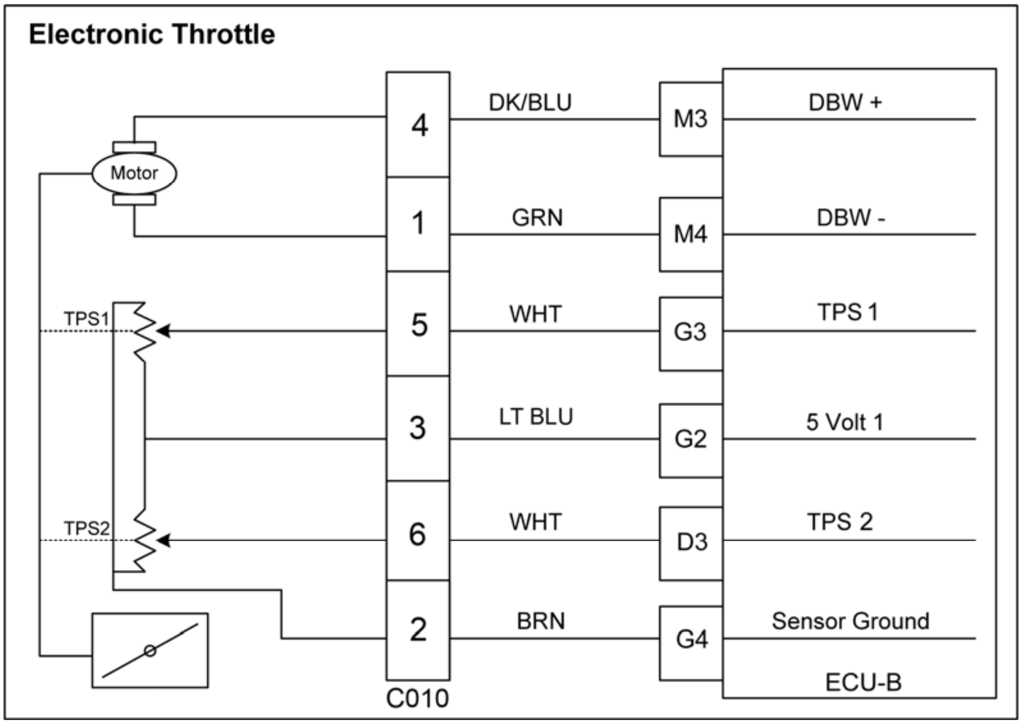
SPN 110
FMI 3

DTC P0118 ECT Voltage High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display ECT (Engine Coolant Temperature) fixed at 30 degrees C?		Go to Step (4)	Go to Step (3)
3	• Disconnect the ECT sensor connector C019 and Jump terminals A and B together • Ignition ON Does the DST display ECT temperature fixed at 30 degrees C?		Go to Step (4)	Go to Step (6)
4	• Ignition OFF • Disconnect ECT sensor connector • Using a DVOM check the resistance between the two terminals of the ECT sensor and compare the resistance reading to the chart Does the resistance value agree with the chart?	See resistance chart vs. temperature in the DTC P0118 circuit description	Go to Step (6)	Go to Step (5)
5	Replace ECT sensor Is the replacement complete?		Go to Step (10)	-
6	• Ignition OFF • Disconnect connector C0J3 • Using a DVOM check for continuity between ECT connector pin B and C0J3 connector pin 30 Does the DVOM show continuity?		Go to Step (7)	Repair the open sensor ground circuit. See Wire Harness repair Section.
7	Using a DVOM check for continuity between ECT connector pin A and C0J3 connector pin 46 Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor signal circuit. See Wire Harness repair Section.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between ECT connector pin A and engine ground. Does the DVOM show continuity?		Repair the sensor signal short to ground. See Wire Harness Repair Section.	Go to Step (9)
9	Replace the ECM Is the replacement complete?		Go to Step (10)	-
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and operate the engine to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0118 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0122 ETC TPS 1 Range



Conditions for Setting the DTC

- Electronic Throttle Control
- Check Condition-Ignition ON
- Fault Condition-TPS 1 voltage below 0.25 TPS 1 voltage greater than 4.95
- MIL-On during active fault

Circuit Description

Dual throttle position sensors (TPS) are used with the electronic throttle control (ETC) to determine throttle plate position. The TPS values are used by the ECM to determine if the throttle is opening and closing as commanded. The ECM runs several checks at ignition on to validate the working condition of the ETC. This fault will set if the ECM detects a problem with the TPS sensor range.

Diagnostic Aid

SPN 65602
FMI 2

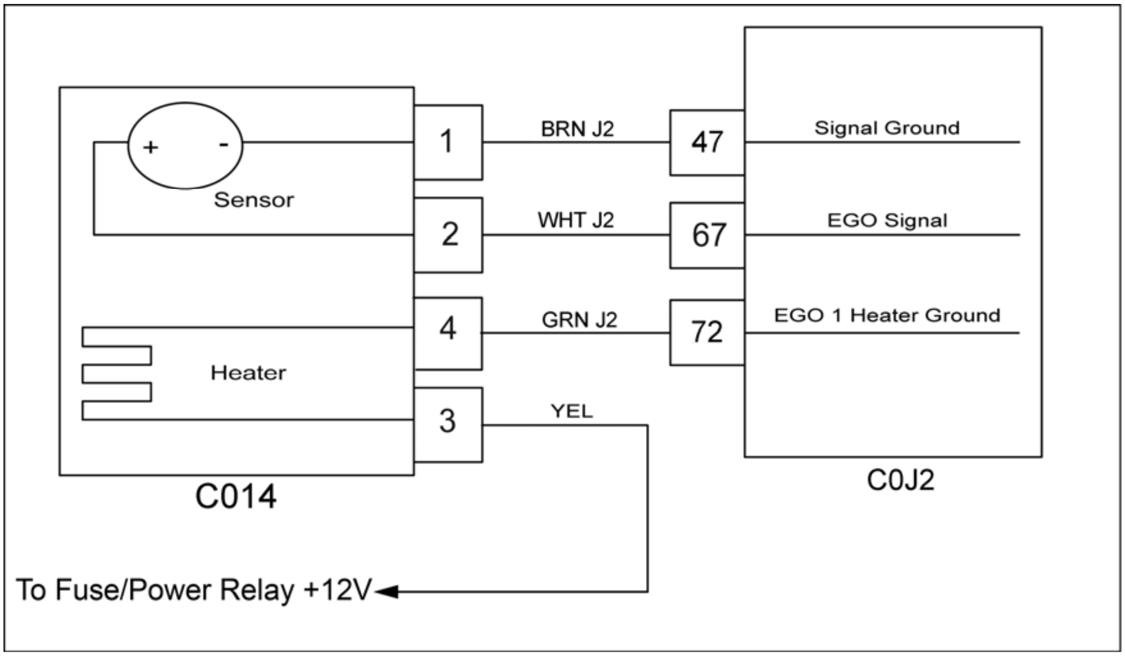
DTC P0122 ETC TPS 1 Range

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in data stream mode. • Clear DTC P0122 • Start the engine Does DTC P0122 re-set?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect electronic throttle connector C010 • Disconnect wire harness connector C0J2 • Inspect the electronic throttle connector and ECM wire harness connector for damage corrosion or contamination Did you find a problem?		Correct the problem as required. See wire harness repair.	Go to Step (4)
4	• Ignition OFF • Disconnect electronic throttle connector C010 • Disconnect ECM wire harness connector C0J2 • Using a DVOM check for continuity between electronic throttle connector pin 2 and C0J2 connector pin 44 Does the DVOM show continuity?		Go to Step (5)	Repair the open ground circuit as necessary. Refer to Wiring Repairs.
5	Using a DVOM check for continuity between electronic throttle connector pin 6 and C0J2 connector pin 63 Does the DVOM show continuity?		Go to Step (6)	Repair the open circuit as necessary. Refer to Wiring Repairs.
6	Using a DVOM check for continuity between electronic throttle connector pin 6 and engine ground Does the DVOM show continuity?		Repair the shorted to ground TPS circuit as necessary. Refer to Wiring Repairs.	Go to Step (7)
7	Using a DVOM check for continuity between electronic throttle connector pin 3 and C0J2 connector pin 43 Does the DVOM show continuity?		Go to Step (8)	Repair the open 5 volt circuit as necessary. Refer to Wiring Repairs.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between electronic throttle connector pin 3 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (9)
9	Using a DVOM check for continuity between electronic throttle connector pin 5 and C0J2 connector pin 65 Does the DVOM show continuity?		Go to Step (10)	Repair the open TPS circuit as necessary. Refer to Wiring Repairs.
10	Using a DVOM check for continuity between electronic throttle connector pin 5 and engine ground Does the DVOM show continuity?		Repair the shorted TPS circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (11)
11	Using a DVOM check for continuity between electronic throttle connector pin 1 and C0J2 connector pin 16 Does the DVOM show continuity?		Go to Step (12)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
12	Using a DVOM check for continuity between electronic throttle connector pin 2 and C0J2 connector pin 44 Does the DVOM show continuity?		Go to Step (13)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
13	Using a DVOM check for continuity between electronic throttle connector pin 2 and engine ground Does the DVOM show continuity?		Repair the shorted DBW circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (14)
14	• Ignition ON • Using a DVOM check for voltage between electronic throttle connector pin 5 and engine ground Does the DVOM show voltage?		Repair the TPS signal shorted to voltage as necessary. Refer to Wiring Repairs.	Go to Step (15)
15	Replace throttle Is the replacement complete?		Go to Step (16)	-

Step	Action	Value(s)	Yes	No
16	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0122 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (17)
17	Replace the ECM Is the replacement complete?		Go to Step (18)	-
18	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0122 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0130 Oxygen Sensor Voltage Open



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check condition-Engine running
- Fault condition-EGO sensor less than 50mv, ECT above 122°F (50°C) with minimum engine run time of 60 seconds.
- MIL-On during active fault

Circuit Description

The EGO sensor (Exhaust Gas Oxygen) sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. This fault will set if the EGO signal circuit is open or unresponsive.

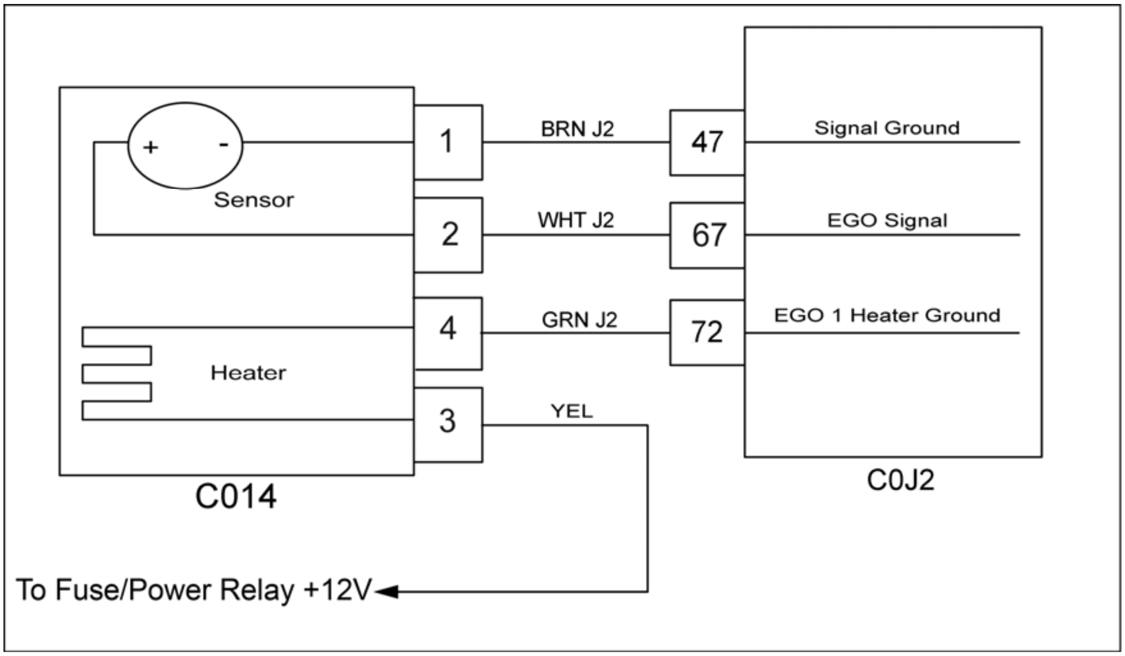
Diagnostic Aid

SPN 65561
FMI 5
EGO voltage fixed between 0.35 and 0.488 volts is a good indication that the signal circuit is open.

DTC P0130 Oxygen Sensor Voltage Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature Does DST display HEGO voltage fixed between 0.3 and 0.5 volts after at least 60 seconds run time?		Go to Step (3)	Intermittent problem. See Electrical Section Intermittent Electrical Diagnosis
3	• Ignition OFF • Disconnect EGO 1 connector C014 • Ignition ON • Does the DST now show EGO voltage at 0.45 volts?		Go to Step (4)	Go To Step (6)
4	• Jump HEGO connector pins 1 and 2 Does the DST now show HEGO voltage at less than 0.1 volts		Go to Step (5)	Go to step (6)
5	• Replace the oxygen sensor Is the replacement complete?		Go to Step (9)	-
6	• Ignition OFF • Disconnect ECM connector C0J2 • Using a DVOM check for continuity between HEGO connector pin 2 and C0J2 connector pin 67. Does the DVOM show continuity?		Go to Step (7)	Repair the open HEGO signal circuit. See wire harness repair.
7	• Using a DVOM Check for continuity between HEGO pin B and engine ground. Does the DVOM show continuity?		Repair the shorted to ground HEGO signal circuit. See wire harness repair	Go to Step (8)
8	• Replace ECM Is the replacement complete?		Go to Step (9)	-

DTC P0131 Oxygen Sensor Voltage Low



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check condition-Engine running
- Fault condition-EGO less than 48.8 mv with ECT greater than 122°F (50°C), ignition voltage >10 volts.
- MIL-On

Circuit Description

The EGO sensor (Exhaust Gas Oxygen) sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. This fault will set if the EGO voltage is persistently below 48.8 mv during closed loop operation.

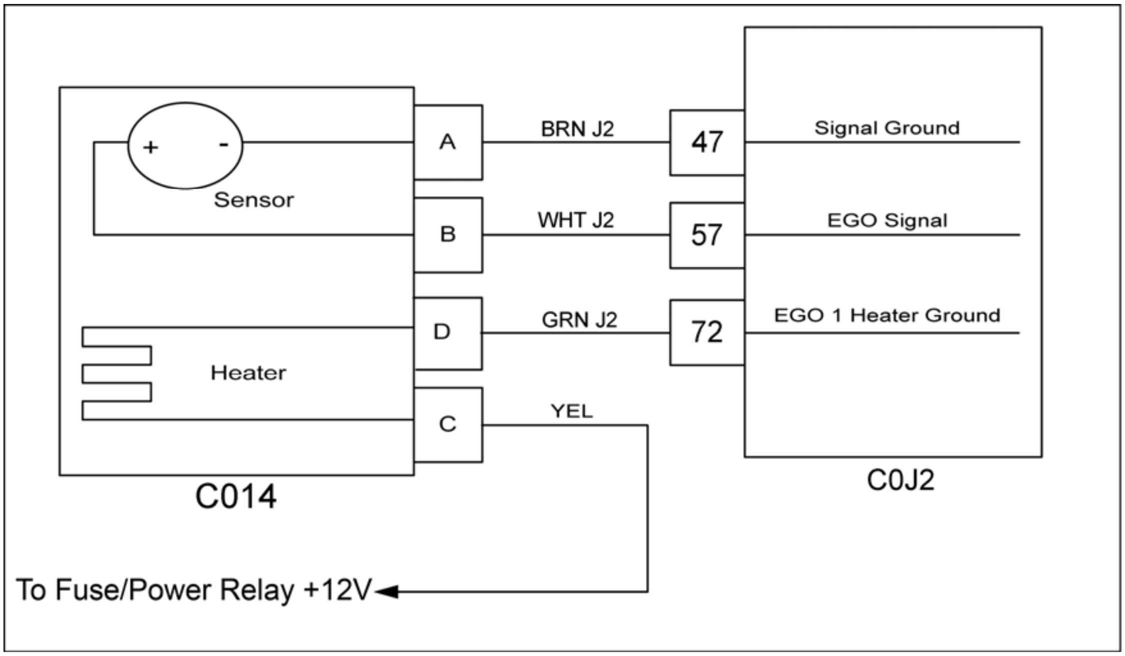
Diagnostic Aid
SPN 65561
FMI 4

DTC P0131 Oxygen Sensor Voltage Low

Step	Action	Value(s)	Yes	No
1	Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • Power Relay Fuse • The HEGO sensor installed securely and the wire leads not damaged or contacting the exhaust manifold • ECM grounds for being clean and tight. • Run the fuel system diagnostic checks Was a repair made?		Go to Step (6)	Go to Step (4)
3	Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (13)	Go to Step (2)
4	• Ignition ON • Disconnect HEGO sensor wire harness connector C014. • Using a DVOM check for voltage between HEGO connector pins 3 and 4. Do you have voltage?	System Battery Voltage	Go to Step (7)	Go to Step (5)
5	Using a DVOM check for voltage between HEGO connector pin 3 and engine ground. Does the DVOM show voltage?		Repair the open HEGO heater ground circuit as necessary. Refer to wiring harness repair.	Go to Step (6)
6	Using a DVOM check for voltage between HEGO connector pin 4 and battery positive. Does the DVOM show voltage?		Repair the open HEGO heater power supply circuit as necessary. Refer to wiring harness repair	Go to Step (7)
7	• Ignition OFF • Disconnect connector C0J2 • Using a DVOM check for continuity between C0J2 pin 2 and HEGO connector pin 1. Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor ground circuit as necessary. Refer to wiring harness repair.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between C0J2 pin 67 and HEGO connector pin 2. Does the DVOM show continuity?		Go to Step (9)	Repair the open sensor signal circuit as necessary. Refer to wiring harness repair.
9	Using a DVOM check for continuity between C0J2 pin 72 and HEGO connector pin 4. Does the DVOM show continuity?		Go to Step (10)	Repair the open HEGO heater ground circuit as necessary. Refer to wiring harness repair
10	Using a DVOM check for continuity between HEGO connector pin 2 and engine ground Does the DVOM show continuity?		Repair the signal shorted to ground circuit. Refer to wiring harness repair.	Go to Step (11)
11	Inspect C0J2 pins 47, 67 and 72 and HEGO pins 1-4 for damage, corrosion or contamination. Did you find a problem?		Repair the connector as necessary. Refer to wiring harness repair	Go to Step (12)
12	Replace the HEGO sensor Is the replacement complete?		Go to Step(13)	-
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0131 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (14)
14	Replace the ECM Is the replacement complete?		Go to Step (13)	-

DTC P0132 Oxygen Sensor Voltage High



Conditions for Setting the DTC

- EGO
- Check condition-Engine running.
- Fault condition-EGO voltage greater than 966mv for 5 seconds or longer with ECT greater than 122°F (50°C), with system ignition voltage above 10 volts.
- MIL-On during active fault

Circuit Description

The EGO sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the block learn memory. This fault detects an EGO sensor signal shorted high or excessively rich biased fuel metering.

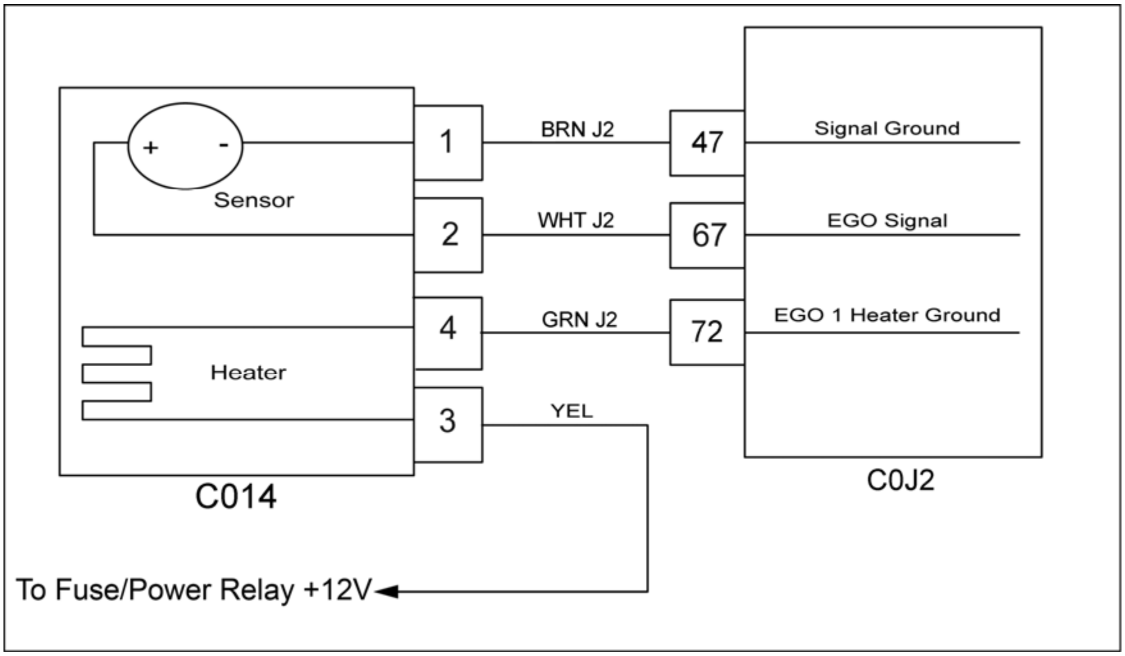
Diagnostic Aid

SPN 65561
FMI 3
Always run the fuel system diagnostic checks before proceeding with this diagnostic chart.

DTC P0132 Oxygen Sensor Voltage High

Step	Action	Value(s)	Yes	No
1	Perform the On-Board (OBD) System Check. Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • The air intake duct for being collapsed or restricted • The air filter for being plugged • The HEGO sensor installed securely and the wire leads not damaged or contacting the secondary ignition wires • ECM grounds for being clean and tight. • Run the fuel system diagnostic checks Was a repair made?		Go to Step (6)	Go to Step (4)
3	Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (6)	Go to Step (4)
4	• Ignition OFF • Disconnect HEGO sensor wire harness connector C014 • Disconnect ECM wire harness connector C0J2 • Ignition ON • Using a DVOM check for voltage at the HEGO connector C014 signal pin 2 and engine ground Do you have voltage above 0.5 volts?		Repair the circuit short to voltage as necessary. Refer to wiring harness repair.	Go to Step (5)
5	Replace HEGO sensor Is the replacement complete?		Go to Step (6)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and operate the engine to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0132 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0133 Oxygen Sensor Response Slow



Conditions for Setting the DTC

- EGO (Exhaust Gas Oxygen Sensor)
- Check condition-Engine running.
- Fault condition-EGO Average lean to rich time >241ms and average rich to lean time 269ms.
- ECT greater than 122°F (60°C) with MAP greater than 20 kPa but less than 85 kPa.
- RPM greater than 500 but less than 3000 with minimum engine run time of 60 seconds.
- MIL-On during active fault

Circuit Description

The EGO sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the BLM (block learn memory). This fault detects a degraded sensor by monitoring the average response time of rich to lean and lean to rich switching points.

Diagnostic Aid

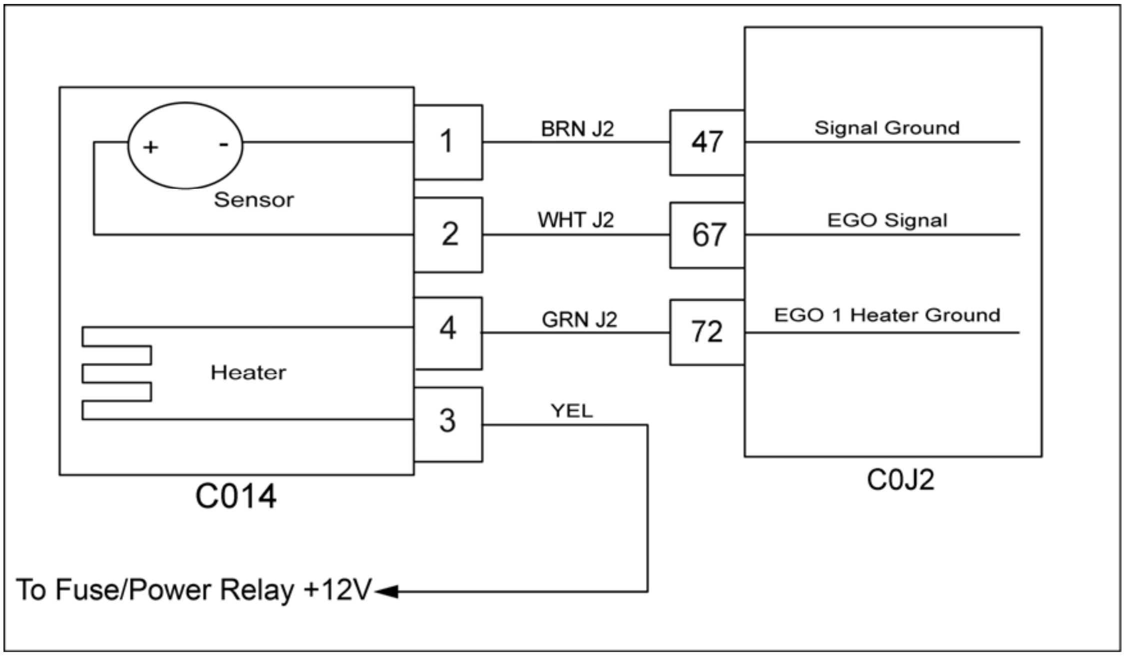
SPN 65567
FMI 10
*Always run the fuel system diagnostic checks before proceeding with this diagnostic chart.

DTC P0133 Oxygen Sensor Response Slow

Step	Action	Value(s)	Yes	No
1	Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • Check for vacuum leaks at the Mixer adapter. • That the HEGO sensor is installed securely and the wire leads are not damaged or contacting the exhaust manifold or secondary spark plug wires. • ECM grounds for being clean and tight. • Run the fuel system diagnostic checks Was a repair made?		Go to Step (6)	Go to Step (4)
3	Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (13)	Go to Step (2)
4	• Ignition ON • Disconnect HEGO sensor wire harness connector C014. • Using a DVOM check for voltage between HEGO connector pins 3 and 4. Do you have voltage?	System Battery Voltage	Go to Step (7)	Go to Step (5)
5	Using a DVOM check for voltage between HEGO connector pin 3 and engine ground. Does the DVOM show voltage?		Repair the open HEGO heater ground circuit as necessary. Refer to wiring harness repair.	Go to Step (6)
6	Using a DVOM check for voltage between HEGO connector pin 4 and battery positive. Does the DVOM show voltage?		Repair the open HEGO heater power supply circuit as necessary. Refer to wiring harness repair	Go to Step (7)
7	• Ignition OFF • Disconnect ECM connector C0J2 • Using a DVOM check for continuity between C0J2 pin 47 and HEGO connector pin 1. Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor ground circuit as necessary. Refer to wiring harness repair.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between C0J2 pin 67 and HEGO connector pin 2. Does the DVOM show continuity?		Go to Step (9)	Repair the open sensor signal circuit as necessary. Refer to wiring harness repair.
9	Using a DVOM check for continuity between C0J2 pin 72 and HEGO connector pin 4. Does the DVOM show continuity?		Go to Step (10)	Repair the open HEGO heater ground circuit as necessary. Refer to wiring harness repair
10	Using a DVOM check for continuity between HEGO connector pin 2 and engine ground Does the DVOM show continuity?		Repair the signal shorted to ground circuit. Refer to wiring harness repair.	Go to Step (11)
11	Inspect C0J2 pins 72, 67 and 47 and HEGO pins 1-4 for damage, corrosion or contamination. Did you find a problem?		Repair the connector as necessary. Refer to wiring harness repair	Go to Step (12)
12	Replace the HEGO sensor Is the replacement complete?		Go to Step(13)	-
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0133 check for any stored codes. • Does the engine operate normally with no stored codes?		System OK	Go to Step (14)
14	Replace the ECM Is the replacement complete?		Go to Step (13)	-

DTC P0134 Oxygen Sensor Insufficient Switching



Conditions for Setting the DTC

- EGO (Exhaust Gas Oxygen) Sensor.
- Check condition-Engine running
- Fault condition-EGO sensor less than 4 cross counts (rich lean transitions) within 30 seconds.
- Engine running for 60 seconds.
- ECT greater than 122°F (50°C)
- MAP greater than 20 kPa but less than 85 kPa.
- RPM greater than 500 but less than 3000.
- MIL-On

Circuit Description

The EGO sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the adaptive block learn. This fault will set if the EGO sensor switching is slow indicating a possible problem with the sensor.

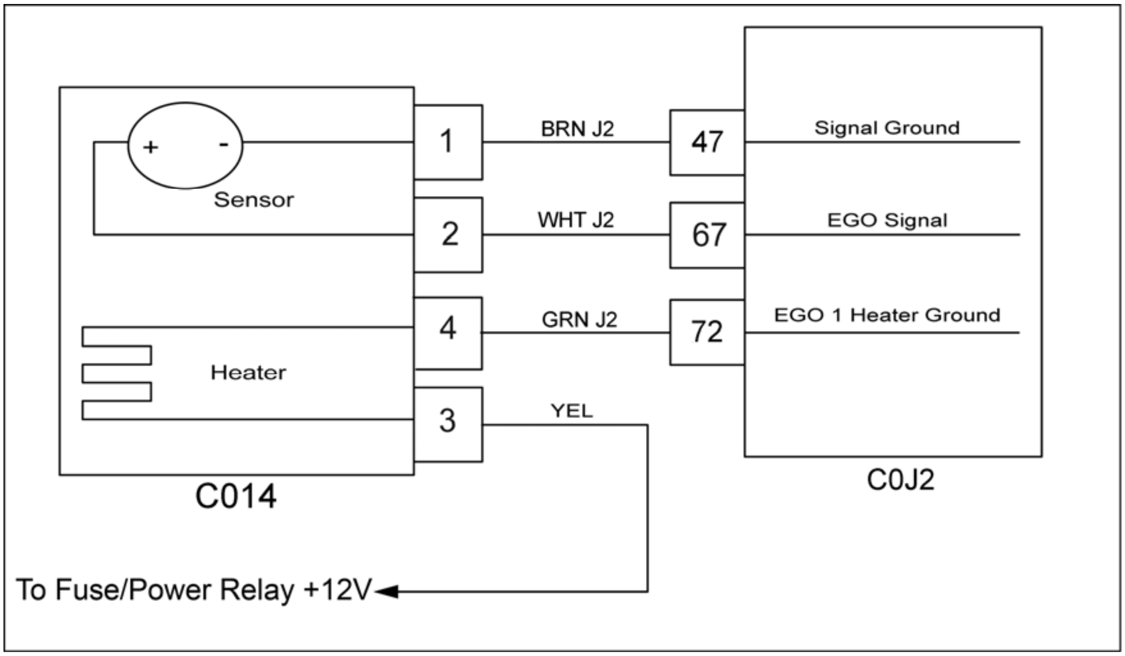
Diagnostic Aid
SPN Sensor A1 65567
FMI 8
Always run the fuel system diagnostic checks before performing this diagnostic. Never use silicone sprays, lubricants or sealants that are not labeled “oxygen sensor safe.” Air leaks at the Mixer adapter may also cause the sensor to switch slow.

DTC P0134 Oxygen Sensor Insufficient Switching

Step	Action	Value(s)	Yes	No
1	Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • Check for vacuum leaks at the Mixer adapter. • That the HEGO sensor is installed securely and the wire leads are not damaged or contacting the exhaust manifold or secondary spark plug wires. • ECM grounds for being clean and tight. • Run the fuel system diagnostic checks Was a repair made?		Go to Step (6)	Go to Step (4)
3	Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (13)	Go to Step (2)
4	• Ignition ON • Disconnect HEGO sensor wire harness connector C014. • Using a DVOM check for voltage between HEGO connector pins 3 and 4. Do you have voltage?	System Battery Voltage	Go to Step (7)	Go to Step (5)
5	Using a DVOM check for voltage between HEGO connector pin 3 and engine ground. Does the DVOM show voltage?		Repair the open HEGO heater ground circuit as necessary. Refer to wiring harness repair.	Go to Step (6)
6	Using a DVOM check for voltage between HEGO connector pin 4 and battery positive. Does the DVOM show voltage?		Repair the open HEGO heater power supply circuit as necessary. Refer to wiring harness repair	Go to Step (7)
7	• Ignition OFF • Disconnect ECM connector C0J2 • Using a DVOM check for continuity between C0J2 pin 47 and HEGO connector pin 1. Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor ground circuit as necessary. Refer to wiring harness repair.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between C0J2 pin 67 and HEGO connector pin 2. Does the DVOM show continuity?		Go to Step (9)	Repair the open sensor signal circuit as necessary. Refer to wiring harness repair.
9	Using a DVOM check for continuity between C0J2 pin 72 and HEGO connector pin 4. Does the DVOM show continuity?		Go to Step (10)	Repair the open HEGO heater ground circuit as necessary. Refer to wiring harness repair
10	Using a DVOM check for continuity between HEGO connector pin 2 and engine ground Does the DVOM show continuity?		Repair the signal shorted to ground circuit. Refer to wiring harness repair.	Go to Step (11)
11	Inspect C0J2 pins 72, 67, 47 and HEGO pins 1-4 for damage, corrosion or contamination. Did you find a problem?		Repair the connector as necessary. Refer to wiring harness repair	Go to Step (12)
12	Replace the HEGO sensor Is the replacement complete?		Go to Step(13)	-
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0134 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (14)
14	Replace the ECM Is the replacement complete?		Go to Step (13)	-

DTC P0135 Oxygen Sensor Heater Duty Cycle High



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition-Ignition ON
- Fault Condition-HEGO duty cycle greater than 96% for more than 150 seconds
- MIL-On

Circuit Description

The EGO sensor (Exhaust Gas Oxygen) sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The EGO sensor uses an internal heating element to keep the sensor active. This fault will set if the ECM detects a problem with the HEGO heater feedback control circuit.

Diagnostic Aid

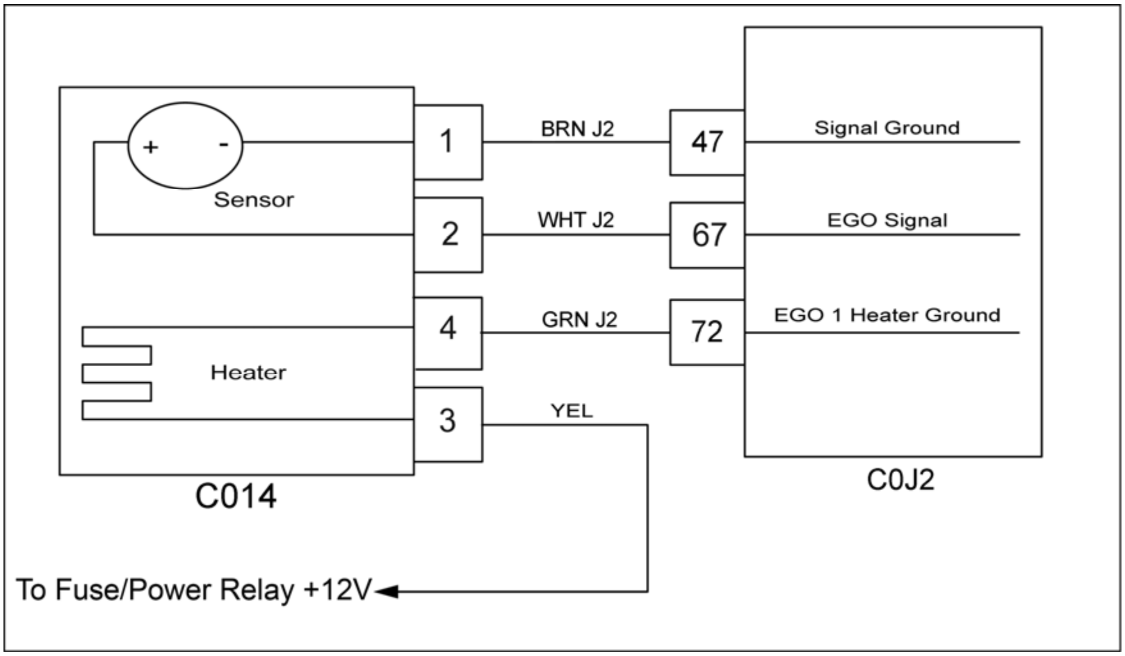
SPN 66019
FMI 8

DTC P0135 Oxygen Sensor Heater Duty Cycle High

Step	Action	Value(s)	Yes	No
1	Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • That the HEGO sensor electrical connector C014 is not damaged, corroded or contaminated, and is connected properly and securely. Was a repair made?		Go to Step (9)	Go to Step (3)
3	Diagnose any other DTC codes before proceeding with this chart. Always repair existing codes starting with the lowest numerical code set first. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (9)	Go to Step (4)
4	• Ignition OFF • Disconnect HEGO connector C014 • Using a DVOM measure the resistance of the HEGO heater (sensor side) between pins 3 and 4 (the two white wires). Does the DVOM show a resistance value between 5 and 20 Ohms?	Between 5 and 20 Ohms	Go to Step (6)	Go to Step (5)
5	Replace EGO 1 sensor Is the replacement complete?		Go to Step (9)	-
6	• Disconnect ECM connector C0J2 • Using a high impedance DVOM check for continuity between HEGO connector pin 4 and C0J2 pin 72 Does the DVOM show continuity?		Go to Step (7)	Repair the open HEGO heater ground circuit. See wire harness repair.
7	Using a high impedance DVOM check for continuity between HEGO connector pin 3 and power relay terminal 87. Do you have continuity?		Go to Step (8)	Repair the open HEGO heater power supply circuit. See wire harness repair.
8	Replace the ECM Is the replacement complete?		Go to Step (9)	-

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the Ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0135 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0171 Fuel Trim High



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition-Engine Running
- Fault Condition-BLM greater than 50% for 2 seconds
- MIL-On

Circuit Description

The EGO (Exhaust Gas Oxygen) sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the BLM (Block Learn Memory). This fault will set if the BLM exceeds 50% fuel correction for two or more seconds.

Diagnostic Aid

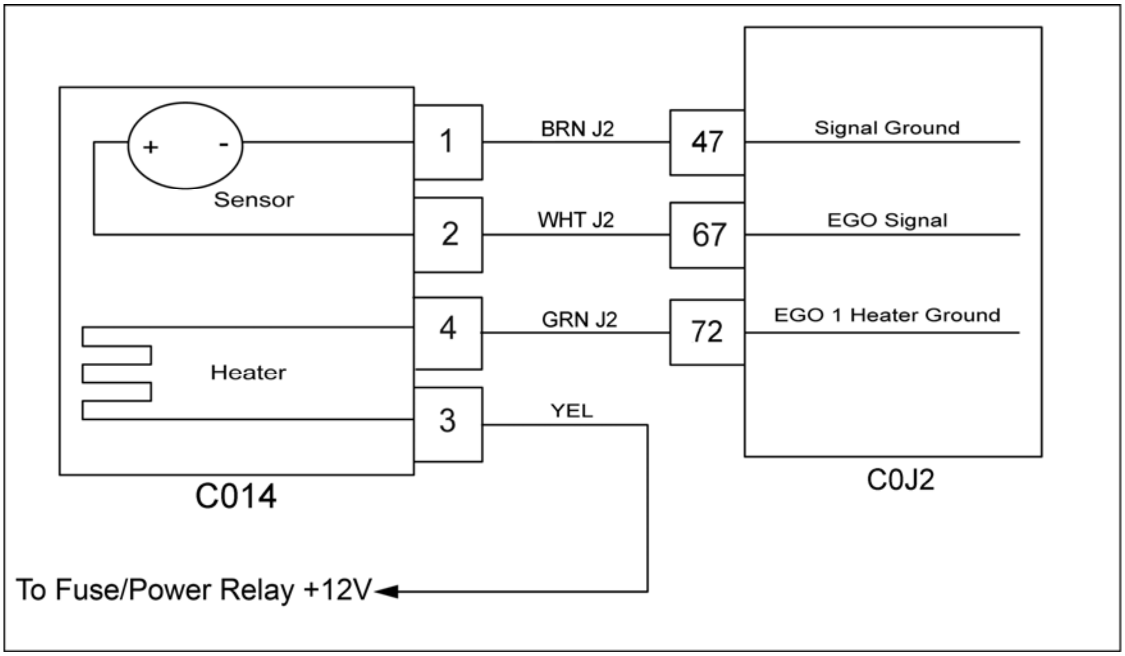
SPN 65565
FMI 0
Always run the fuel system diagnostic checks before using the following this diagnostic chat.
EGO Sensor Wires EGO sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Vacuum leaks, plugged feedback jet and crankcase leaks can cause a lean exhaust condition especially at light load.
Fuel Mixer The system can be lean due to faulty fuel mixer or Mixer adapter seal.
Fuel Pressure Low regulator inlet/outlet fuel pressure or a faulty fuel pressure regulator can cause fuel the system to run lean.
Exhaust Leaks If there is an exhaust leak, outside air can be pulled into the exhaust and past the EGO sensor causing a false lean condition.
Fuel Quality Contaminated or spoiled fuel can cause the fuel system to be lean.
Ground Problem ECM grounds must be clean, tight and in the proper location.

DTC P0171 Fuel Trim High

Step	Action	Value(s)	Yes	No
1	Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • Power Relay Fuse • The HEGO sensor installed securely and the wire leads not damaged or contacting the exhaust manifold • ECM grounds for being clean and tight. • Run the fuel system diagnostic checks Was a repair made?		Go to Step (6)	Go to Step (4)
3	Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (13)	Go to Step (2)
4	• Ignition ON • Disconnect HEGO sensor wire harness connector C014 • Using a DVOM check for voltage between HEGO connector pins 3 and 4 Do you have voltage?	System Battery Voltage	Go to Step (7)	Go to Step (5)
5	Using a DVOM check for voltage between HEGO connector pin 3 and engine ground Does the DVOM show voltage?		Repair the open HEGO heater ground circuit as necessary. Refer to wiring harness repair.	Go to Step (6)
6	Using a DVOM check for voltage between HEGO connector pin 4 and battery positive Does the DVOM show voltage?		Repair the open HEGO heater power supply circuit as necessary. Refer to wiring harness repair	Go to Step (7)
7	• Ignition OFF • Disconnect ECM connector C0J2 • Using a DVOM check for continuity between C0J2 pin 47 and HEGO connector pin 1 Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor ground circuit as necessary. Refer to wiring harness repair.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between C0J2 pin 67 and HEGO connector pin 2 Does the DVOM show continuity?		Go to Step (9)	Repair the open sensor signal circuit as necessary. Refer to wiring harness repair.
9	Using a DVOM check for continuity between C0J2 pin 72 and HEGO connector pin 4 Does the DVOM show continuity?		Go to Step (10)	Repair the open HEGO heater ground circuit as necessary. Refer to wiring harness repair
10	Using a DVOM check for continuity between HEGO connector pin 2 and engine ground Does the DVOM show continuity?		Repair the signal shorted to ground circuit. Refer to wiring harness repair.	Go to Step (11)
11	Inspect C0J2 pins 72, 67, 47 and HEGO pins 1-4 for damage, corrosion or contamination Did you find a problem?		Repair the connector as necessary. Refer to wiring harness repair	Go to Step (12)
12	Replace the HEGO sensor Is the replacement complete?		Go to Step(13)	-
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM • Turn the Ignition OFF and wait 30 seconds • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0171 check for any stored codes Does the engine operate normally with no stored codes?		System OK	Go to Step (14)
14	Replace the ECM Is the replacement complete?		Go to Step (13)	-

DTC P0172 Fuel Trim Low



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition-Engine running
- Fault Condition-BLM (Block Learn Memory) less than 50% for 2 seconds.
- MIL-On

Circuit Description

The EGO (Exhaust Gas Oxygen) sensor is used to determine if the fuel flow to the engine is correct by measuring the oxygen content in the exhaust gas. The ECM uses this information to correct the fuel flow with the BLM (Block Learn Memory). This fault will set if the BLM exceeds -50% fuel corrections.

Diagnostic Aid

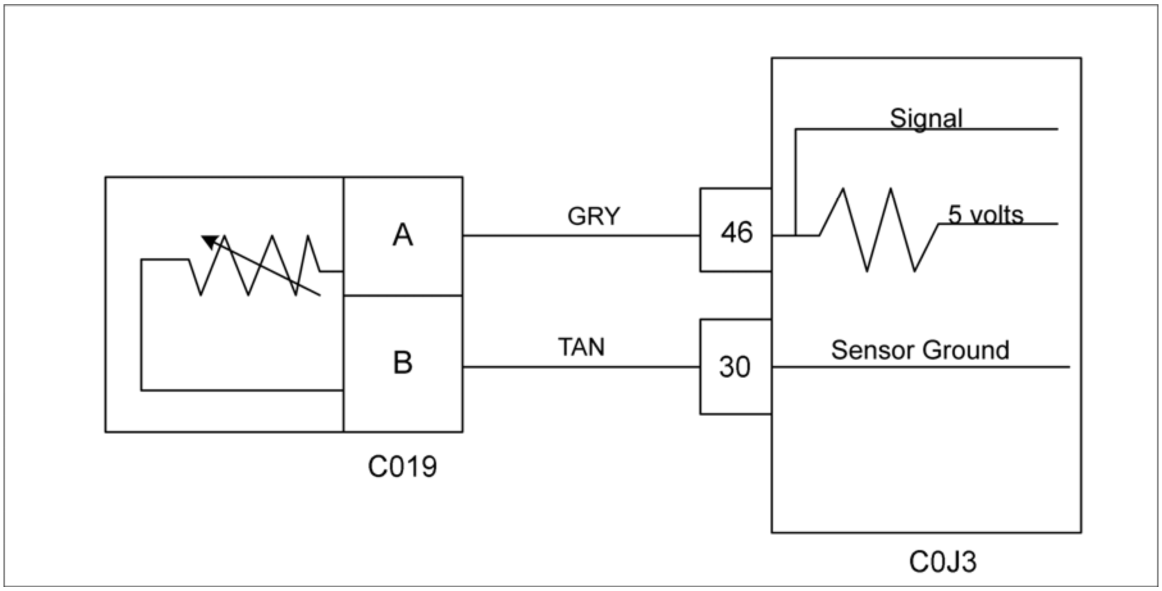
SPN 65565
FMI 1

Fuel System High secondary fuel pressure will cause the system to run rich. A faulty fuel Mixer or pressure regulator may also cause the system to run rich.
FCV A faulty fuel control valve can cause the system to run rich.
Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the fuel system to run rich.
Air Filter A plugged, damaged or modified air filter may cause the system to run rich.

DTC P0172 Fuel Trim Low

Step	Action	Value(s)	Yes	No
1	Perform the On-Board (OBD) System Check? Are any other DTCs present?		Go to Step (3)	Go to Step (2)
2	Visually and physically check the following items: • The air intake duct for being collapsed or restricted • The air filter for being plugged • The HEGO sensor installed securely and the wire leads not damaged contacting the secondary ignition wires • ECM grounds for being clean and tight • Run the fuel system diagnostic checks Was a repair made?		Go to Step (6)	Go to Step (4)
3	Diagnose any other DTC codes before proceeding with this chart Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (6)	Go to Step (4)
4	• Ignition OFF • Disconnect EGO sensor wire harness connector C014 • Disconnect ECM wire harness connector C0J2 • Ignition ON • Using a DVOM check for voltage at the HEGO connector pin B and engine ground Do you have voltage?		Repair the circuit short to voltage as necessary. Refer to wiring harness repair.	Go to Step (5)
5	Replace EGO sensor Is the replacement complete?		Go to Step (6)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM • Turn the Ignition OFF and wait 30 seconds. • Start the engine and operate the engine to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0172 check for any stored codes Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0217-Coolant Temp High Warning



Conditions for Setting the DTC

- Cylinder head temperature
- Check Condition-Engine running
- Fault Condition-ECT temperature greater than 248°F (120°C) for ten seconds.
- MIL-On during active fault
- Engine shut down

Temp (deg F)	Ohms
242.4	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-6.2	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located at the cylinder head or near the thermostat housing. It is used for the engine airflow calculation, ignition timing and other temperature dependant functions. This fault will set if the engine temperature exceeds 248°F (120°C) and deactivated if temperature falls to 221°F (105°C).

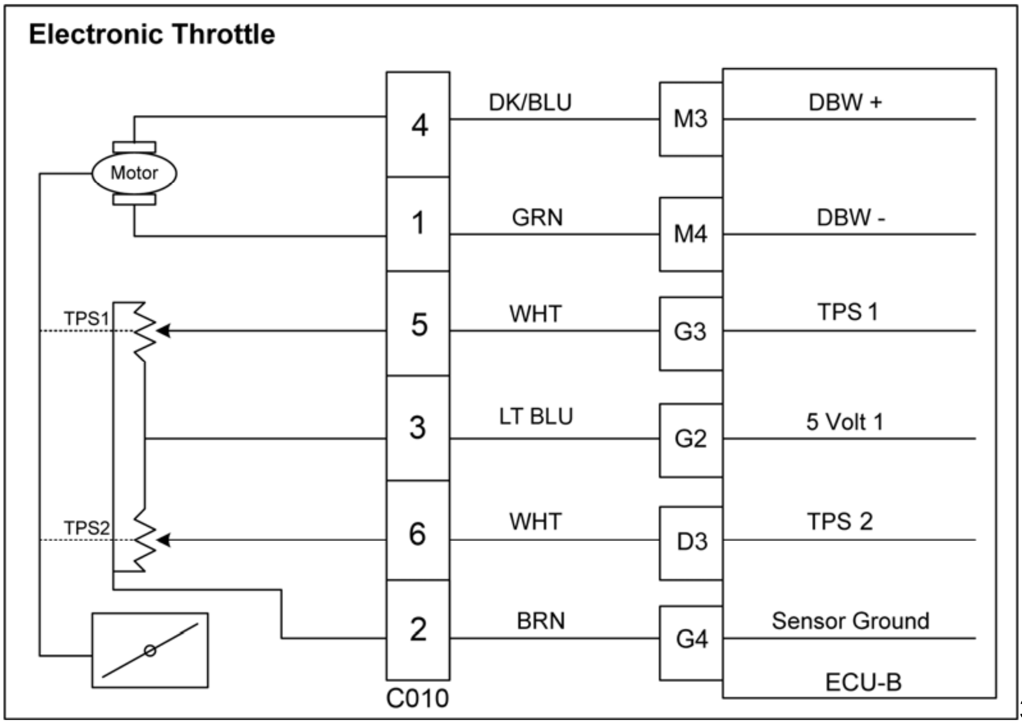
Diagnostic Aid

SPN 65601
FMI 16
Use the temperature vs. Ohms chart above to determine the sensor accuracy. Resistance readings should be ±5%.

DTC P0217 ECT Temp High Warning

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear DTC P0217 • Run the engine to full operating temperature, and then load the engine to at least 50% load. Does the DST display ECT temperature of 221°F (105°C) or greater with the engine running at 50% load?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	Verify with a temperature gauge that the engine coolant is 221°F (105°C) or greater Does the temperature gauge indicate 221°F (105°C) or greater?		Repair the Cooling system.	Go to Step (4)
4	Verify ECT circuit function. Follow the DTC chart procedure for DTC P0117 ECT/CHT Low Voltage		-	-

DTC P0222 ETC TPS 2 Range



3

Conditions for Setting the DTC

- Electronic Throttle Control
- Check Condition-Ignition ON
- Fault Condition-TPS 2 voltage below 0.25 at 5% or TPS 2 voltage greater than 4.95 at 98% for 247ms.
- MIL-On during active fault

Circuit Description

Dual throttle position sensors (TPS) are used with the electronic throttle control (ETC) to determine throttle plate position. The TPS values are used by the ECM to determine if the throttle is opening and closing as commanded. The ECM runs several checks at ignition on to validate the working condition of the ETC. This fault will set if the ECM detects a problem with the TPS sensor range.

Diagnostic Aid

SPN 65601
FMI 2

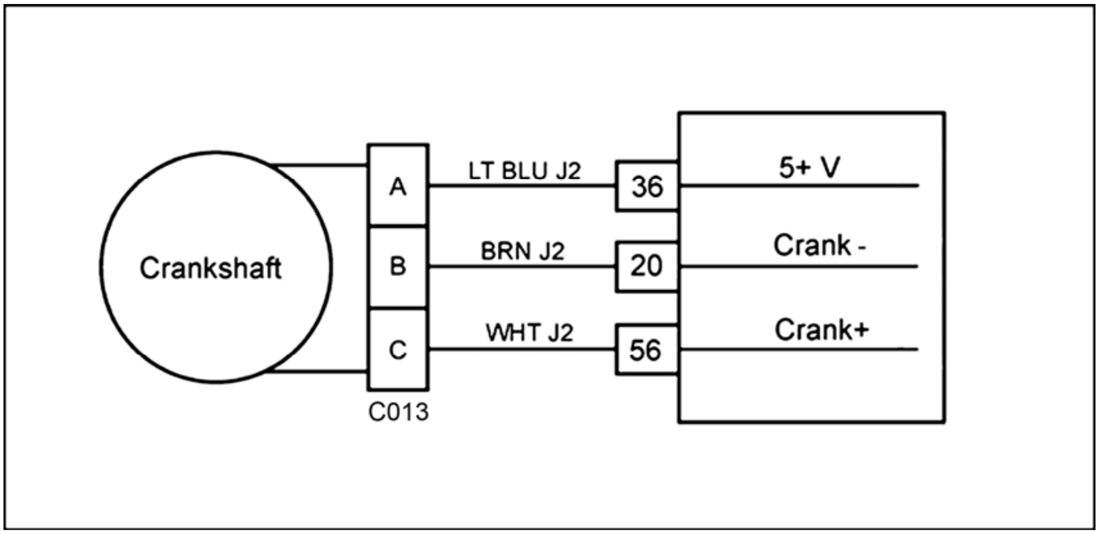
DTC P0222 ETC TPS 2 Range

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in data stream mode. • Clear DTC P0222 • Start the engine Does DTC P0222 re-set?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect electronic throttle connector C010 • Disconnect ECM wire harness connector C0J2 • Inspect the electronic throttle connector and C0J2 wire harness connector for damage corrosion or contamination Did you find a problem?		Correct the problem as required. See wire harness repair.	Go to Step (4)
4	• Ignition OFF • Disconnect electronic throttle connector C010 • Disconnect ECM wire harness connector C0J2 • Using a DVOM check for continuity between electronic throttle connector pin 3 and C0J2 connector pin 43 Does the DVOM show continuity?		Go to Step (5)	Repair the open ground circuit as necessary. Refer to Wiring Repairs.
5	• Disconnect ECM wire harness connector C0J2 • Using a DVOM check for continuity between electronic throttle connector pin 5 and C0J3 connector pin 65 Does the DVOM show continuity?		Go to Step (6)	Repair the open circuit as necessary. Refer to Wiring Repairs.
6	Using a DVOM check for continuity between electronic throttle connector pin 5 and engine ground Does the DVOM show continuity?		Repair the shorted to ground TPS circuit as necessary. Refer to Wiring Repairs.	Go to Step (7)

Step	Action	Value(s)	Yes	No
7	Using a DVOM check for continuity between electronic throttle connector pin 4 and C0J2 connector pin 15 Does the DVOM show continuity?		Go to Step (8)	Repair the open 5 volt circuit as necessary. Refer to Wiring Repairs.
8	Using a DVOM check for continuity between electronic throttle connector pin 4 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (9)
9	Using a DVOM check for continuity between electronic throttle connector pin 1 and C0J2 connector pin 16 Does the DVOM show continuity?		Go to Step (10)	Repair the open TPS circuit as necessary. Refer to Wiring Repairs.
10	Using a DVOM check for continuity between electronic throttle connector pin 1 and engine ground Does the DVOM show continuity?		Repair the shorted TPS circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (11)
11	Using a DVOM check for continuity between electronic throttle connector pin 3 and C0J2 connector pin 43 Does the DVOM show continuity?		Go to Step (12)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
12	Using a DVOM check for continuity between electronic throttle connector pin 2 and C0J2 connector pin 44 Does the DVOM show continuity?		Go to Step (13)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
13	Using a DVOM check for continuity between electronic throttle connector pin 2 and engine ground Does the DVOM show continuity?		Repair the shorted DBW circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (14)
14	• Ignition ON • Using a DVOM check for voltage between electronic throttle connector pin 1 and engine ground Does the DVOM show voltage?		Repair the TPS signal shorted to voltage as necessary. Refer to Wiring Repairs.	Go to Step (15)

Step	Action	Value(s)	Yes	No
15	Replace throttle Is the replacement complete?		Go to Step (16)	-
16	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0222 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (17)
17	Replace the ECM Is the replacement complete?		Go to Step (18)	-
18	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0222 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0336 System Lost Sync with Crank



Conditions for setting the DTC

- Crankshaft Position sensor
- Check Condition-Engine cranking
- Fault Condition-1 invalid crank re-sync in less than 25 ms
- MIL-On

Circuit Description

The Crankshaft position sensor is a 5 volt powered sensor mounted to the lower front engine block. A pulse wheel located on the crankshaft is used to measure engine rpm and its signal is used to synchronize the ignition and fuel systems. This fault will set if no signal is present for 25 ms or longer.

Diagnostic Aid

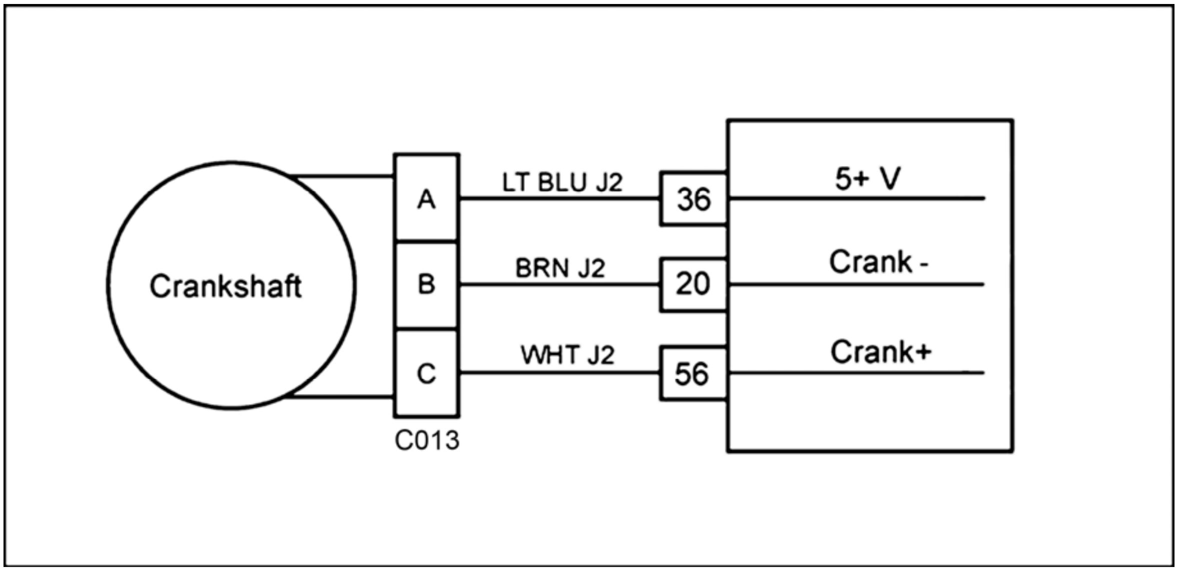
SPN 636
FMI 2

DTC P0336 System Lost Sync with Crank

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Check that the system power and ground terminals C002, C003, C012 and C016 are clean and tight Are the power ground terminals clean and tight?		Go to Step (3)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Ignition OFF • Disconnect ECM connector C0J2 • Disconnect CKP (Crankshaft Position Sensor) connector C013 • Using a DVOM check for continuity between CKP connector pin A and C0J2 pin 36 Does the DVOM show continuity?		Go to Step (4)	Repair the open circuit as necessary. Refer to Wiring harness Repair.
4	• Using a DVOM check for continuity between CKP connector pin B and C0J2 pin 20 Does the DVOM show continuity?		Go to Step (5)	Repair the open circuit as necessary. Refer to Wiring harness Repair.
5	• Using a DVOM check for continuity between CKP connector pin C and C0J2 pin 56 Does the DVOM show continuity?		Go to Step (6)	Repair the open circuit as necessary. Refer to Wiring harness Repair
6	• Using a DVOM check for continuity between CKP connector pins B and C Does the DVOM show continuity?		Repair the shorted circuit as necessary. Refer to Wiring harness Repair	Go to Step (7)
7	• Using a DVOM check for continuity between CKP connector pin B and engine ground Does the DVOM show continuity?		Repair the shorted to ground circuit as necessary. Refer to Wiring harness Repair	Go to Step (8)

Step	Action	Value(s)	Yes	No
8	• Using a DVOM check for continuity between CKP connector pin C and engine ground Does the DVOM show continuity?		Repair the shorted to ground circuit as necessary. Refer to Wiring harness Repair	Go to Step (9)
9	• Replace CKP sensor Is the replacement complete?		Go to Step (11)	-
10	Replace ECM Is the replacement complete?		Go to Step (12)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate to full operating temperature • Observe the MIL • Observe engine performance and drivability • After operating the engine within the test parameters of DTC P0337 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (10)
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0336 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0337 Crank Sync Fault



Conditions for setting the DTC

- CKP (Crankshaft Position Sensor)
- Check Condition-Engine Cranking or Running
- Fault Condition-Crank Sync Loss for more than 25 ms
- MIL-On during active fault

Circuit Description

The CKP is a 5 volt powered sensor that picks up signals from the crankshaft. A pulse wheel located on the crankshaft is used with the CKP sensor to measure engine rpm and its signal is used to synchronize the ignition and fuel system. This fault will set if no signal is present for 25 ms or longer.

Diagnostic Aid

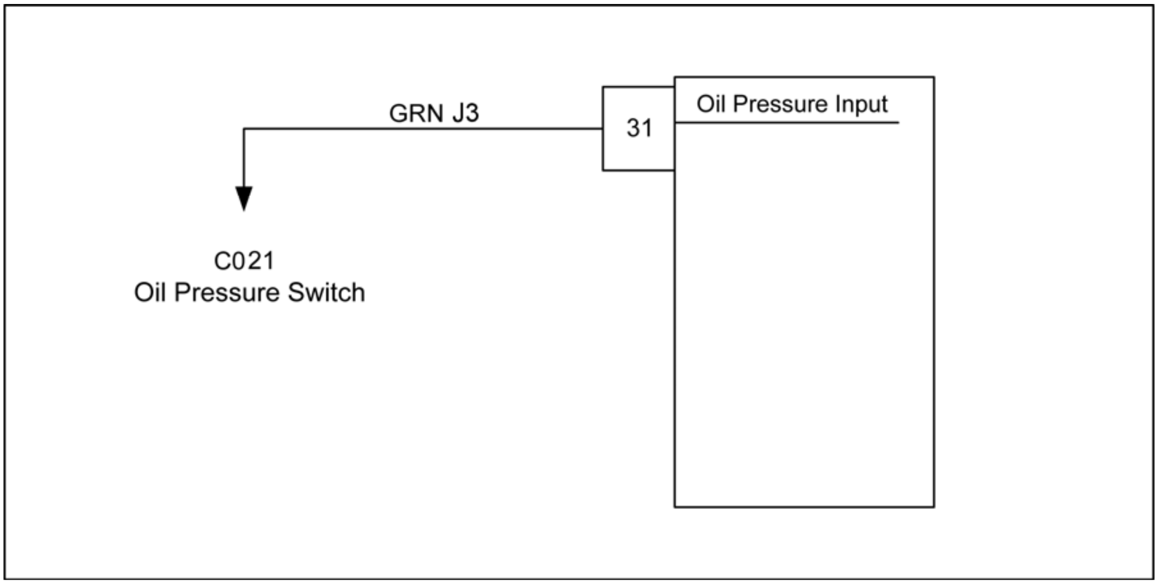
SPN 636
FMI 8
Poor engine grounds, open spark plug wires faulty cap and rotor are known causes of EMI that may set this code. If this code is set with DTC P0642 run the diagnostic chart for this code first as a failure of the 5 volt circuit may cause this code to set.

DTC P0337 Crank Sync Fault

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	Check that the system power and ground terminals C002, C003, C012 and C016 are clean and tight Are the power ground terminals clean and tight?		Go to Step (3)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Ignition OFF • Disconnect ECM connector C0J2 • Disconnect CKP (Crankshaft Position Sensor) connector C013 • Using a DVOM check for continuity between CKP connector pin A and C0J2 pin 36 Does the DVOM show continuity?		Go to Step (4)	Repair the open circuit as necessary. Refer to Wiring harness Repair.
4	Using a DVOM check for continuity between CKP connector pin B and C0J2 pin 20 Does the DVOM show continuity?		Go to Step (5)	Repair the open circuit as necessary. Refer to Wiring harness Repair.
5	Using a DVOM check for continuity between CKP connector pin C and C0J2 pin 56 Does the DVOM show continuity?		Go to Step (6)	Repair the open circuit as necessary. Refer to Wiring harness Repair
6	Using a DVOM check for continuity between CKP connector pins B and C Does the DVOM show continuity?		Repair the shorted circuit as necessary. Refer to Wiring harness Repair	Go to Step (7)
7	Using a DVOM check for continuity between CKP connector pin B and engine ground Does the DVOM show continuity?		Repair the shorted to ground circuit as necessary. Refer to Wiring harness Repair	Go to Step (8)

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between CKP connector pin C and engine ground Does the DVOM show continuity?		Repair the shorted to ground circuit as necessary. Refer to Wiring harness Repair	Go to Step (9)
9	Replace CKP sensor Is the replacement complete?		Go to Step (11)	-
10	Replace ECM Is the replacement complete?		Go to Step (12)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0336 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (10)
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0337 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0524-Oil Pressure Low Warning



Conditions for Setting the DTC

- Engine Low Oil Pressure Signal
- Check Condition-Engine running for greater than 10 seconds with engine speed greater than 500 rpm.
- Fault Condition-No oil pressure signal for more than 10 seconds
- Engine shut down

Circuit Description

The Oil Pressure Switch is used to communicate a low oil pressure condition to the ECM. Engine damage can occur if the engine is operated with low oil pressure. This fault will set if the oil pressure switch remains closed with the engine running. The switch is set to open above 6 PSI.

Circuit Description

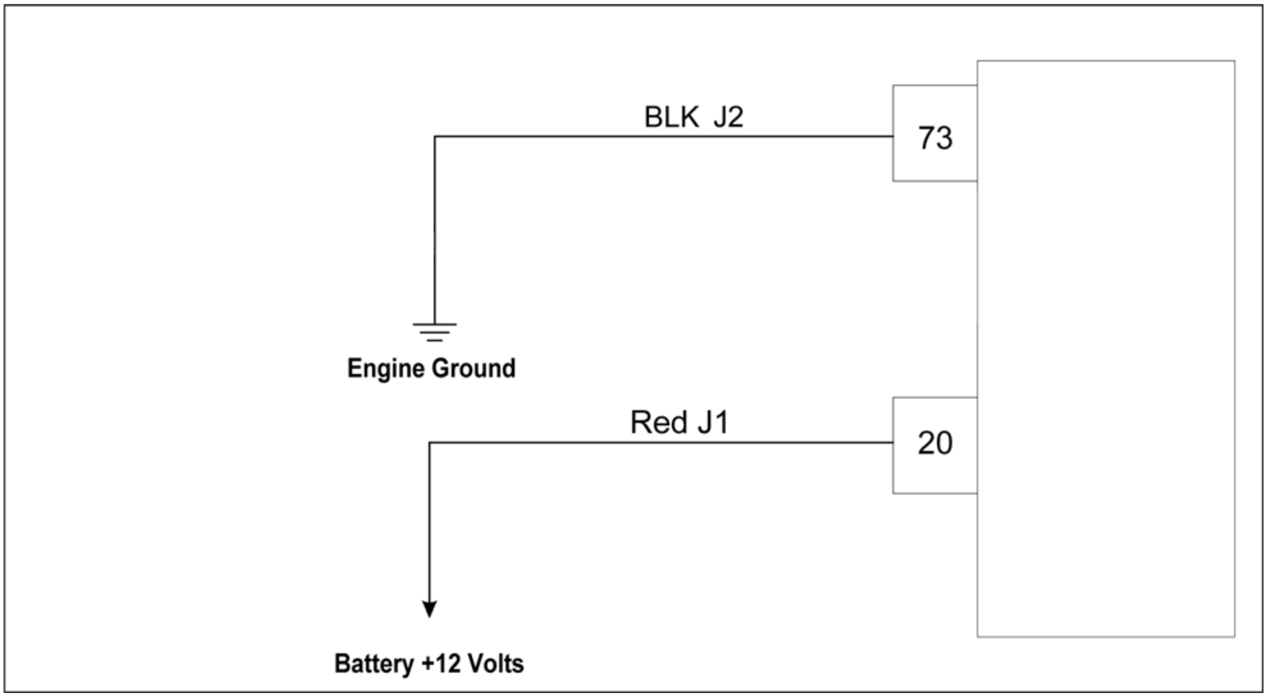
Never assume the fault is due to an electrical malfunction. Low oil pressure can damage the engine. Verify oil pressure before proceeding with this diagnostic.

DTC P0524-Oil Pressure Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System. Check Section
2	Verify that the engine has oil pressure using a mechanical oil pressure gauge before proceeding with this chart. Oil pressure must remain above 6 psi. Does the engine have oil pressure above 6 psi?		Go to Step (3)	Repair faulty Oiling System
3	• Ignition ON, Engine Running DST connected in stem Data Mode • Clear DTC P0524 • Warm the engine by idling until the ECT temperature is above 160 degrees F. and has been running for at least one minute • Increase engine speed above 500 RPM Does DTC P0524 reset?		Go to Step (4)	Intermittent problem. Go to Intermittent section
4	• Clear DTC P0524 • Key OFF • Disconnect oil pressure switch connector C021 and isolate the connector from engine ground. • Start and run the engine Does DTC P0524 reset?		Go to Step (6)	Go to Step (5)
5	Replace oil pressure switch Is the replacement complete?		Go to Step (9)	-
6	• Ignition OFF • Disconnect ECM harness connector C0J3 • Using a DVOM check for continuity between the oil pressure switch connector pin and engine ground Does the DVOM show continuity?		Repair the shorted to ground oil pressure circuit as necessary. Refer to Wiring Repairs.	Go to Step (7)
7	Inspect C0J2 connector pin 31 for damage corrosion or contamination Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)

Step	Action	Value(s)	Yes	No
8	Replace ECM Is the replacement complete?		Go to Step (9)	-
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0524 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0562 System Voltage Low Warning



Conditions for Setting the DTC

- System Voltage
- Check Condition-Ignition ON
- Fault Condition-System voltage less than 10 volts for 5 seconds.
- MIL-On

Circuit Description

The battery voltage powers the ECM and must be measured to correctly operate drivers, trim valves and ignition coils. This fault will set if the ECM detects a system supply voltage less than 10 volts.

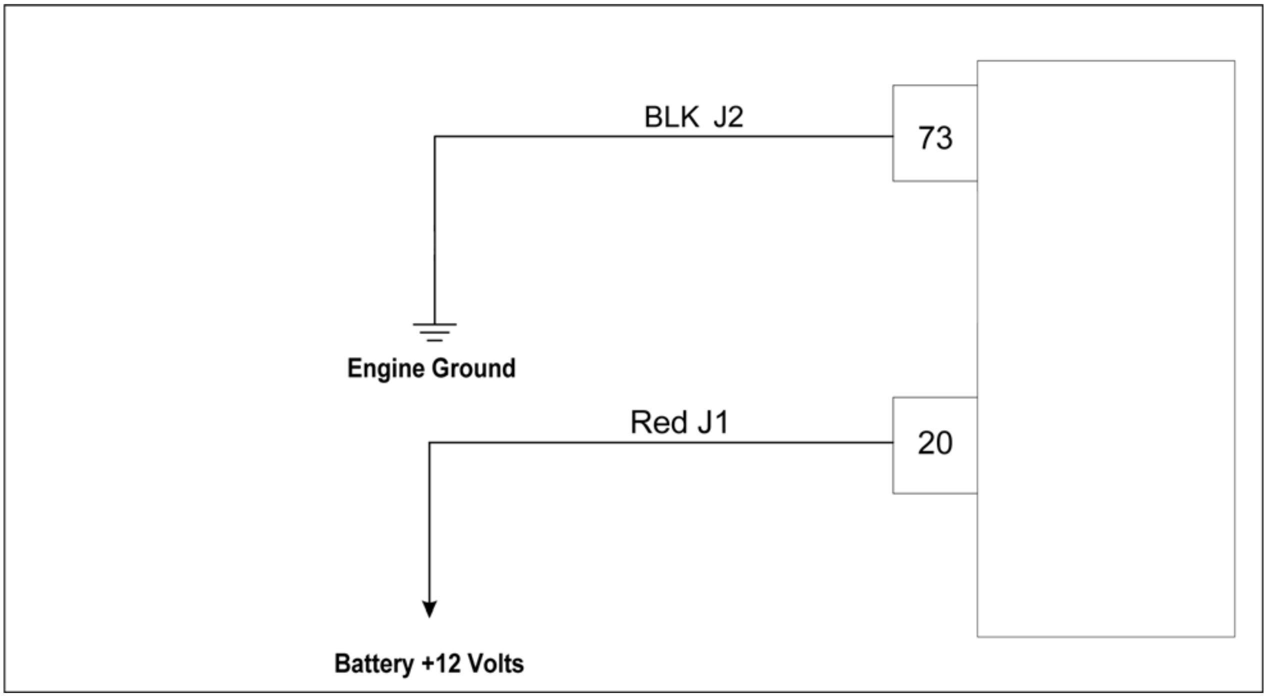
Diagnostic Aid

SPN 627
FMI 17
Check battery condition and cables, charging system and starter condition before proceeding with this diagnostic chart.

DTC P0562 System Voltage Low Warning

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine greater than 1500 rpm. Does DST display system voltage greater than 16 volts?	-	Go To Step (3)	Intermittent problem. Go to Engine Electrical Intermittent section
3	Check voltage at battery terminals with DVOM with engine speed greater than 1500 rpm Is it greater than 16 volts?	-	Go to Step (4)	Go to Step (5)
4	Repair the charging system Has the charging system been repaired?	-	Go to Step (6)	-
5	Replace ECM Is the replacement complete?		Go to Step (6)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0562 check for any stored codes. Does the engine operate normally with no stored codes?	-	System OK	Go to OBD System Check

DTC P0563 System Voltage High Warning



Conditions for Setting the DTC

- System Voltage to ECM
- Check Condition-Ignition ON
- Fault Condition-System battery voltage at ECM greater than 16 volts for 5 seconds
- MIL-On for active fault

Circuit Description

The battery voltage powers the ECM and must be measured to correctly operate drivers, trim valves and ignition coils. This fault will set if the ECM detects a supply voltage greater than 16 volts.

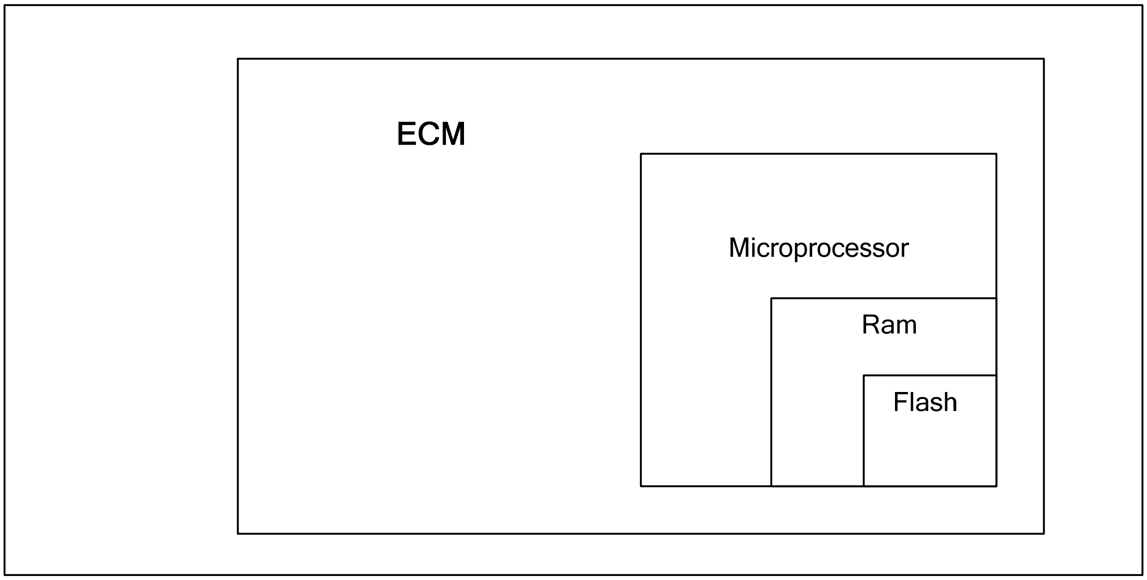
Diagnostic Aid

SPN 627
FMI 15
Avoid the use of “boost start” battery chargers. Check the condition of the charging system before proceeding with this diagnostic.

DTC P0563 System Voltage High Warning

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?		Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Start and run the engine. Does DST display system voltage greater than 16 volts?		Go To Step (3)	Intermittent problem. Go to Engine Electrical Intermittent section
3	Check voltage at the battery terminals with DVOM with the engine running. Does the DVOM show voltage greater than 16 volts?	Greater than 16 volts	Go to Step (4)	Go to Step (5)
4	Repair the charging system Has the charging system been repaired?		Go to Step (6)	-
5	Replace ECM Is the replacement complete?		Go to Step (6)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0563 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0601 Cal Memory Failure



Conditions for Setting the DTC

- Engine Control Module
- Check Condition-Ignition ON
- Fault Condition-Internal microprocessor error
- MIL-On

Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). This diagnostic also addresses if the ECM is not programmed or the program checksum does not match or has become corrupted. Always verify that the ECM was flashed with the proper calibration files before using the following diagnostic chat.

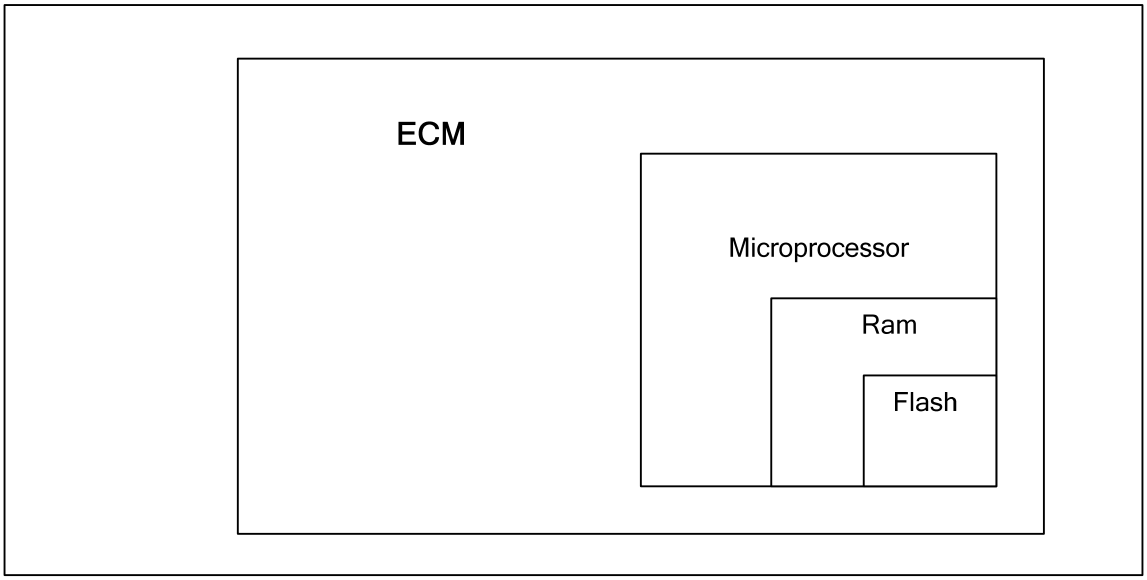
Diagnostic Aid

SPN 630
FMI 13

DTC P0601 Cal Memory Failure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear system fault code • Ignition OFF • Ignition ON Does DTC P0601 reset with the Ignition ON?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Check ECM power and ground connections at C0J1 pin 20, C0J2 pin 73, C002, C012 and C016 Did the power and ground circuits check OK?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Re-flash the ECM with the correct calibration file • Repeat all in step (2). Does DTC P0601 still set?		Go to Step (5)	Go to Step (6)
5	Replace ECM Is the replacement complete?		Go to Step (5)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM • Turn the Ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0601 check for any stored codes Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0606 MHC Failure



Conditions for Setting the DTC

- Engine Control Module
- Check Condition-Key ON
- Fault Condition-Malfunction in control module (Main Help Coprocessor)
- MIL-On
- Engine shut down

Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). This diagnostic also addresses if the ECM is not programmed or the program checksum does not match or has become corrupted. Always verify that the ECM was flashed with the proper calibration files before using the following diagnostic chat.

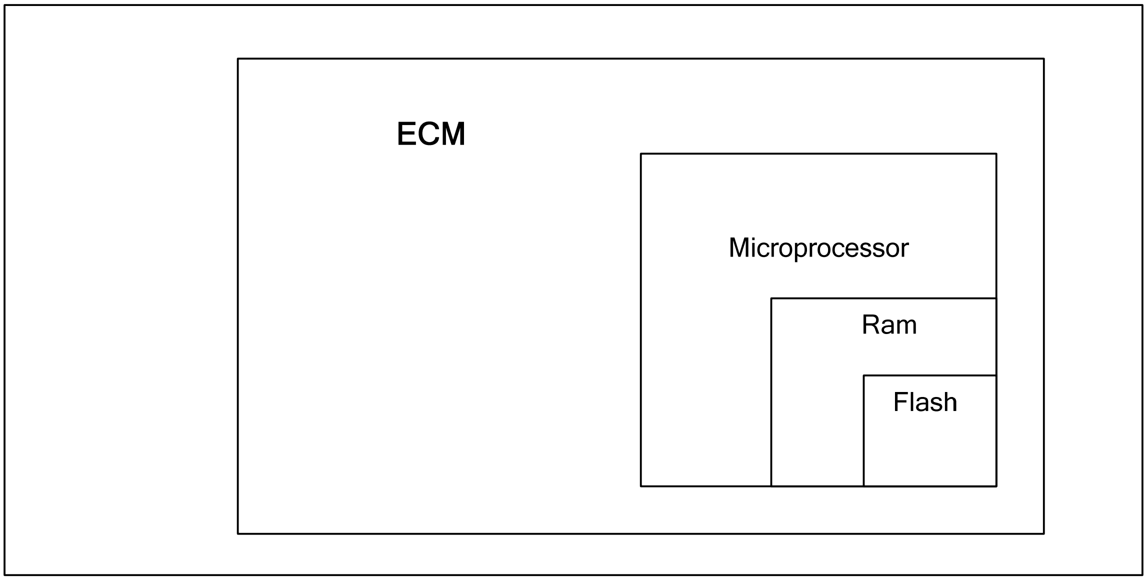
Diagnostic Aid

SPN 65580
FMI 12

DTC P0606 MHC Failure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition On • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear system fault code • Ignition OFF • Ignition ON Does DTC P0606 reset with the Ignition ON?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	Check ECM power and ground connections at C0J1 pin 20, C0J2 pin 73, C002, C012 and C016 Did the power and ground circuits check OK?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Re-flash the ECM with the correct calibration file • Repeat all in step (2). Does DTC P0606 still set?		Go to Step (5)	Go to Step (6)
5	Replace ECM Is the replacement complete?		Go to Step (5)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0606 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P06B8 NV Ram Failure



Conditions for Setting the DTC

- Engine Control Module
- Check Condition-Ignition ON
- Fault Condition-NV (non volatile) RAM Checksum does not match
- System voltage greater than 8 volts.
- MIL-On

Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). This diagnostic also addresses if the ECM is not programmed or the program checksum does not match or has become corrupted. Always verify that the ECM was flashed with the proper calibration files before using the following diagnostic chat.

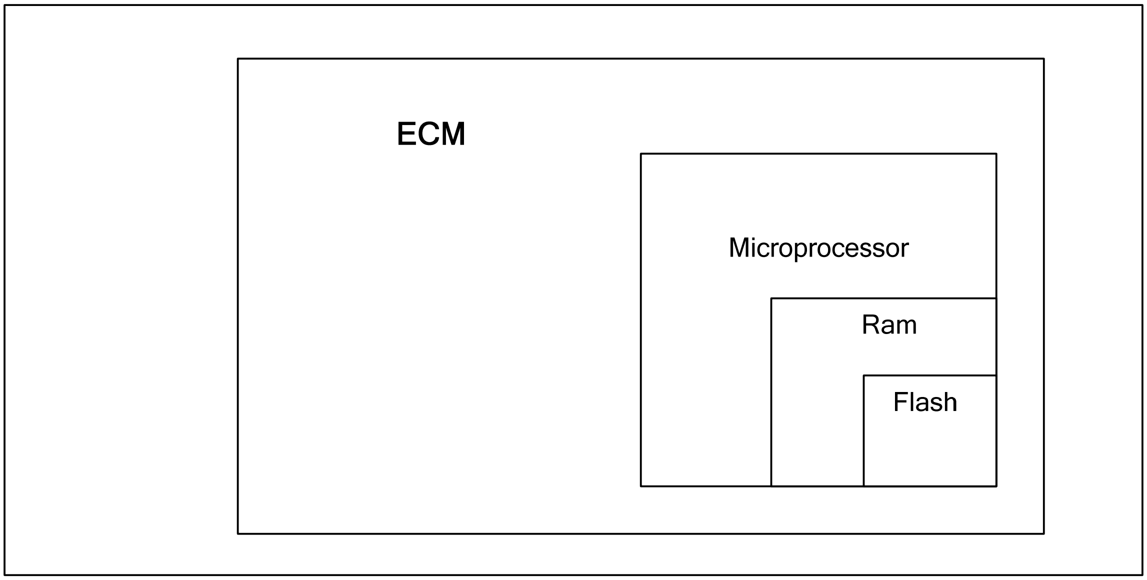
Diagnostic Aid

SPN 65582
FMI 2

DTC P06B8 NV Ram Failure

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear system fault code • Ignition OFF • Ignition ON Does DTC P06B8 reset with the Key on?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Check the system power and ground connections at C0J1 pin 20, C0J2 pin 73, C002, C012 and C016 Did the power and ground circuits check OK?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Re-flash the ECM with the correct calibration file • Repeat all in step (2) Does DTC P06B8 still set?		Go to Step (5)	Go to Step (6)
5	• Replace ECM Is the replacement complete?		Go to Step (5)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the engine to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P06B8 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0613 ETC Process Fault



Conditions for Setting the DTC

- Engine Control Module
- Check Condition-Ignition ON
- Fault Condition-Malfunction in control module
- MIL-On

Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). This diagnostic also addresses if the ECM is not programmed or the program checksum does not match or has become corrupted. Always verify that the ECM was flashed with the proper calibration files before using the following diagnostic chat. This fault will set if an error is detected in the ETC (electronic throttle control) process of the ECM.

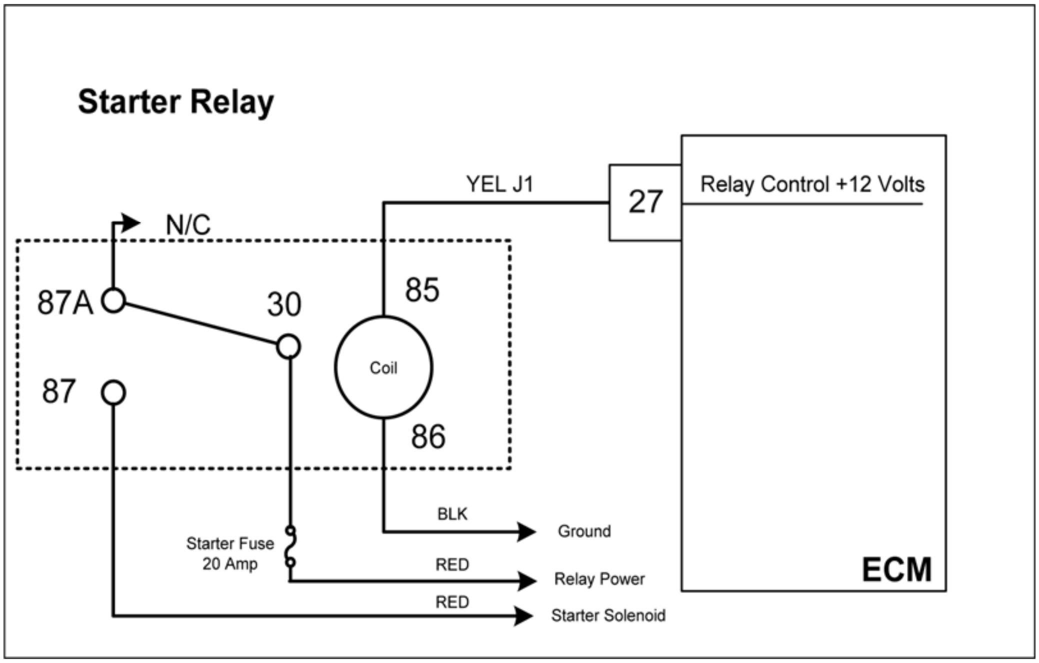
Diagnostic Aid

SPN 65616
FMI 12

DTC P0613 ETC Process Fault

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear system fault code • Key Off • Key On Does DTC P0613 reset with the Key on?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Check the system power and ground connections at C0J2 pin 73, C0J1 pin 20 Did the power and ground circuits check OK?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Re-flash the ECM with the correct calibration file • Repeat all in step (2). Does DTC P0613 still set?		Go to Step (5)	Go to Step (6)
5	• Replace ECM Is the replacement complete?		Go to Step (5)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the engine to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0613 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0616 Starter Relay High Side Driver Short Low



Conditions for Setting the DTC

- Power relay check
- Check Condition-Key ON
- Fault Condition-Relay

Circuit Description

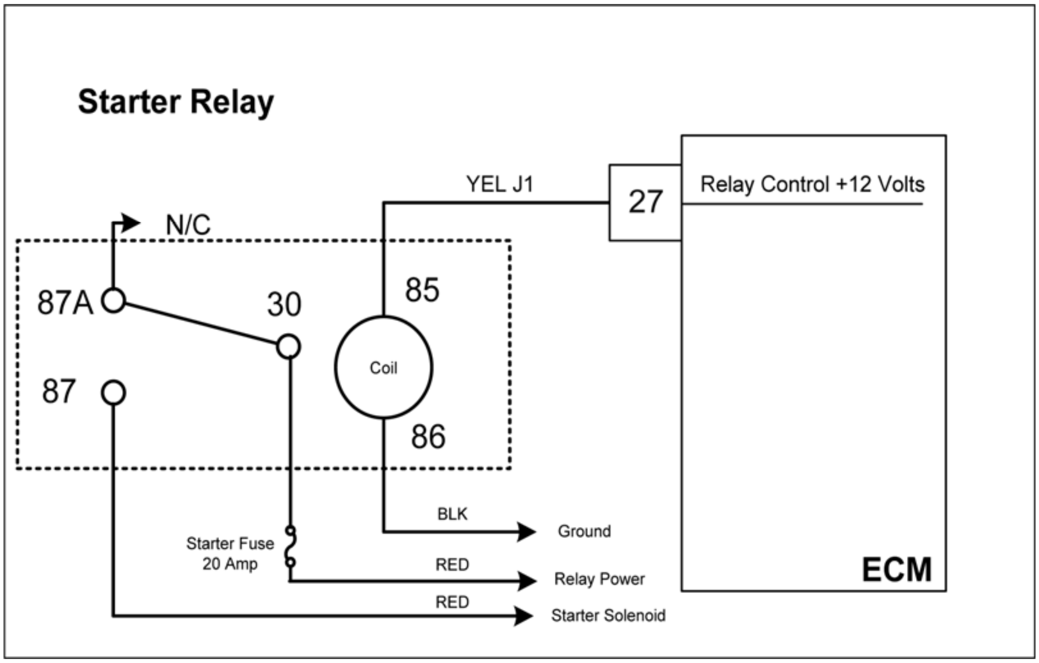
The power relay switches power out to various sensors, actuators and solenoids in the fuel system. This fault will set if the ECM detects a short circuit to power on the relay control output.

Diagnostic Aid
SPN 66002
FMI 4

DTC P0616 Starter Relay High Side Driver Short Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, DST connected in the System Data mode • Clear DTC P0616 • Start the engine Does DTC P0616 re-set?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Kef OFF • Disconnect ECM connector C0J1 • Using a DVOM check the resistance value between C0J1pin 27 and engine ground Is the resistance less than 60 ohms?		Go to Step (4)	Go to Step (6)
4	• Remove the power relay from the fuse block • Using a DVOM check the resistance value again between C0J1 pin 27 and engine ground Is the resistance less than 60 ohms?		Repair the shorted to ground relay control circuit as necessary. See wiring harness repairs	Go to Step (5)
5	Replace the power relay Is the replacement complete?		Go to Step (7)	–
6	Replace ECM Is the replacement complete?		Go to Step (7)	–
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0616 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0617 Starter Relay High Side Driver Short High/Open



Conditions for Setting the DTC

- Power relay check
- Check Condition-Ignition ON
- Fault Condition-Relay control circuit at zero volts for 5 seconds

Circuit Description

The power relay switches power out to various sensors, actuators and solenoids in the fuel system. This fault will set if the ECM detects a short circuit to power or open circuit on the relay control output.

Diagnostic Aid

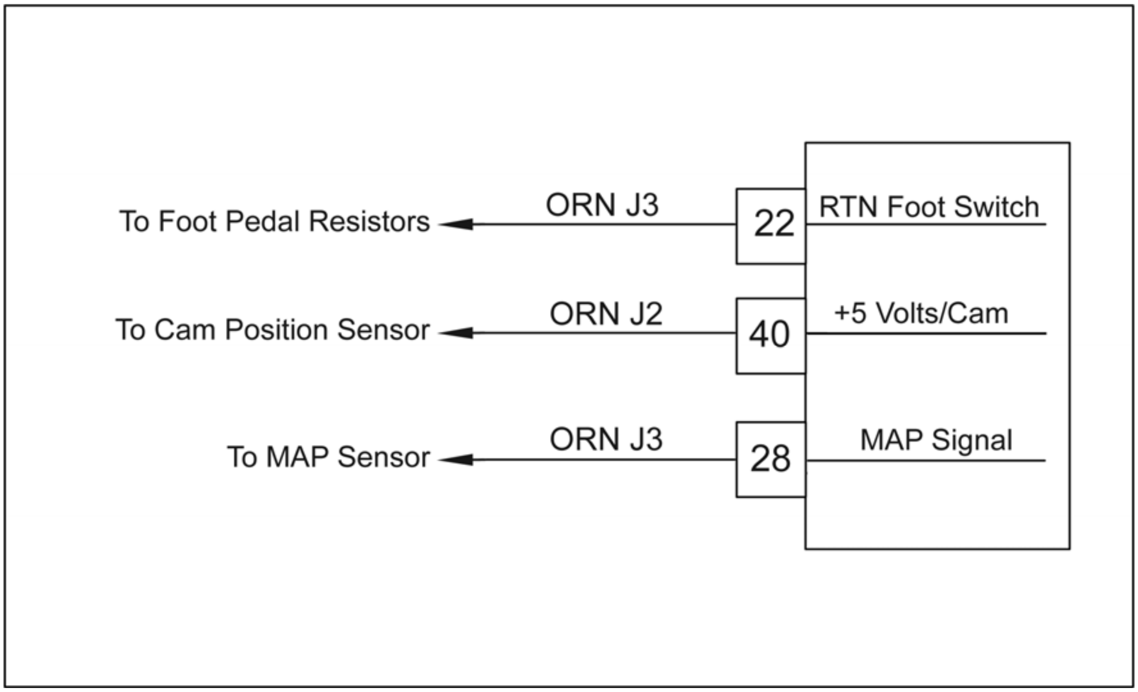
SPN 66002
FMI 5
Relay coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values, be sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

DTC P0617 Starter Relay High Side Driver Short High/Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Ignition OFF • Remove the power relay from the fuse block • Using a DVOM check the resistance of the relay coil between terminals 85 and 86 Is the resistance value greater than 125 ohms?		Go to Step (3)	Go to Step (4)
3	Replace the power relay Is the replacement complete?		Go to Step (11)	–
4	• Disconnect ECM connector C0J1 • Using a DVOM check for continuity between C0J1 pin 27 and terminal 85 for the power relay at the fuse box Does the DVOM show continuity?		Go to Step (5)	Repair the open power relay control circuit as required. See wiring harness repairs
5	Using a DVOM check for continuity between engine ground and terminal 86 for the power relay at the fuse box Does the DVOM show continuity?		Go to Step (6)	Repair the open power relay control circuit as required. See wiring harness repairs
6	• Ignition ON • Using a DVOM check for voltage between engine ground and terminal 86 for the power relay at the fuse box Does the DVOM show voltage?		Repair the shorted to power relay control circuit as required. See wiring harness repairs	Go to Step (7)
7	Using a DVOM check for voltage between engine ground and terminal 85 for the power relay at the fuse box Does the DVOM show voltage?		Repair the shorted to power relay control circuit as required. See wiring harness repairs	Go to Step (8)
8	Replace the power relay Is the replacement complete?		Go to Step (10)	-

Step	Action	Value(s)	Yes	No
9	Replace the ECM Is the replacement complete?		Go to Step (11)	–
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0617 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (9)
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0617 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0642 5 Volt Buffer A Reference Low



Conditions for Setting the DTC

- External 5 volt reference
- Check Condition-Engine cranking or running
- Fault Condition-5 volt reference voltage lower than 4.43 volts
- MIL-On

Circuit Description

The 5 volt supply powers many of the sensors and other components of the fuel system. The accuracy of the 5 volt supply is very important to the accuracy of these powered sensors used by the ECM. The ECM is able to determine if they are overloaded, shorted, or otherwise out of specification by monitoring the 5 volt supply. This fault will set if the 5 volt reference A is below 4.43 volts.

Diagnostic Aid

SPN 65520
FMI 4
Shorted sensors or 5 volt supply wires are common reasons for this code to set.

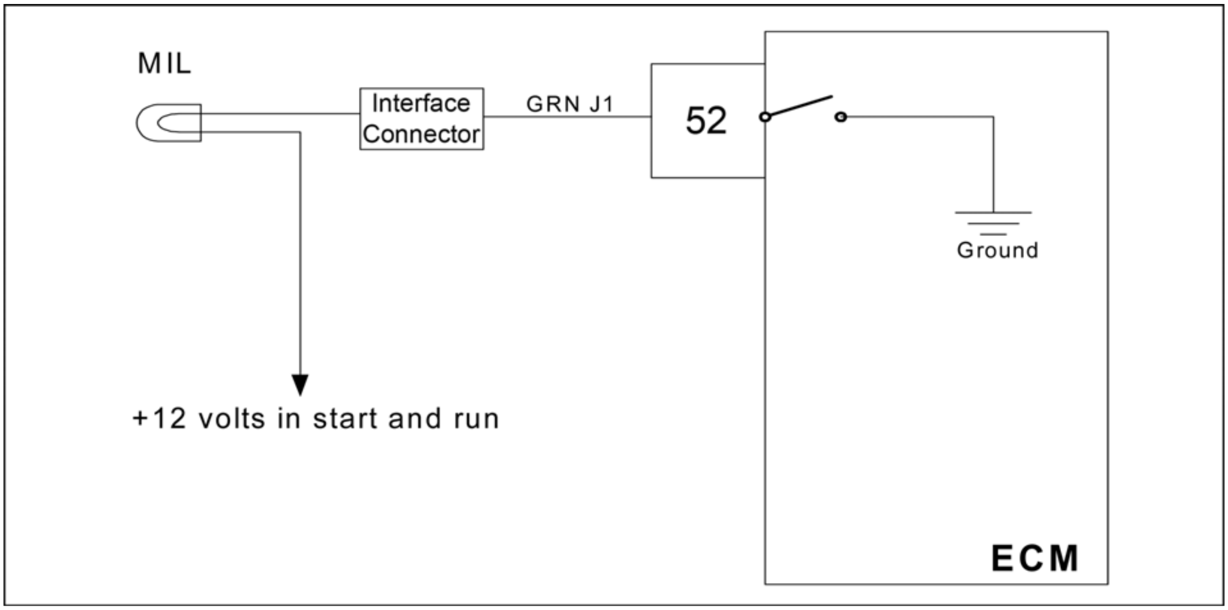
DTC P0642 5 Volt Buffer A Reference Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Engine Running • DST (Diagnostic Scan Tool) connected in System Fault Mode Does DST display DTC P0642?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect ECM connector C0J3 • Using DVOM check for continuity between C0J3 pin 22 and C0J2 pin 73 engine ground Does the DVOM show a resistance value of 4.1K Ohms ±10%	4.1K Ohms ±10%	Go to Step (4)	Repair the open 5 volt circuit. Refer to wire harness repair section
4	Using a DVOM check between C0J3 pin 22 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit. Refer to wire harness repair section	Go to Step (5)
5	• Disconnect the ECM connector C0J2 • Disconnect the cam sensor connector C015 • Using a DVOM check for continuity between C0J2 pin 40 and cam sensor pin 3 Does the DVOM show continuity?		Go to Step (6)	Repair the open 5 volt circuit. Refer to wire harness repair section
6	Using a DVOM check between C0J3 pin 22 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit. Refer to wire harness repair section	Go to Step (7)
7	• Disconnect the ECM connector C0J3 • Disconnect the TMAP sensor connector C020 • Using a DVOM check for continuity between ECM connector pin C0J3 pin 28 and TMAP connector pin 3 Does the DVOM show continuity?		Go to Step (8)	Repair the open 5 volt circuit. Refer to wire harness repair section

Step	Action	Value(s)	Yes	No
8	Using a DVOM check between C0J3 pin 36 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit. Refer to wire harness repair section	Go to Step (9)
9	• While monitoring DVOM for continuity between ECM 5 volt reference and engine ground • Disconnect each sensor (below) one at a time to find the shorted 5 volt reference. When continuity to engine ground is lost the last sensor disconnected is the area of suspicion. Inspect the 5 volt reference supply wire leads for shorts before replacing the sensor. • TMAP • Camshaft Sensor While disconnecting each sensor one at a time did you lose continuity?		Go to Step (10)	Repair or replace shorted wire harness or foot pedal resistor block.
10	Replace the last disconnected sensor Is the replacement complete?		Go to Step (11)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0642 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (12)
12	Replace the ECM Is the replacement complete?		Go to Step (13)	-

Step	Action	Value(s)	Yes	No
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0642 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System check

DTC P0650 MIL Driver shorted Low/Open



Conditions for setting the DTC

- MIL check
- Check Condition-Ignition ON
- Fault Condition-ECM MIL circuit shorted low or open
- MIL Command-ON

Circuit Description

The fuel system is equipped with OBD (On-Board Diagnostics). The system incorporates a MIL (Malfunction Indicator Lamp). The MIL serves as notification of an emissions related system problem. The following DTC charts in this manual will instruct the technician to perform the OBD system check. This simply means to verify the proper operation of the MIL. The MIL should illuminate when the key is in the ON position, and the engine is not running. This feature verifies that the MIL and control circuit is in proper working order. If the MIL does not illuminate with the vehicle key ON and engine OFF, repair it as soon as possible. It is part of the emission control system. Once the engine is in start or run mode, the MIL should turn OFF. If the MIL stays ON while the engine is in the start or run mode, a current diagnostic trouble code may be set or a problem may exist with the MIL control circuit. The electrical schematic above shows the MIL power source supplied to the lamp. The ECM completes the circuit to ground to turn the MIL ON. This fault will set if the ECM MIL control circuit is open or shorted low.

Diagnostic Aid

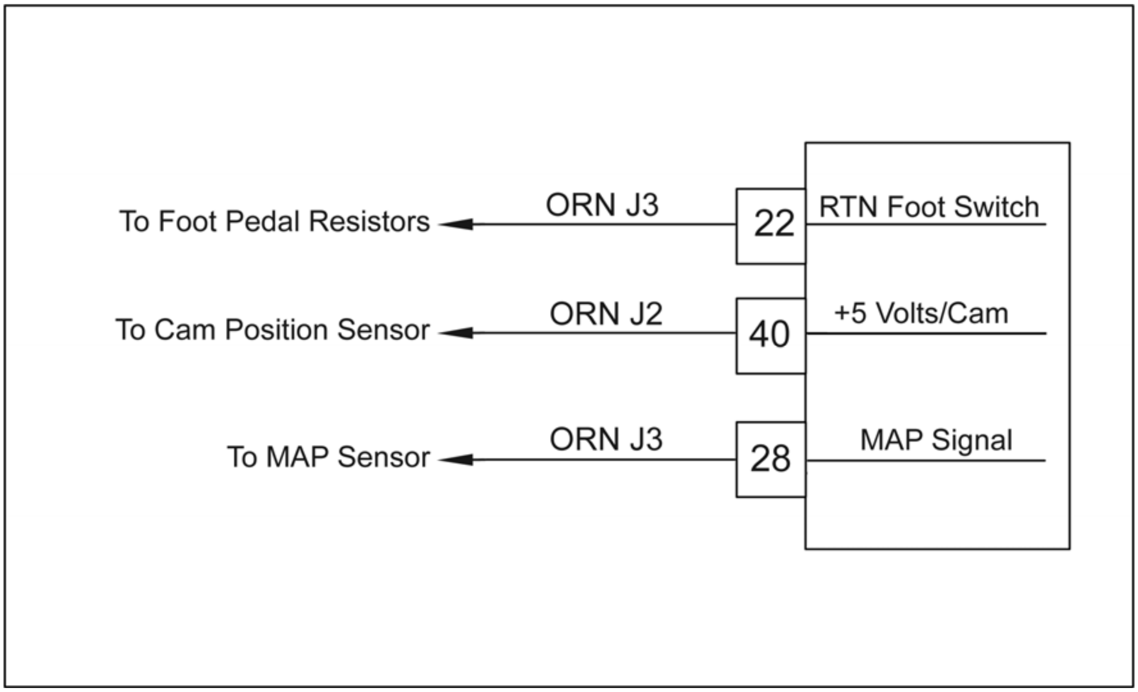
SPN 66003
FMI 5

DTC P0650 MIL Driver Short Low Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear system fault code • Key OFF • Key ON Does DTC P0650 reset?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Remove the MIL bulb. • Inspect the MIL bulb socket. • Using a DVOM check for continuity through the bulb. Do you have continuity?		Go to step (5)	Go to step (4)
4	• Replace the open MIL bulb or faulty socket. Is the replacement complete?		Go to Step (8)	–
5	• Key OFF • Re-install the bulb or driver device • Disconnect the interface connector C001 • Using a DVOM check for continuity between vehicle interface connector pin G and battery positive Do you have continuity?		Go to step (6)	Repair the open circuit as required. See wire harness repair
6	• Disconnect ECM wire harness connector C0J1 • Using a DVOM check for continuity between ECM harness connector pin 12 and vehicle interface connector pin G Do you have continuity?		Go to step (7)	Repair the open circuit as required. See wire harness repair
7	• Inspect ECM wire harness connector pin 12 and vehicle interface connector pin G for damage, corrosion or contamination Did you find a problem?		Correct the problem as required. See wiring harness repair	Go to step (8)
8	• Replace The ECM Is the replacement complete?		Go to Step (9)	-

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the engine to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0650 check for any stored codes. Does the MIL operate normally with no stored codes?		System OK	Go to OBD System check

DTC P0652 5 Volt Buff B Reference Low



Conditions for Setting the DTC

- External 5 volt reference
- Check Condition-Engine cranking or running
- Fault Condition-5 volt reference voltage lower than 4.43 volts
- MIL-On during active fault

Circuit Description

The 5 volt supply powers many of the sensors and other components of the fuel system. The accuracy of the 5 volt supply is very important to the accuracy of these powered sensors used by the ECM. The ECM is able to determine if they are overloaded, shorted, or otherwise out of specification by monitoring the 5 volt supply. This fault will set if the 5 volt reference B is below 4.43 volts.

Diagnostic Aid
SPN 65523
FMI 4

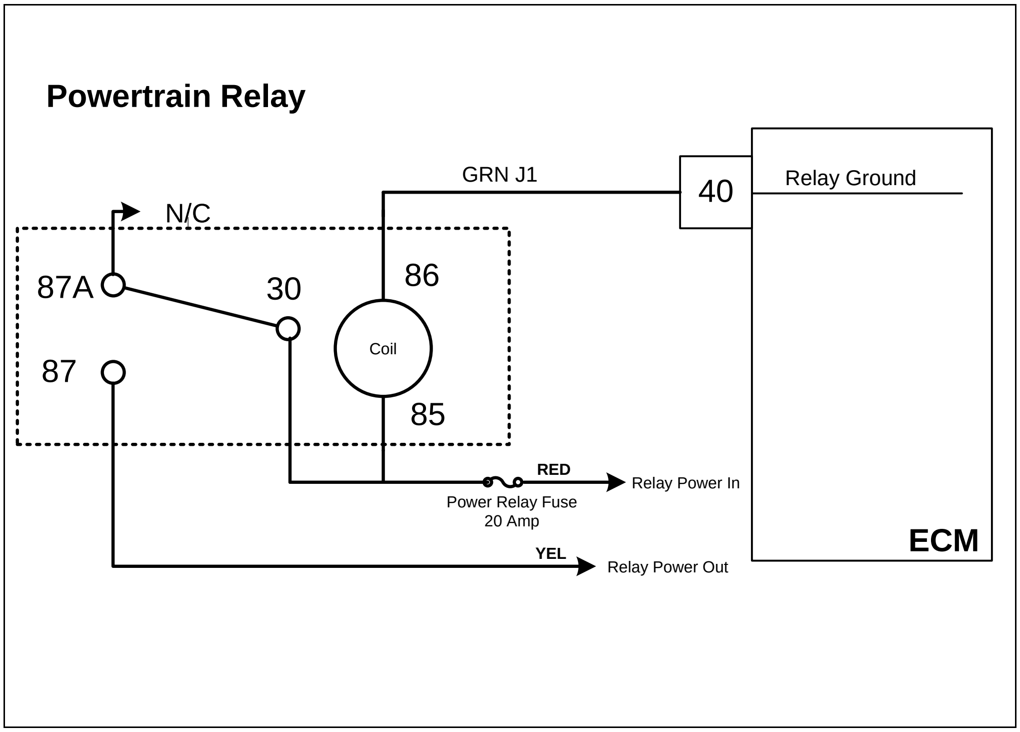
DTC P0652 5 Volt Buff B Reference Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Engine Running • DST (Diagnostic Scan Tool) connected in System Fault Mode Does DST display DTC P0652?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect ECM connector C0J1 • Using DVOM check for continuity between C0J3 pin 22 and C0J2 pin 73 engine ground Does the DVOM show a resistance value of 4.1K Ohms ±10%	4.1K Ohms ±10%	Go to Step (4)	Repair the open 5 volt circuit. Refer to wire harness repair section
4	Using a DVOM check between C0J2 pin 73and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit. Refer to wire harness repair section	Go to Step (5)
5	• Disconnect the ECM connector C0J2 • Disconnect the crank sensor connector C013 • Using a DVOM check for continuity between C0J2 pin 36 and crank sensor pin A Does the DVOM show continuity?		Go to Step (6)	Repair the open 5 volt circuit. Refer to wire harness repair section
6	• Disconnect the ECM connector C0J2 • Using a DVOM check between C0J3 pin 22 and engine ground. Does the DVOM show continuity?		Repair the shorted 5 volt circuit. Refer to wire harness repair section	Go to Step (7)
7	• Disconnect the throttle connector C010 • Using a DVOM check for continuity between C0J2 connector pin 15 and throttle connector pin 4 Does the DVOM show continuity?		Go to Step (8)	Repair the open 5 volt circuit. Refer to wire harness repair section

Step	Action	Value(s)	Yes	No
8	Using a DVOM check between C0J2 pin 15 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit. Refer to wire harness repair section	Go to Step (9)
9	• While monitoring DVOM for continuity between ECM 5 volt reference and engine ground • Disconnect each sensor (below) one at a time to find the shorted 5 volt reference. When continuity to engine ground is lost the last sensor disconnected is the area of suspicion. Inspect the 5 volt reference supply wire leads for shorts before replacing the sensor. • Throttle connector • Crankshaft Sensor While disconnecting each sensor one at a time did you lose continuity?		Go to Step (10)	Repair or replace shorted wire harness or foot pedal resistor block.
10	Replace the last disconnected sensor Is the replacement complete?		Go to Step (11)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0652 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (12)
12	Replace the ECM Is the replacement complete?		Go to Step (13)	-

Step	Action	Value(s)	Yes	No
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0652 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System check

DTC P0685 Powertrain Relay Contact Low



Conditions for Setting the DTC

- Power relay check
- Check Condition-Ignition ON
- Fault Condition-Relay contact voltage 3.0 volts lower that ignition voltage for 2.25 seconds.

Circuit Description

The power relay switches power out to various sensors, actuators and solenoids in the fuel system. This fault will set if the ECM detects relay contact voltage 3.0 volts lower than ignition voltage.

Diagnostic Aid

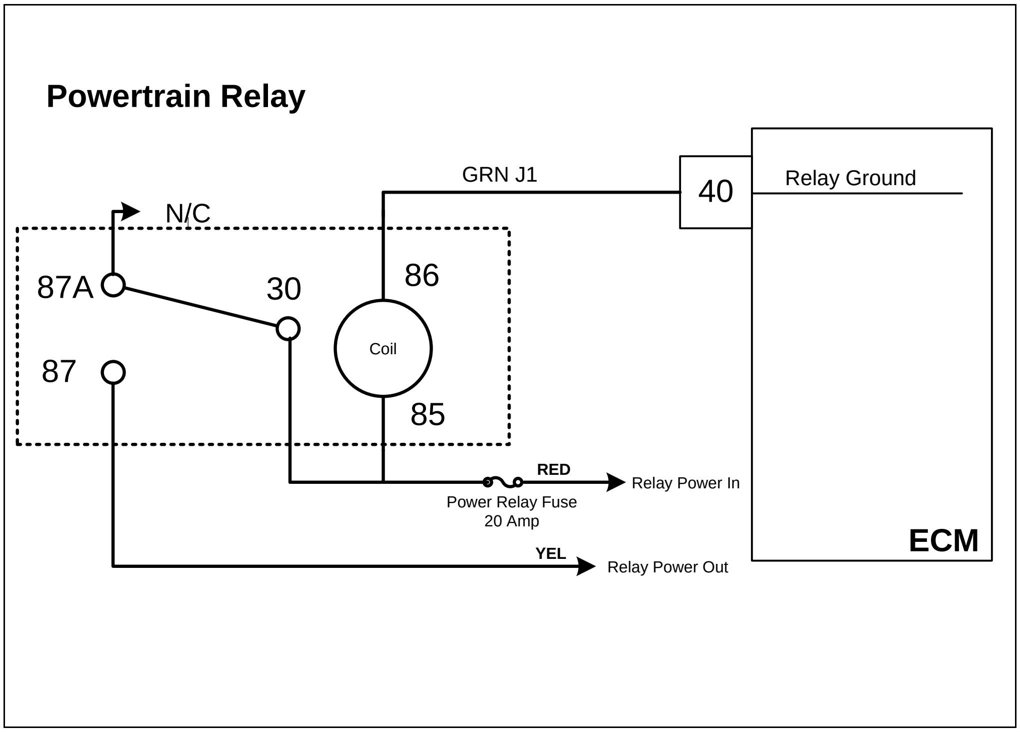
SPN 66014
FMI 4
Check battery and starter condition before proceeding with the diagnostic.

DTC P0685 Powertrain Relay Contact Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Check the system power and ground connections at C002, C012, and C016 for damage corrosion or contamination. • Check the power and ground connections at the GIC (Genset Interface Connector) pins A, D and E for damage, corrosion or contamination. • Check the system power fuse contacts at the VSW fuse, power relay fuse and AUX fuse for damage, corrosion or contamination. Did you find a problem and make a repair?		Go to Step (6)	Go to Step (3)
3	• Ignition OFF • Remove power relay from the fuse box • Remove power relay fuse (20 Amp) • Remove the ECM connector C0J1 • Using a DVOM check for continuity between C0J1 pin 20 and power relay fuse contact (relay side) Does the DVOM show continuity with less than 1.0 Ohm?	Less than 1.0 Ohm	Go to Step (4)	Repair the open power relay circuit. See wire harness repair.
4	• Disconnect ignition coil connector C005 • Using a DVOM check for continuity at the fuse box between the power relay terminal 87 and ignition coil pin A. Does the DVOM show continuity with less than 1.0 Ohm?	Less than 1.0 Ohm	Go to Step (5)	Repair the open power relay circuit. See wire harness repair.
5	• Replace the Power Relay Is the replacement complete?		Go to Step (6)	-

Step	Action	Value(s)	Yes	No
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P0685 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0686 Powertrain Relay Driver Short Low/Open



Conditions for Setting the DTC

- Power relay check
- Check Condition-Ignition ON
- Fault Condition-Power relay control circuit at zero volts.

Circuit Description

The ECM provides ground to energize the power relay coil. This fault will set if the relay control circuit (ground side) detects zero voltage indicating a short to ground or open relay coil control circuit.

Diagnostic Aid

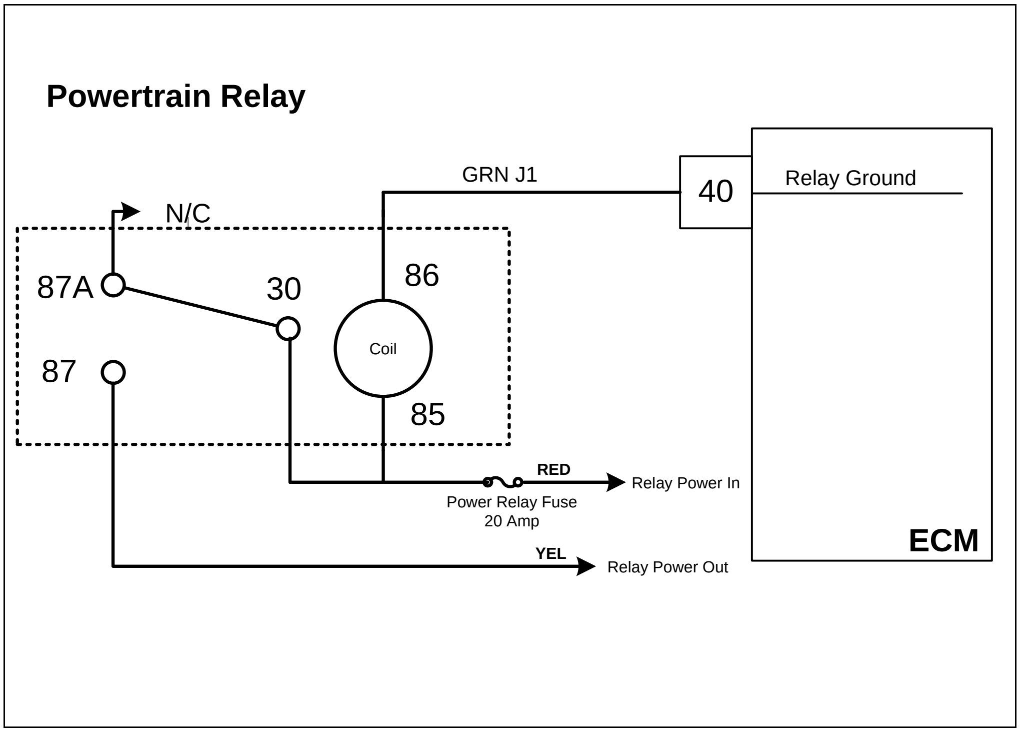
SPN 66013
FMI 5
Relay coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

DTC P0686 Powertrain Relay Driver Short Low/Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Ignition OFF • Remove the power relay from the fuse block • Using a DVOM check the resistance of the relay coil between terminals 85 and 86 Is the resistance value greater than 100 ohms?		Go to Step (3)	Go to Step (4)
3	Replace the power relay Is the replacement complete?		Go to Step (10)	–
4	Check the Power Relay (20 AMP) fuse Is the fuse open?		Replace fuse F2	Go to Step (5)
5	• Disconnect ECM connector C0J1 • Remove Power Relay from fuse box • Using a DVOM check for continuity between C0J2 pin 40 and fuse box terminal for relay pin 86 Do you have continuity?		Go to Step (6)	Repair the open Power Relay Control circuit as required. See wiring harness repairs
6	Using a DVOM check for continuity between C0J2 pin 40 and engine ground Do you have continuity?		Repair the shorted to ground Power Relay Control circuit as required. See wiring harness repairs	Go to Step (7)
7	Replace the power relay Is the replacement complete?		Go to Step (9)	-

Step	Action	Value(s)	Yes	No
8	Replace the ECM Is the replacement complete?		Go to Step (10)	–
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0686 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (8)
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0686 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P0687 Powertrain Relay Driver Short High



Conditions for Setting the DTC

- Power relay control circuit check
- Check Condition-Ignition ON
- Fault Condition-Power relay driver circuit greater than 12.0 volts

Circuit Description

The ECM provides ground to energize the power relay coil. This fault will set if the relay control circuit (ground side) detects voltage above 12 volts indicating a short to voltage or shorted relay coil.

Diagnostic Aid

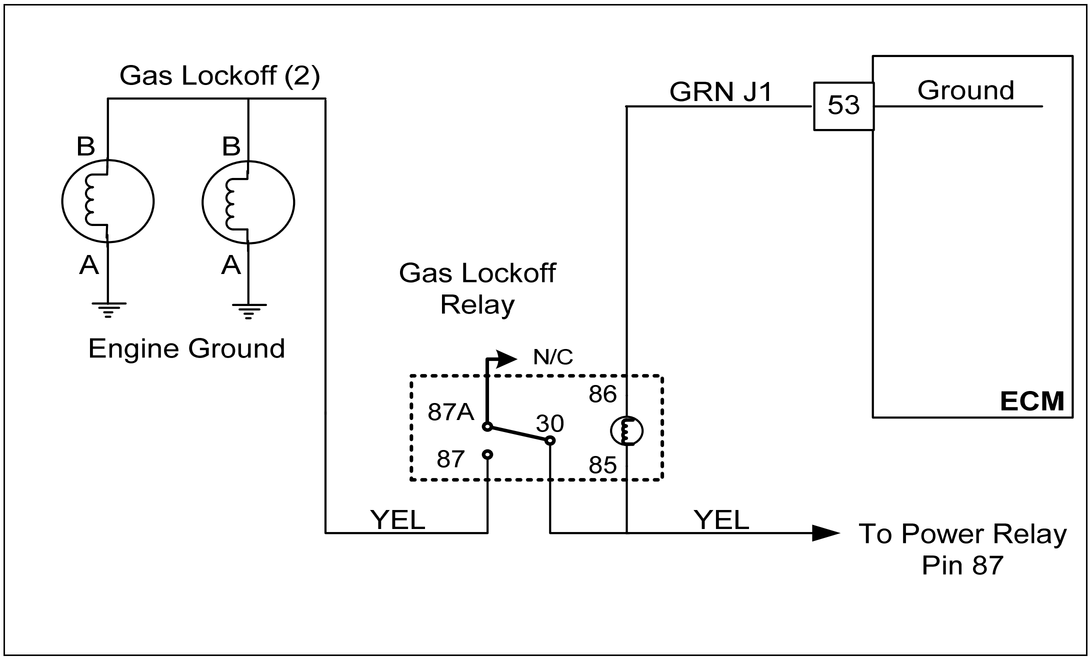
SPN 66013
FMI 3
Relay coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

DTC P0687 Powertrain Relay Driver Short High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Ignition OFF • Remove the power relay from the fuse block • Using a DVOM check the resistance of the relay coil between terminals 85 and 86 Is the resistance value less than 100 ohms?		Go to Step (3)	Go to Step (4)
3	Replace the power relay Is the replacement complete?		Go to Step (8)	–
4	• Disconnect ECM connector C0J1 • Ignition ON • Using a DVOM check for voltage between C0J1 pin 20 and engine ground. Does the DVOM show voltage?		Repair the shorted to voltage power relay control circuit as required. See wiring harness repairs	Go to Step (5)
5	Replace the power relay Is the replacement complete?		Go to Step (7)	-

Step	Action	Value(s)	Yes	No
6	Replace the ECM Is the replacement complete?		Go to Step (8)	–
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0687 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (6)
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P0687 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

P1180 Gas Lock Off Relay Short Low/Open



Conditions for Setting the DTC

- Gas Lock Off Solenoid Relay
- Check Condition-Ignition ON
- Fault Condition-Gas solenoid relay control circuit at zero volts

Circuit Description

The gas lock off solenoid is an electrically operated fuel shutoff shut off safety device. The solenoid is normally closed and opens to allow the flow of natural gas or propane vapor when the solenoid is energized. The gas lock off solenoid is controlled by the gas lock off relay. This code will set if the voltage on the gas solenoid relay control circuit is at zero volts indicating an open relay coil or relay control circuit.

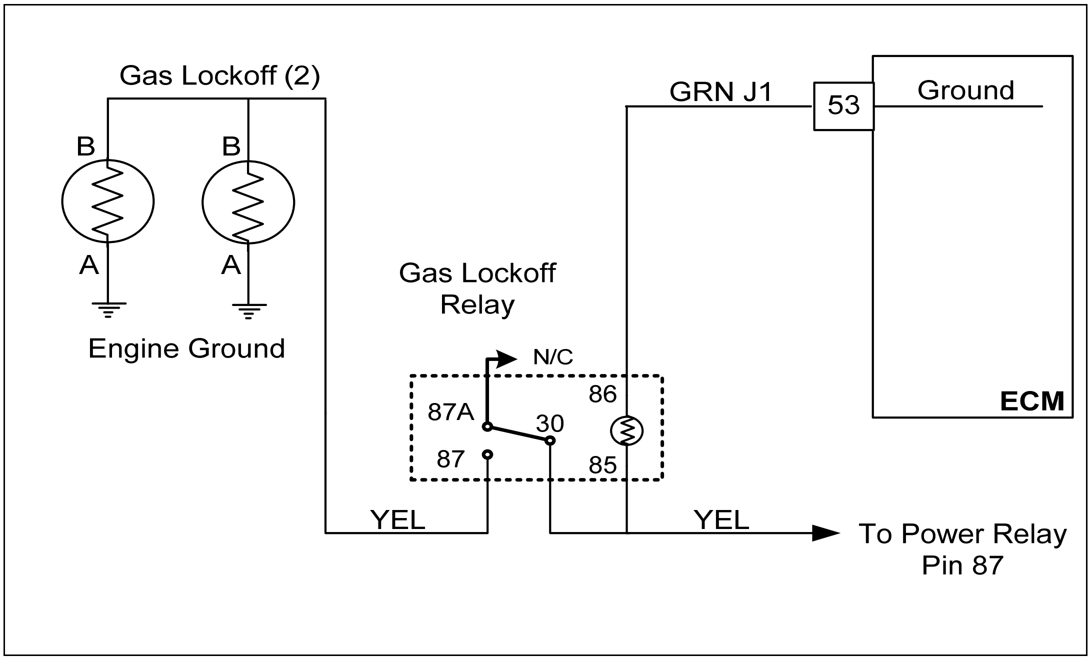
Diagnostic Aid

SPN 66011
FMI 5
Gas solenoid relay coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

P1180 Gas Lock Off Relay Short Low/Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	
2	• Ignition OFF • Remove the gas lock off relay from the fuse box. • Using a DVOM check the resistance between pin 85 and 86 of the relay Does the DVOM show a resistance value greater than 100 Ohms?	Greater than 115 Ohms	Go to Step (3)	Go to Step (4)
3	Replace the Gas Lock Off Relay Is the replacement complete?		Go to Step (8)	-
4	• Ignition OFF • Disconnect the ECM wire harness connector C0J1 • Ignition ON • Using a DVOM check for continuity between C0J1 pin 53 and fuse box pin for relay terminal 86 Does the DVOM show continuity?		Repair the relay control circuit shorted to voltage. See wire harness repair.	Go to Step (6)
6	Inspect the ECM wire harness and connector for damage corrosion or contamination Did you find a problem?		Correct the problem as required. See wire harness repair.	Go to Step (7)
7	Replace the ECM Is the replacement complete?		Go to Step (8)	–
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P1180 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

P1181 Gas Lock Off Relay Short High



Conditions for Setting the DTC

- Gas Lock Off Relay Control
- Check Condition-Ignition ON
- Fault Condition-Gas lock off relay control circuit equal to or higher than system voltage

Circuit Description

The gas lock off solenoid is an electrically operated fuel shutoff shut off safety device. The solenoid is normally closed and opens to allow the flow of natural gas or propane vapor when the solenoid is energized. The gas lock off solenoid is controlled by the gas lock off relay. This code will set if the voltage on the gas solenoid relay control circuit is equal to or greater than system voltage indicating a shorted gas solenoid relay coil or shorted to voltage control circuit.

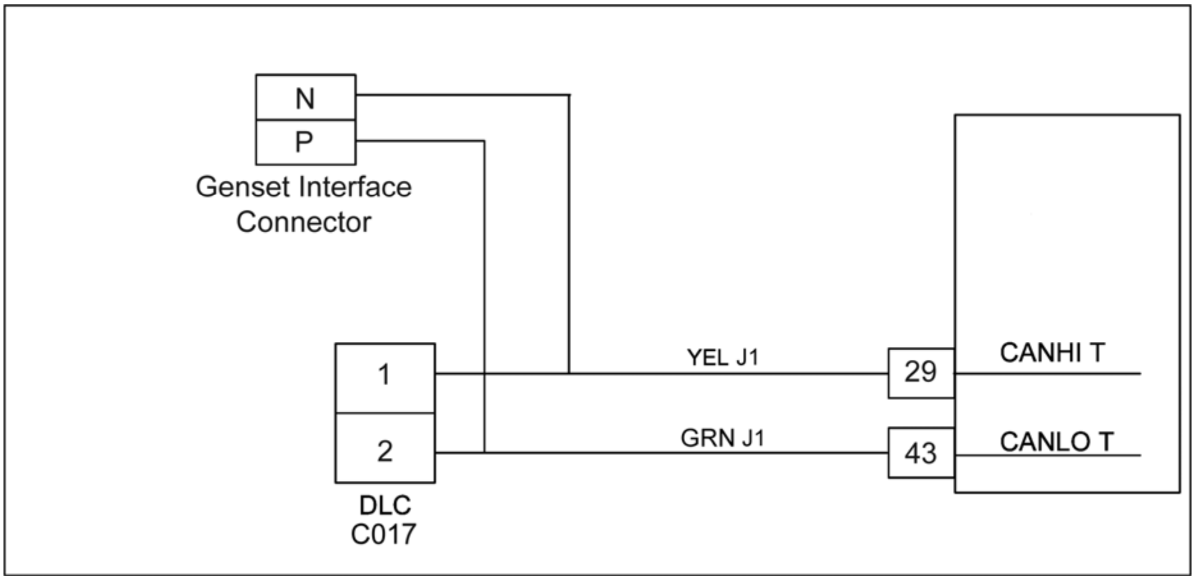
Diagnostic Aid

SPN 66011
FMI 3
Gas solenoid relay coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

P1181 Gas Lock Off Relay Short High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	
2	• Ignition OFF • Remove the gas lock off relay from the fuse box. • Using a DVOM check the resistance between pins 85 and 86 of the gas lock relay Does the DVOM show a resistance value of less than 70 Ohms?	Less than 70 Ohms	Go to Step (3)	Go to Step (4)
3	• Replace the gas lock off relay Is the replacement complete?		Go to Step (8)	-
4	• Ignition OFF • Disconnect the ECM wire harness connector C0J1 • Ignition ON • Using a DVOM check for voltage between C0J1 pin 53 and engine ground Does the DVOM show full system battery voltage?		Repair the relay control circuit shorted to voltage. See wire harness repair.	Go to Step (6)
6	• Inspect the ECM wire harness and fuse box connector for damage corrosion or contamination Did you find a problem?		Correct the problem as required. See wire harness repair.	Go to Step (7)
7	• Replace the ECM Is the replacement complete?		Go to Step (8)	–
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P1181 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P1627 CAN Bus Hardware Fault



Conditions for Setting the DTC

- CAN Rx
- Check Condition-Engine running
- Fault Condition-CAN error packets lost, not received or corrupt for 563 ms.
- Voltage between 9 and 16 volts.

Circuit description

The CAN bus (controller area network) is used by the ECM to communicate with other digital devices used throughout the fuel system. Information is sent over the CAN bus in digital information "packets" that contain information for various control functions. This fault will set if the ECM detects continuous CAN communications hardware errors or CAN policy violations. Engine speed will drop to the reduced rpm threshold.

Diagnostic Aid

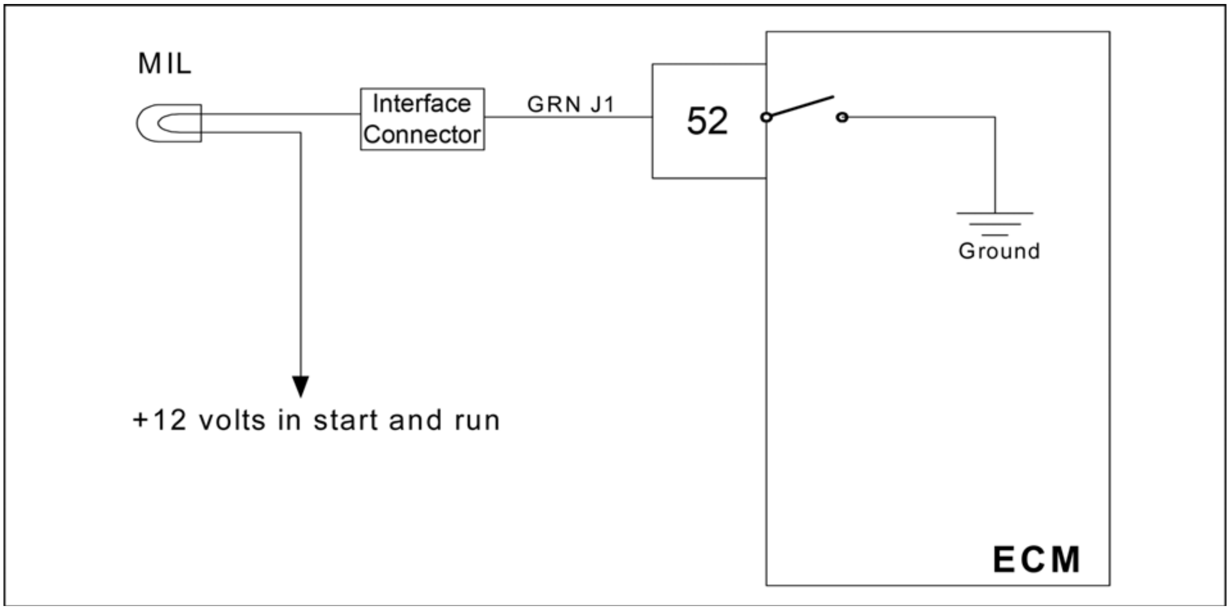
SPN 65559
FMI 11
Always run the Genset control panel diagnostics before proceeding with this chart. Disconnect individual CAN devices that may have been installed on the CAN line to see if the problem is resolved before proceeding with this chart.

DTC P1627 Can Bus Hardware Fault

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear system fault code Does DTC 1627 reset with the engine running?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Check that the power connection C002 is clean and tight • Check that the ground connections C012 and C016 are clean and tight Are the power and ground circuits OK?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Ignition OFF • Disconnect ECM harness connector C0J1 • Disconnect Genset Interface Connector (GIC) • Using a DVOM check for continuity between C0J1 connector pin 43 and Genset Interface Connector pin P Do you have continuity?		Go to Step (5)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between C0J1 29 and GIC connector pin N Do you have continuity?		Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (6)
6	• Using a DVOM check for continuity to engine ground between C0J1 pins 29 and 43 Does the DVOM show a resistance value of less than 40 ohms?	Above 40 Ohms	Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Using a DVOM check for continuity to engine ground on C0J1 pins 29 and 43. Do have continuity them?		Repair the shorted to ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)

Step	Action	Value(s)	Yes	No
8	• Using a DVOM check for continuity to battery positive on C0J1 pins 29 and 43. Do you have continuity between them?		Repair the shorted to voltage circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (9)
9	• Replace the ECM. Is the replacement complete?		Go to Step (10)	-
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM • Turn the Ignition OFF and wait 30 seconds • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P1627 and check for any stored codes Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P1645 MIL Driver Short High



Conditions for setting the DTC

- MIL
- Check Condition-Key ON engine OFF
- Fault Condition- ECM MIL output shorted to ground
- MIL Command-ON

Circuit Description

The fuel system is equipped with OBD (On-Board Diagnostics). The system has a dash mounted MIL (Malfunction Indicator Lamp). The MIL serves as notification of an emissions related problem. The following DTC charts in this manual will instruct the technician to perform the OBD system check. This simply means to verify the operation of the MIL. The lamp should illuminate when the key is in the ON position, and the engine is not running. This feature verifies that the lamp and circuit is in proper working order. If the lamp does not illuminate with the vehicle key ON and engine OFF, repair it as soon as possible. Once the engine is in start or run mode, the lamp should go off. If the lamp stays on while the engine is in the start or run mode, a current diagnostic trouble code may be set or a problem may exist with the MIL electrical wiring. The electrical schematic above shows the MIL power source supplied to the lamp. The ECM completes the circuit to ground to turn the lamp ON. This fault will set if the ECM MIL control is shorted to voltage.

Diagnostic Aid

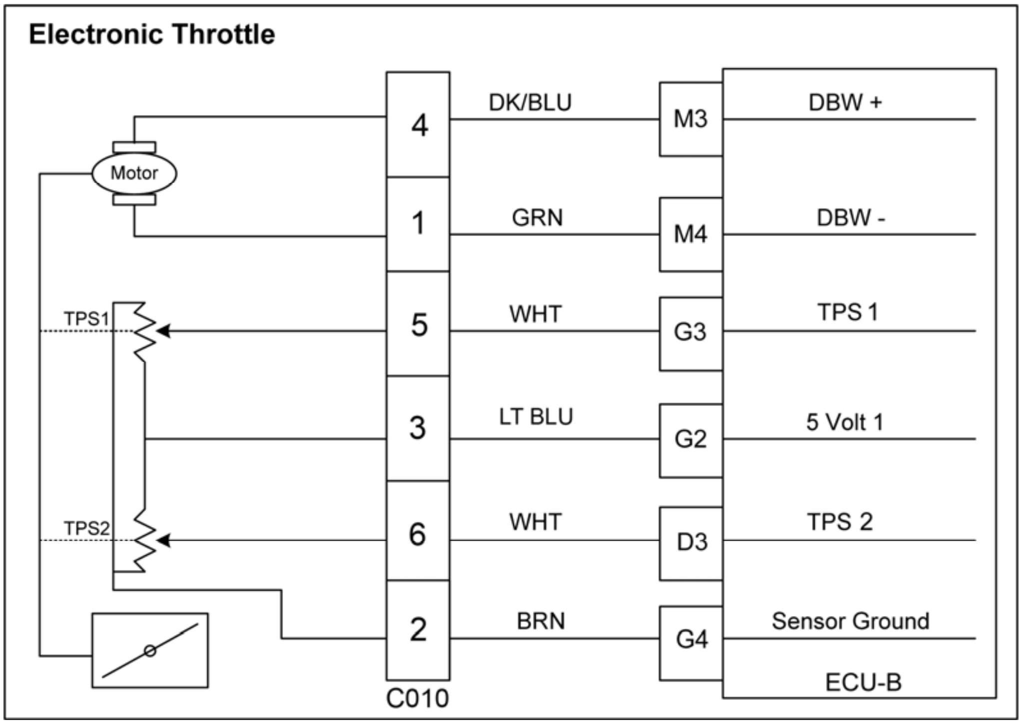
SPN 66003
FMI 3

DTC P1645 MIL Driver Short High

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear system fault code • Key OFF • Key ON Does DTC 1645 reset?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the ECM wire harness connector J1 • Using a DVOM check for continuity between ECM connector pin J1 52 and engine ground Do you have continuity?		Go to step (4)	Intermittent problem Go to Intermittent section
4	• Disconnect vehicle interface connector • Using a DVOM check for continuity between ECM connector pin J1 52 and engine ground Do you have continuity?		Repair the shorted to ground circuit between the ECM connector and engine ground. Then go to step (6)	Repair the MIL control wire short to ground between the vehicle interface connector and vehicle chassis. Then go to step (6)
5	• Replace the ECM Is the replacement complete?		Go to step (7)	_
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC-1645 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to step (5)

Step	Action	Value(s)	Yes	No
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-1645 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System check

DTC P2111 ETC Return Fault



Conditions for Setting the DTC

- Electronic Throttle Control
- Check Condition-Ignition ON
- Fault Condition-Throttle return spring test
- MIL-On during active fault

Circuit Description

Dual throttle position sensors (TPS) are used with the electronic throttle control (ETC) to determine throttle plate position. The TPS values are used by the ECM to determine if the throttle is opening and closing as commanded. The ECM runs several checks at ignition on to validate the working condition of the ETC. This fault will set if the ECM detects a problem with the ETC internal return spring.

Diagnostic Aid

SPN 65618
FMI 7

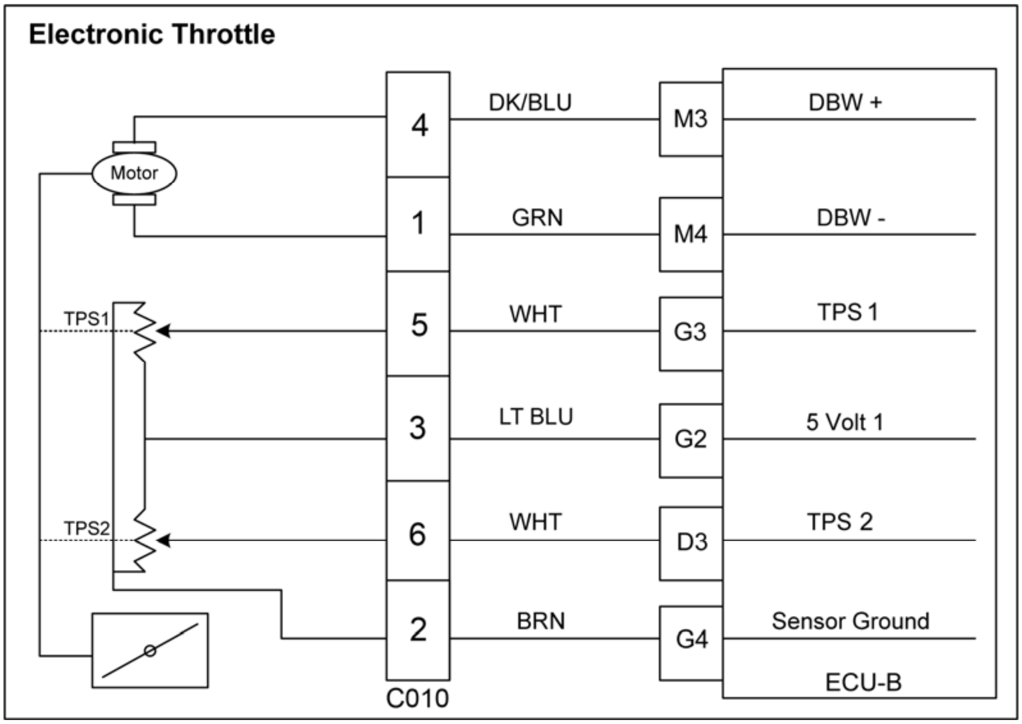
DTC P2111 ETC Return Fault

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in data stream mode. • Clear DTC P2111 • Ignition OFF • Ignition ON Does DTC P2111 re-set?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	Check the electronic throttle for a foreign object in the throttle bore or damaged throttle bore or fly assembly. Did you find damage or a foreign object in the bore?		Remove the foreign object or replace the throttle if damage is found. Go to Step (17)	Go to Step (4)
4	• Ignition OFF • Disconnect electronic throttle connector C010 • Disconnect ECM wire harness connector C0J2 • Using a DVOM check for continuity between electronic throttle connector pin 6 and C0J2 connector pin 63 Does the DVOM show continuity?		Go to Step (5)	Repair the open ground circuit as necessary. Refer to Wiring Repairs.
5	Using a DVOM check for continuity between electronic throttle connector pin 5 and C0J2 connector pin 65 Does the DVOM show continuity?		Go to Step (6)	Repair the open circuit as necessary. Refer to Wiring Repairs.
6	Using a DVOM check for continuity between electronic throttle connector pin 5 and engine ground Does the DVOM show continuity?		Repair the shorted to ground TPS circuit as necessary. Refer to Wiring Repairs.	Go to Step (7)
7	Using a DVOM check for continuity between electronic throttle connector pin 4 and C0J2 connector pin 15 Does the DVOM show continuity?		Go to Step (8)	Repair the open 5 volt circuit as necessary. Refer to Wiring Repairs.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between electronic throttle connector pin 4 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (9)
9	Using a DVOM check for continuity between electronic throttle connector pin 1 and C0J2 connector pin 16 Does the DVOM show continuity?		Go to Step (10)	Repair the open TPS circuit as necessary. Refer to Wiring Repairs.
10	Using a DVOM check for continuity between electronic throttle connector pin 1 and engine ground Does the DVOM show continuity?		Repair the shorted TPS circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (11)
11	Using a DVOM check for continuity between electronic throttle connector pin 3 and C0J2 connector pin 43 Does the DVOM show continuity?		Go to Step (12)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
12	Using a DVOM check for continuity between electronic throttle connector pin 2 and C0J2 connector pin 44 Does the DVOM show continuity?		Go to Step (13)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
13	Using a DVOM check for continuity between electronic throttle connector pin 2 and engine ground. Does the DVOM show continuity?		Repair the shorted DBW circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (14)
14	Replace throttle Is the replacement complete?		Go to Step (15)	-

Step	Action	Value(s)	Yes	No
15	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P2111 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (16)
16	Replace the ECM Is the replacement complete?		Go to Step (17)	-
17	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P2111 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 2119 ETC Actuation Fault



Conditions for Setting the DTC

- Throttle Position Sensor
- Check Condition-Ignition ON
- Fault Condition-Actual and desired throttle position greater than 10%
- Battery voltage greater than 9 volts
- MIL-On during active fault

Circuit Description

Dual throttle position sensors (TPS) are used with the electronic throttle control (ETC) to determine throttle plate position. The TPS values are used by the ECM to determine if the throttle is opening and closing as commanded. This fault will set if the ECM detects a problem with the ETC TPS, malfunctioning throttle control motor or sticking throttle valve assembly.

Diagnostic Aid

SPN 65615
FMI 7

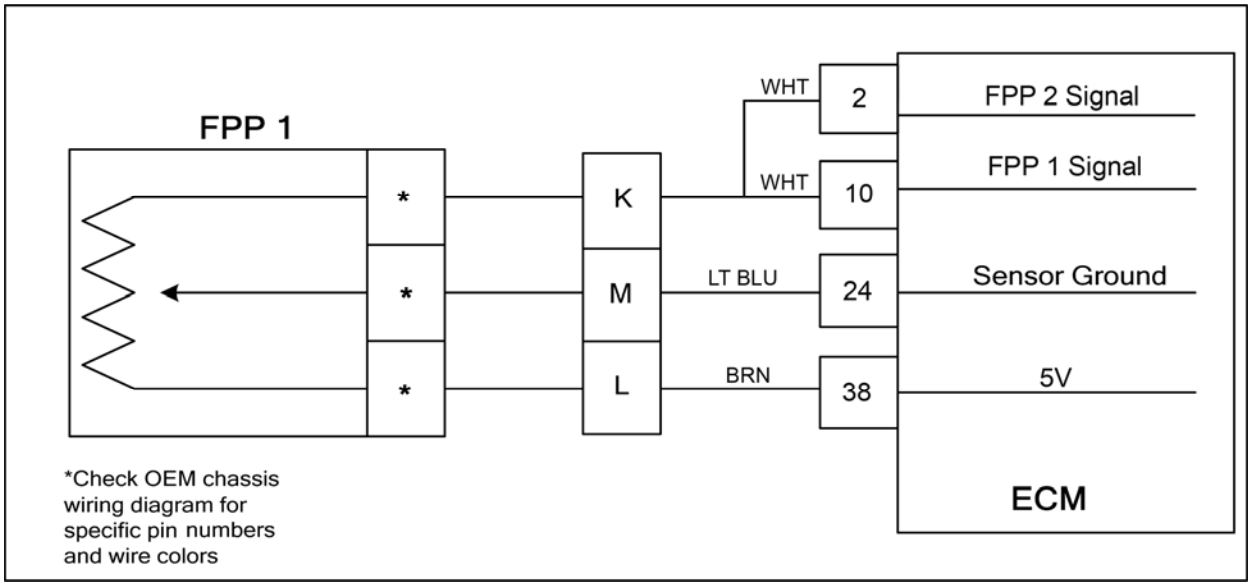
DTC P2119 ETC Actuation Fault

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in data stream mode. • Clear DTC P2119 Does DTC P2119 re-set?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	Check the electronic throttle for a damaged throttle bore or fly assembly Did you find damage or a foreign object in the bore?		Remove the foreign object or replace the throttle if damage is found. Go to Step (17)	Go to Step (4)
4	• Ignition OFF • Disconnect electronic throttle connector C010 • Disconnect ECM wire harness connector C0J2 • Using a DVOM check for continuity between electronic throttle connector pin 6 and C0J2 connector pin 63 Does the DVOM show continuity?		Go to Step (5)	Repair the open ground circuit as necessary. Refer to Wiring Repairs.
5	Using a DVOM check for continuity between electronic throttle connector pin 5 and C0J2 connector pin 65 Does the DVOM show continuity?		Go to Step (6)	Repair the open circuit as necessary. Refer to Wiring Repairs.
6	Using a DVOM check for continuity between electronic throttle connector pin 5 and engine ground Does the DVOM show continuity?		Repair the shorted to ground TPS circuit as necessary. Refer to Wiring Repairs.	Go to Step (7)
7	Using a DVOM check for continuity between electronic throttle connector pin 4 and C0J2 connector pin 15 Does the DVOM show continuity?		Go to Step (8)	Repair the open 5 volt circuit as necessary. Refer to Wiring Repairs.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between electronic throttle connector pin 2 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (9)
9	Using a DVOM check for continuity between electronic throttle connector pin 1 and C0J2 connector pin 16 Does the DVOM show continuity?		Go to Step (10)	Repair the open TPS circuit as necessary. Refer to Wiring Repairs.
10	Using a DVOM check for continuity between electronic throttle connector pin 1 and engine ground Does the DVOM show continuity?		Repair the shorted TPS circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (11)
11	Using a DVOM check for continuity between electronic throttle connector pin 3 and C0J2 connector pin 43 Does the DVOM show continuity?		Go to Step (12)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
12	Using a DVOM check for continuity between electronic throttle connector pin 2 and C0J2 connector pin 44 Does the DVOM show continuity?		Go to Step (13)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
13	Using a DVOM check for continuity between electronic throttle connector pin 2 and engine ground Does the DVOM show continuity?		Repair the shorted DBW circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (14)
14	Replace throttle Is the replacement complete?		Go to Step (15)	-

Step	Action	Value(s)	Yes	No
15	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P2119 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (16)
16	Replace the ECM Is the replacement complete?		Go to Step (17)	-
17	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P2119 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 2122-FPP 1 Voltage Out of Range



Conditions for Setting the DTC

- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP1 sensor voltage exceeds 4.65 volts or less than 0.26 volts
- Open or shorted circuit
- MIL-On during active fault
- Low rev limit
- Force idle

Circuit Description

The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. This fault will set if the FPP 1 exceeds 4.65 volts or drops to less than 0.26 volts any operating condition while the key is on, the FPP is considered to be out of specification and the MIL command is ON..

Diagnostic Aid

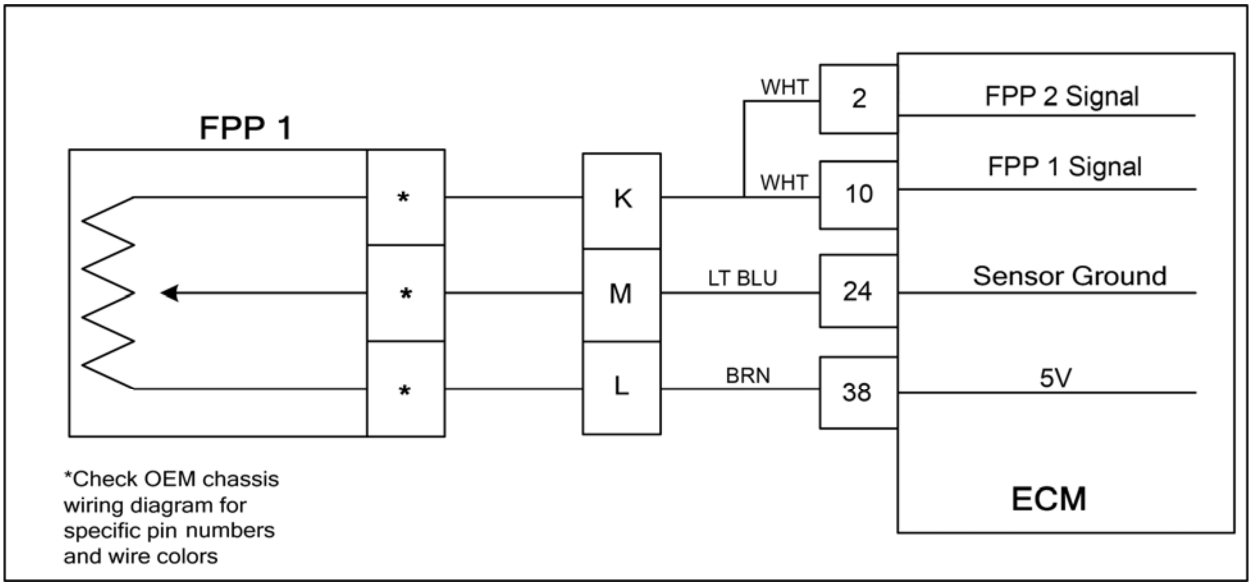
FPP sensors are OEM specific and vary in configuration. The exact wire color and pin numbers for the FPP connection must be verified in the OEM chassis wiring schematic. The FPP sensor used in this system provides two sensors in one packaged assembly.

DTC 2122-FPP 1 Voltage Out of Range

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display FPP voltage of 4.65 volts or drops to less than 0.26 volts?	>4.65 volts or <0.26 volts	Go to Step (3)	Go to Step (3)
3	• Slowly increase FPP while observing FPP 1 voltage Does DST FPP voltage ever exceed 4.65 volts or drops to less than 0.26 volts?	>4.65 volts or <0.26 volts	Go to step (4)	Intermittent problem Go to Intermittent section
4	• Disconnect the FPP sensor connector Does the DST now show FPP 1 voltage below 0.260 volts?	0.260 volts or less	Go to step (5)	Go to step (6)
5	• Replace FPP sensor Is the replacement complete?		Go to step (10)	-
6	• Key OFF • Disconnect ECM connector J1 • Disconnect vehicle interface connector • Using a DVOM check continuity between Interface connector pin K and J1 pins 2 and 10 Do you have continuity?		Go to step (7)	Repair the open ground circuit as required
7	• Key ON • Using a DVOM check for voltage between the FPP connector pin L and engine ground Do you have voltage?	No voltage	Repair the signal shorted to voltage circuit	Go to step (8)
8	• Inspect ECM and FPP connectors for damage corrosion or contamination Did you find a problem		Repair the circuit as required. See wire harness repair section	Go to step (9)
9	• Replace ECM Is the replacement complete?		Go to step (10)	-

Step	Action	Value(s)	Yes	No
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-2122 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 2127-FPP 2 Voltage Out of Range



Conditions for Setting the DTC

- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP2 sensor voltage exceeds 4.65 volts or less than 0.26 volts
- Open or shorted circuit
- MIL-On during active fault
- Low rev limit
- Force idle

Circuit Description

The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. This fault will set if the FPP 2 exceeds 4.65 volts or drops to less than 0.26 volts any operating condition while the key is on, the FPP is considered to be out of specification. The MIL command is ON. Forced idle and low rev limit will be in effect during this code set limiting full power output.

Diagnostic Aid

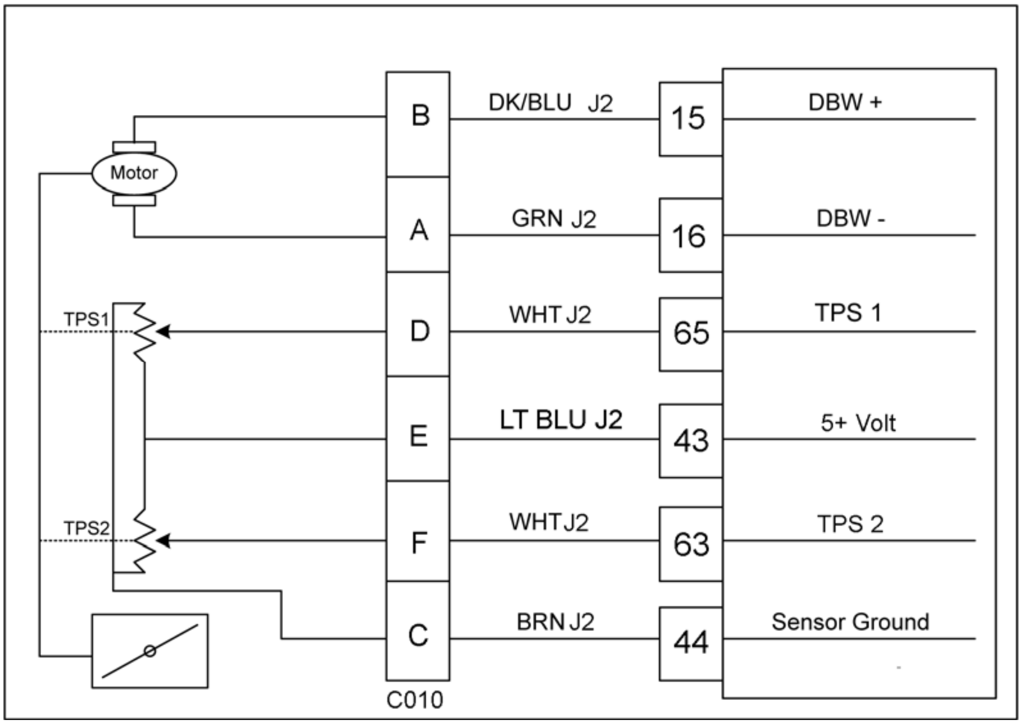
FPP sensors are OEM specific and vary in configuration. The exact wire color and pin numbers for the FPP connection must be verified in the OEM chassis wiring schematic. The FPP sensor used in this system provides two sensors in one packaged assembly. FPP1 and FPP 2 are not serviceable individually, and in the event of a failure the complete foot pedal sensor assembly must be replaced.

DTC 2127-FPP 2 Voltage Out of Range

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display FPP 2 voltage of 4.65 volts or drops to less than 0.26 volts with the foot pedal in the idle position?	>4.65 volts or <0.26 volts	Go to Step (3)	Go to Step (3)
3	• Slowly increase FPP while observing FPP 2 voltage Does DST FPP 2 voltage ever exceed 4.65 volts or drops to less than 0.26 volts?	>4.65 volts or <0.26 volts	Go to step (4)	Intermittent problem Go to Intermittent section
4	• Disconnect the FPP sensor connector Does the DST now show FPP 2 voltage below 0.260 volts?	0.260 volts or less	Go to step (5)	Go to step (6)
5	• Replace FPP sensor Is the replacement complete?		Go to step (10)	-
6	• Key OFF • Disconnect ECM connector J1 • Disconnect vehicle interface connector • Using a DVOM check continuity between Interface connector pin K and J1 pins 2 and 10 Do you have continuity?		Go to step (7)	Repair the open ground circuit as required
7	• Key ON • Using a DVOM check for voltage between the FPP connector pin L and engine ground Do you have voltage?	No voltage	Repair the signal shorted to voltage circuit	Go to step (8)
8	• Inspect ECM and FPP connectors for damage corrosion or contamination Did you find a problem		Repair the circuit as required. See wire harness repair section	Go to step (9)
9	• Replace ECM Is the replacement complete?		Go to step (10)	-

Step	Action	Value(s)	Yes	No
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-2127 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P2135 ETC TPS 1 and TPS 2 Range



Conditions for Setting the DTC

- Electronic Throttle Control
- Check Condition-Ignition ON
- Fault Condition-TPS 1 and 2 calculated values exceed 10%
- MIL-On during active fault

Circuit Description

Dual throttle position sensors (TPS) are used with the electronic throttle control (ETC) to determine throttle plate position. Although the actual voltage values between them are inverse, the calculated position values should remain very close. The TPS values are used by the ECM to determine if the throttle is opening and closing as commanded. This fault will set if the ECM detects more than a 10% difference in calculated values between TPS 1 and TPS 2.

Diagnostic Aid

SPN 65610
FMI 2

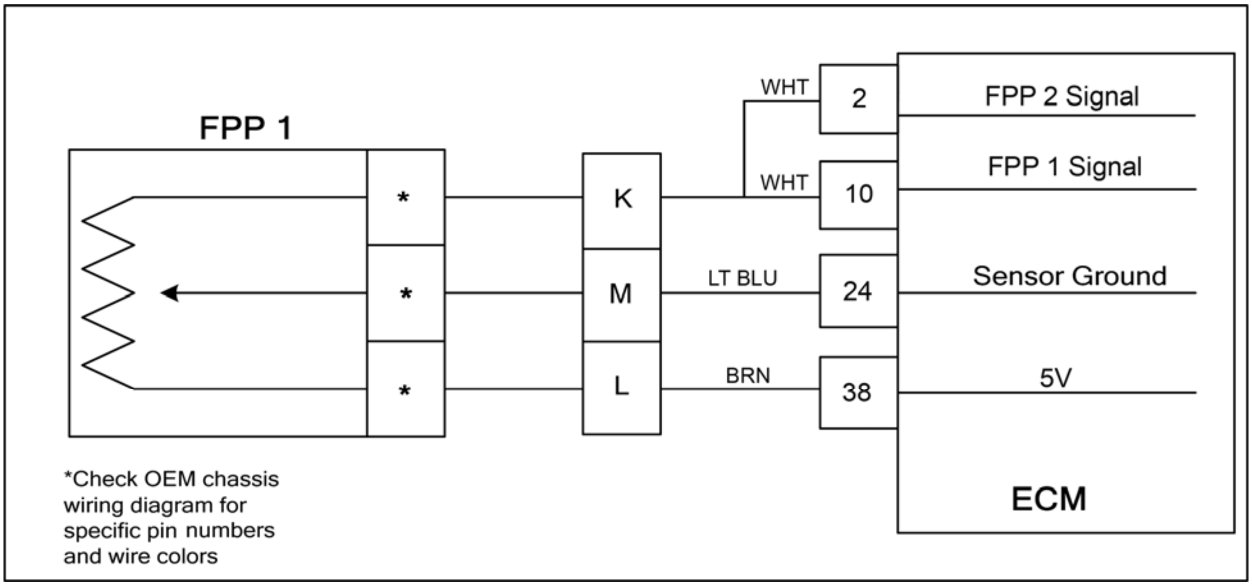
DTC P2135 ETC TPS 1 and TPS 2 Range

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON • DST (Diagnostic Scan Tool) connected in data stream mode. • Clear DTC P2135 • Start the engine Does DTC P2135 re-set?		Go to Step (3)	Intermittent problem. Go to Intermittent section
3	• Ignition OFF • Disconnect electronic throttle connector C010 • Disconnect ECM wire harness connector C0J2 • Inspect the electronic throttle connector and ECM wire harness connector for damage corrosion or contamination Did you find a problem?		Correct the problem as required. See wire harness repair.	Go to Step (4)
4	• Ignition OFF • Disconnect electronic throttle connector C010 • Disconnect ECM wire harness connector C0J2 • Using a DVOM check for continuity between electronic throttle connector pin 6 and C0J2 connector pin 63 Does the DVOM show continuity?		Go to Step (5)	Repair the open ground circuit as necessary. Refer to Wiring Repairs.
5	Using a DVOM check for continuity between electronic throttle connector pin 5 and C0J2 connector pin 65 Does the DVOM show continuity?		Go to Step (6)	Repair the open circuit as necessary. Refer to Wiring Repairs.
6	Using a DVOM check for continuity between electronic throttle connector pin 5 and engine ground Does the DVOM show continuity?		Repair the shorted to ground TPS circuit as necessary. Refer to Wiring Repairs.	Go to Step (7)
7	Using a DVOM check for continuity between electronic throttle connector pin 2 and C0J2 connector pin 15 Does the DVOM show continuity?		Go to Step (8)	Repair the open 5 volt circuit as necessary. Refer to Wiring Repairs.

Step	Action	Value(s)	Yes	No
8	Using a DVOM check for continuity between electronic throttle connector pin 2 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (9)
9	Using a DVOM check for continuity between electronic throttle connector pin 1 and C0J2 connector pin 16 Does the DVOM show continuity?		Go to Step (10)	Repair the open TPS circuit as necessary. Refer to Wiring Repairs.
10	Using a DVOM check for continuity between electronic throttle connector pin 1 and engine ground Does the DVOM show continuity?		Repair the shorted TPS circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (11)
11	Using a DVOM check for continuity between electronic throttle connector pin 3 and C0J2 connector pin 43 Does the DVOM show continuity?		Go to Step (12)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
12	Using a DVOM check for continuity between electronic throttle connector pin 6 and C0J2 connector pin 63 Does the DVOM show continuity?		Go to Step (13)	Repair the open DBW circuit as necessary. Refer to Wiring Repairs.
13	Using a DVOM check for continuity between electronic throttle connector pin 6 and engine ground Does the DVOM show continuity?		Repair the shorted DBW circuit to ground as necessary. Refer to Wiring Repairs.	Go to Step (14)
14	• Ignition ON • Using a DVOM check for voltage between electronic throttle connector pin 5 and engine ground Does the DVOM show voltage?		Repair the TPS signal shorted to voltage as necessary. Refer to Wiring Repairs.	Go to Step (15)
15	Replace throttle Is the replacement complete?		Go to Step (16)	-

Step	Action	Value(s)	Yes	No
16	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P2135 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to Step (17)
17	Replace the ECM Is the replacement complete?		Go to Step (18)	-
18	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature. • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P2135 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 2137-FPP 1 & 2 Out of Range



Conditions for Setting the DTC

- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP 1 or 2 sensor variance >8%
- MIL-On during active fault
- Low rev limit
- Force idle

Circuit Description

The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. This fault will set if the difference between FPP 1 and FPP 2 exceeds 8%. The MIL command is ON.

Diagnostic Aid

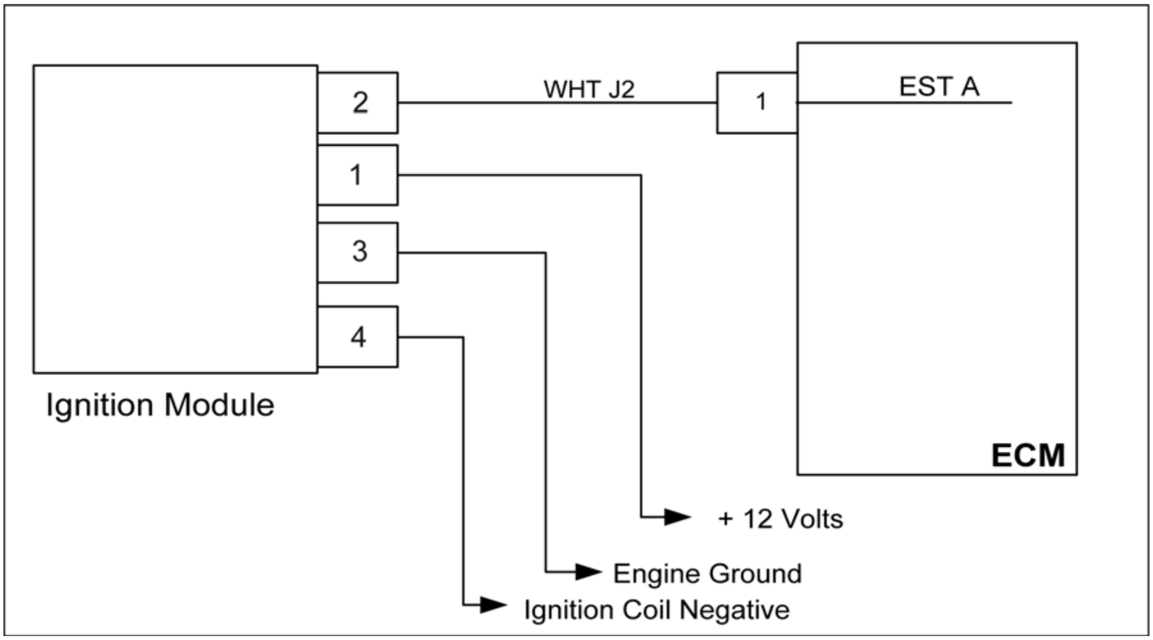
FPP sensors are OEM specific and vary in configuration. The exact wire color and pin numbers for the FPP connection must be verified in the OEM chassis wiring schematic. The FPP sensor used in this system provides two sensors in one packaged assembly. FPP1 and FPP 2 are not serviceable individually, and in the event of a failure the complete foot pedal sensor assembly must be replaced.

DTC 2137-FPP 2 High Voltage

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display FPP 1 or 2 voltage of 4.65 volts or drops to less than 0.26 volts with the foot pedal in the idle position?	>4.65 volts or <0.26 volts	Go to Step (3)	Go to Step (3)
3	• Slowly increase FPP while observing FPP 1 and 2 voltage Does DST FPP 1 or 2 voltage ever exceed 4.65 volts or drops to less than 0.26 volts?	>4.65 volts or <0.26 volts	Go to step (4)	Intermittent problem Go to Intermittent section
4	• Disconnect the FPP sensor connector Does the DST now show FPP 1 or 2 voltage below 0.260 volts?	0.260 volts or less	Go to step (5)	Go to step (6)
5	Is the difference between FPP1 and FPP 2 greater than 8%?		Go to step (6)	Go to step (7)
6	• Replace FPP sensor Is the replacement complete?		Go to step (11)	-
7	• Key OFF • Disconnect ECM connector J1 • Disconnect vehicle interface connector • Using a DVOM check continuity between Interface connector pin K and J1 pins 2 and 10 Do you have continuity?		Go to step (8)	Repair the open ground circuit as required
8	• Key ON • Using a DVOM check for voltage between the FPP connector pin L and engine ground Do you have voltage?	No voltage	Repair the signal shorted to voltage circuit	Go to step (9)
9	• Inspect ECM and FPP connectors for damage corrosion or contamination Did you find a problem		Repair the circuit as required. See wire harness repair section	Go to step (10)
10	• Replace ECM Is the replacement complete?		Go to step (11)	-

Step	Action	Value(s)	Yes	No
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-2127 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC P2300 EST Short Low



Conditions for Setting the DTC

- Check condition-Engine running or cranking
- Fault condition-0 volts from EST A for .5 seconds
- MIL-On during active fault

Circuit Description

The ECM triggers the ignition module by providing a signal to the EST A pin 2. The ignition module then completes the ignition coil primary circuit ground from pin 4 to power the ignition coil. This code will set if the ECM detects the EST circuit to be shorted low.

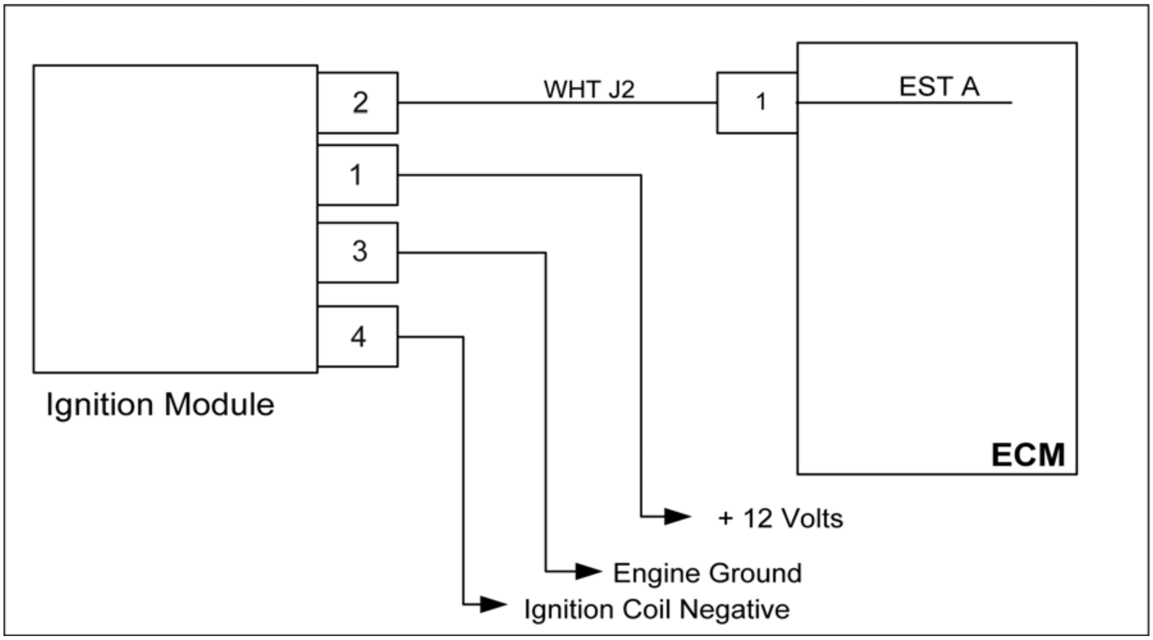
Diagnostic Aid
SPN 65541
FMI 4

DTC P2300 EST Short Low

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear DTC P2300 • Crank the engine Does DTC P2300 re-set?		Go to Step (3)	Intermittent problem. See Electrical Section Intermittent Electrical Diagnosis
3	• Ignition OFF • Disconnect the ignition module connector C004 • Disconnect the ECM connector C0J2 • Using a DVOM check for continuity between C0J2 connector pin 2 and engine ground Does the DVOM show continuity?		Repair the shorted to ground EST control circuit	Go to Step (4)
4	Replace the Ignition module Is the replacement complete?		Go to Step (5)	-

Step	Action	Value(s)	Yes	No
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P2300 check for any stored codes Does the engine operate normally with no stored codes?		System OK	Go to Step (6)
6	Replace the ECM Is the replacement complete?		Go to Step (7)	–
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM • Turn the Ignition OFF and wait 30 seconds • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P2300 check for any stored codes Does the engine operate normally with no stored codes?		System OK	Go to OBD system check

DTC P2301 EST Short High or Open



Conditions for Setting the DTC

- Check condition-Engine running or cranking
- Fault condition-0 volts from EST/Crank has lost sync
- MIL-On during active fault

Circuit Description

The ECM triggers the ignition module by providing a signal to the EST A pin 2. The ignition module then completes the ignition coil primary circuit ground from pin 4 to power the ignition coil. This code will set if the ECM detects the EST circuit to be shorted to voltage or open.

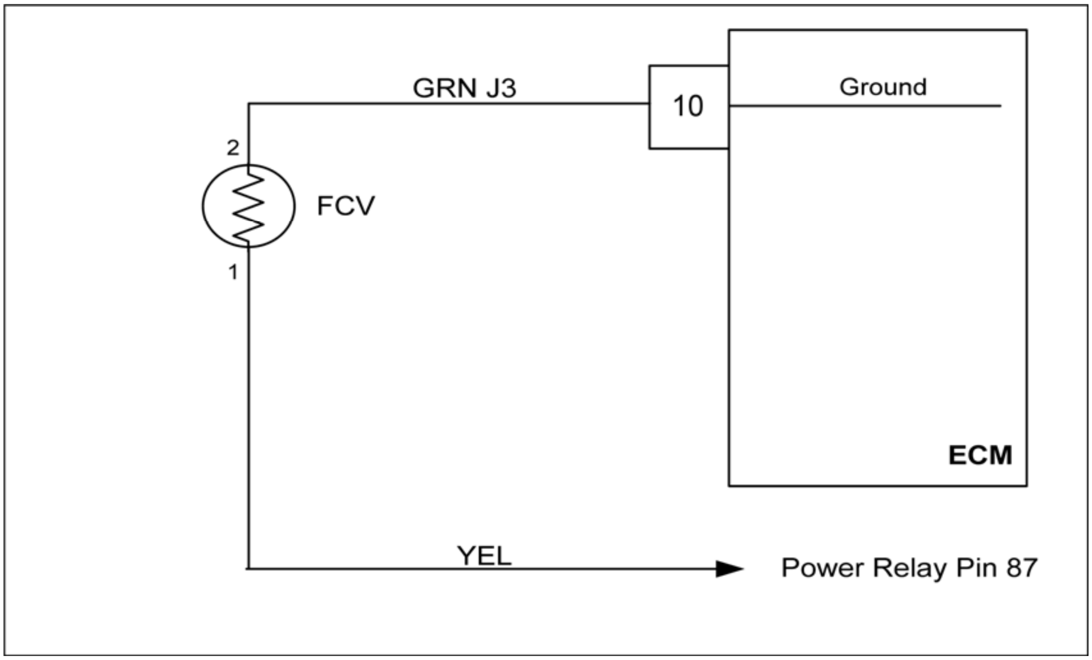
Diagnostic Aid
SPN 65541
FMI 5

DTC P2301 EST Short High or Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• Ignition ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode • Clear DTC P2301 • Crank the engine Does DTC P2301 re-set?		Go to Step (3)	Intermittent problem. See Electrical Section Intermittent Electrical Diagnosis
3	• Ignition OFF • Disconnect the ignition module connector C004 • Disconnect the ECM connector C0J2 • Using a DVOM check for continuity between C0J2 connector pin 1 and ignition module connector pin 2. Does the DVOM show continuity?		Repair the open EST control circuit	Go to Step (4)
4	• Ignition ON • Using a DVOM • Check for voltage between C0J2 pin 1 and engine ground Does the DVOM show voltage?		Repair the shorted to voltage EST control circuit. See wire harness repair.	Go to Step (5)
5	Replace the Ignition module Is the replacement complete?		Go to Step (6)	-

Step	Action	Value(s)	Yes	No
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P2301 check for any stored codes Does the engine operate normally with no stored codes?		System OK	Go to Step (7)
7	Replace the ECM Is the replacement complete?		Go to Step (8)	–
8	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM • Turn the Ignition OFF and wait 30 seconds • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance • After operating the engine within the test parameters of DTC P2301 check for any stored codes Does the engine operate normally with no stored codes?		System OK	Go to OBD system check

P2633 Fuel Control Valve Short Low/Open



Conditions for Setting the DTC

- FCV
- Check Condition-Ignition ON
- Fault Condition-FCV control circuit zero volts

Circuit Description

The FCV (Fuel Control Valve) is used to control the fuel regulator pressure output. The ECM cycles the FCV to provide the rich lean transitions required for low exhaust emissions and peak engine performance. This code will set if the voltage on the FCV control circuit is at zero volts indicating a short to ground or open FCV.

Diagnostic Aid

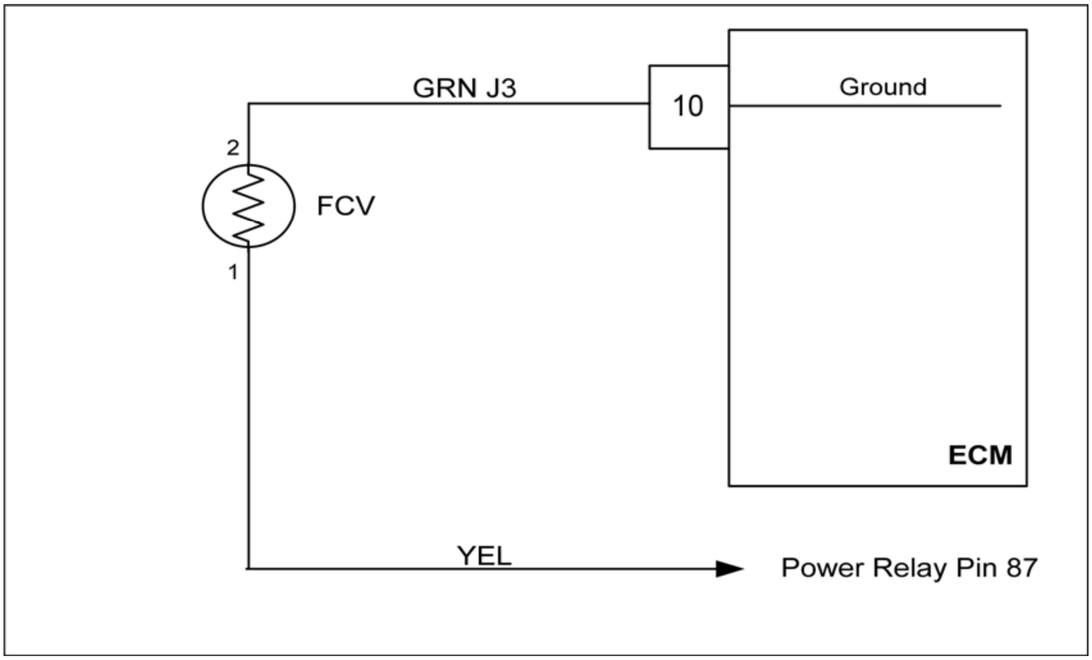
SPN 1765
FMI 5
FCV coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

P2633 Fuel Control Valve Short Low/Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD system Check Section
2	Check the Power Relay fuse and fuse contacts Are the Power Relay Fuse and contacts OK?		Go to Step (3)	Replace the fuse as required.
3	• Ignition OFF • Disconnect the FCV (Fuel Control Valve) connector C018 • Using a DVOM check the resistance between the two pins of the FCV solenoid Does the DVOM show a resistance value greater than 42 Ohms?	Greater than 42 Ohms	Go to Step (4)	Go to Step (5)
4	Replace the FCV Is the replacement complete?		Go to Step (9)	-
5	• Ignition OFF • Disconnect the ECM wire harness connector C0J3 • Ignition ON • Using a DVOM check continuity between C0J3 pin 10 and FCV connector pin 2 Does the DVOM show continuity?		Go to Step (6)	Repair the open FCV control circuit as required. See wire harness repair.
6	• Remove the power relay from the fuse box • Using a DVOM check for continuity between FCV connector and the fuse box terminal for the 87 pin for the power relay. Does the DVOM show continuity?		Go to Step (7)	Repair the open FCV control circuit as required. See wire harness repair
7	Using a DVOM check for continuity between FCV connector pin 2 and engine ground Does the DVOM show continuity?		Repair the shorted to ground FCV control circuit as required. See wire harness repair	Go to Step (8)
8	Inspect the ECM wire harness and connector and FCV connector for damage corrosion or contamination Did you find a problem?		Correct the problem as required. See wire harness repair.	Go to Step (9)
9	Replace the ECM Is the replacement complete?		Go to Step (10)	–

Step	Action	Value(s)	Yes	No
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P2633 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

P2634 Fuel Control Valve Short High



Conditions for Setting the DTC

- FCV
- Check Condition-Ignition ON
- Fault Condition-FCV control circuit signal higher than 12 volts

Circuit Description

The FCV (Fuel Control Valve) is used to control the fuel regulator pressure output. The ECM cycles the FCV to provide the rich lean transitions required for low exhaust emissions and peak engine performance. This code will set if the voltage on the FCV control circuit is equal to or greater than 12 volts indicating a shorted FCV valve coil or shorted to voltage control circuit.

Diagnostic Aid

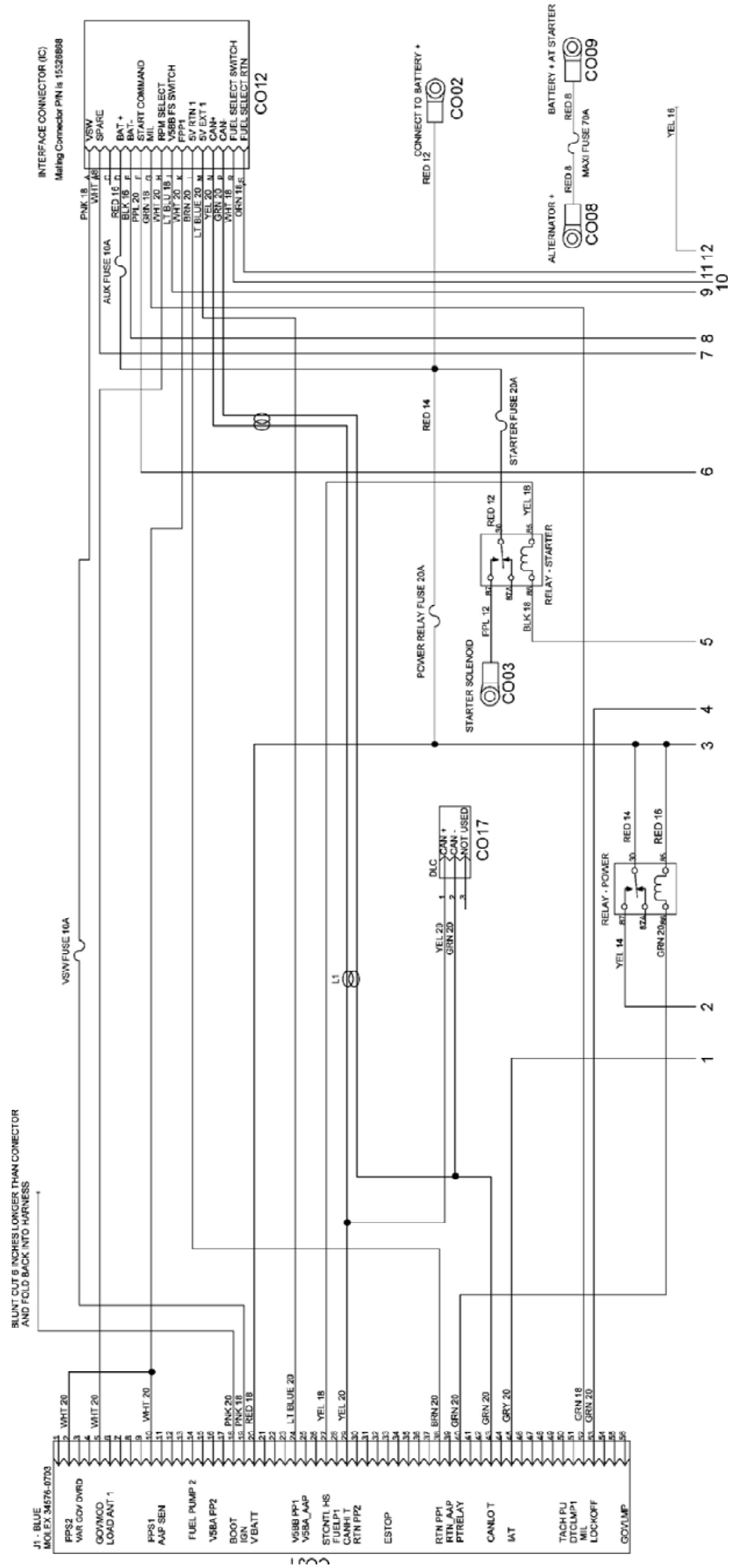
SPN 1765
FMI 3
FCV coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

P2634 Fuel Control Valve Short High

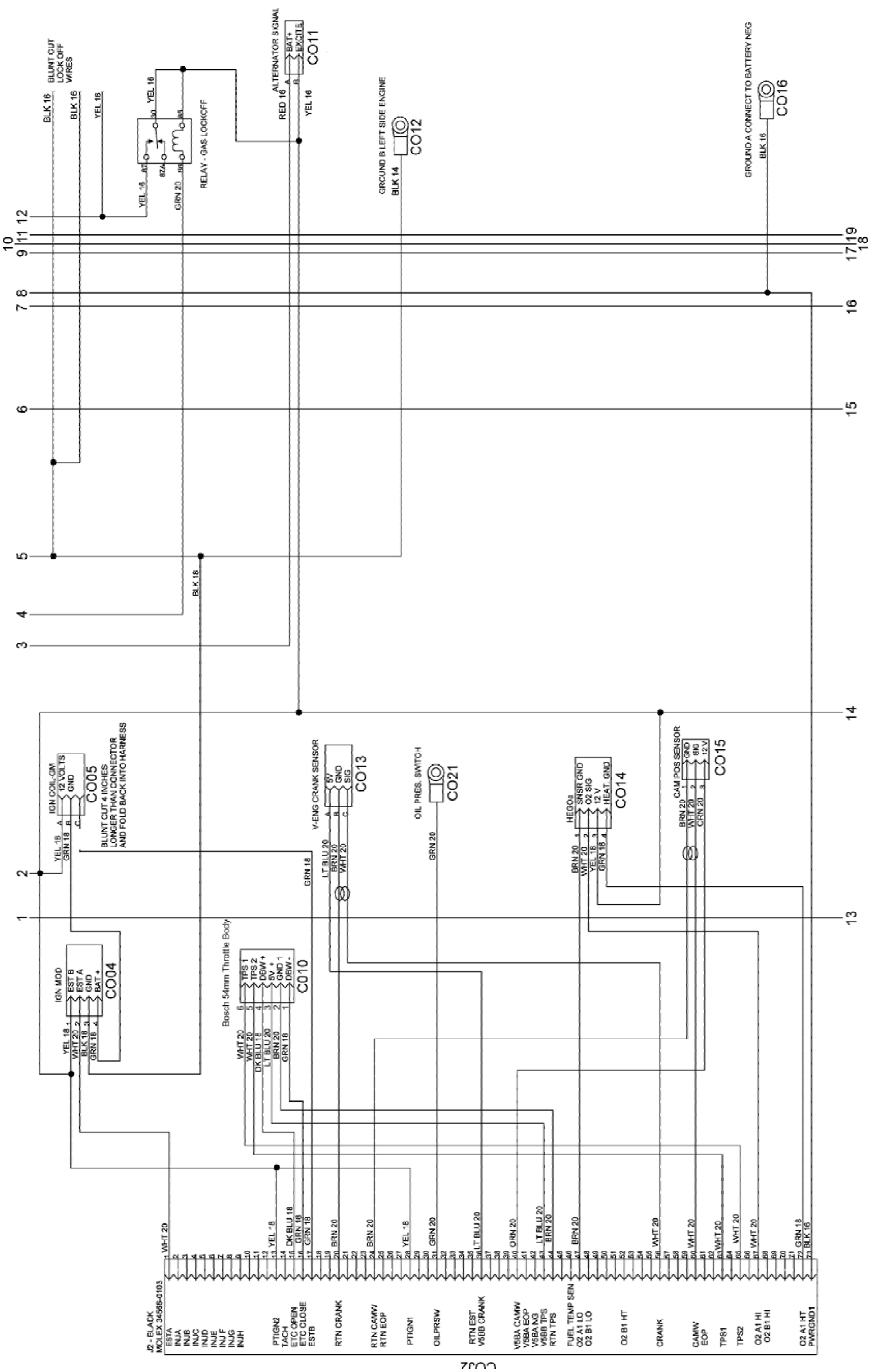
Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	
2	• Ignition OFF • Disconnect the FCV (Fuel Control Valve) connector C018 • Using a DVOM check the resistance between the two pins of the FCV solenoid Does the DVOM show a resistance value of less than 32 Ohms?	Less than 32 Ohms	Go to Step (3)	Go to Step (4)
3	Replace the FCV Is the replacement complete?		Go to Step (7)	-
4	• Ignition OFF • Disconnect the ECM wire harness connector C0J3 • Ignition ON • Using a DVOM check for voltage between C018 pin 1 and engine ground Does the DVOM show full system battery voltage?		Repair the FCV control circuit shorted to voltage. See wire harness repair.	Go to Step (5)
5	Inspect the ECM wire harness and connector for damage corrosion or contamination Did you find a problem?		Correct the problem as required. See wire harness repair.	Go to Step (6)
6	Replace the ECM Is the replacement complete?		Go to Step (7)	–
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and run to full operating temperature • Observe the MIL • Observe engine performance. • After operating the engine within the test parameters of DTC P2634 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

Engine Wiring Schematic

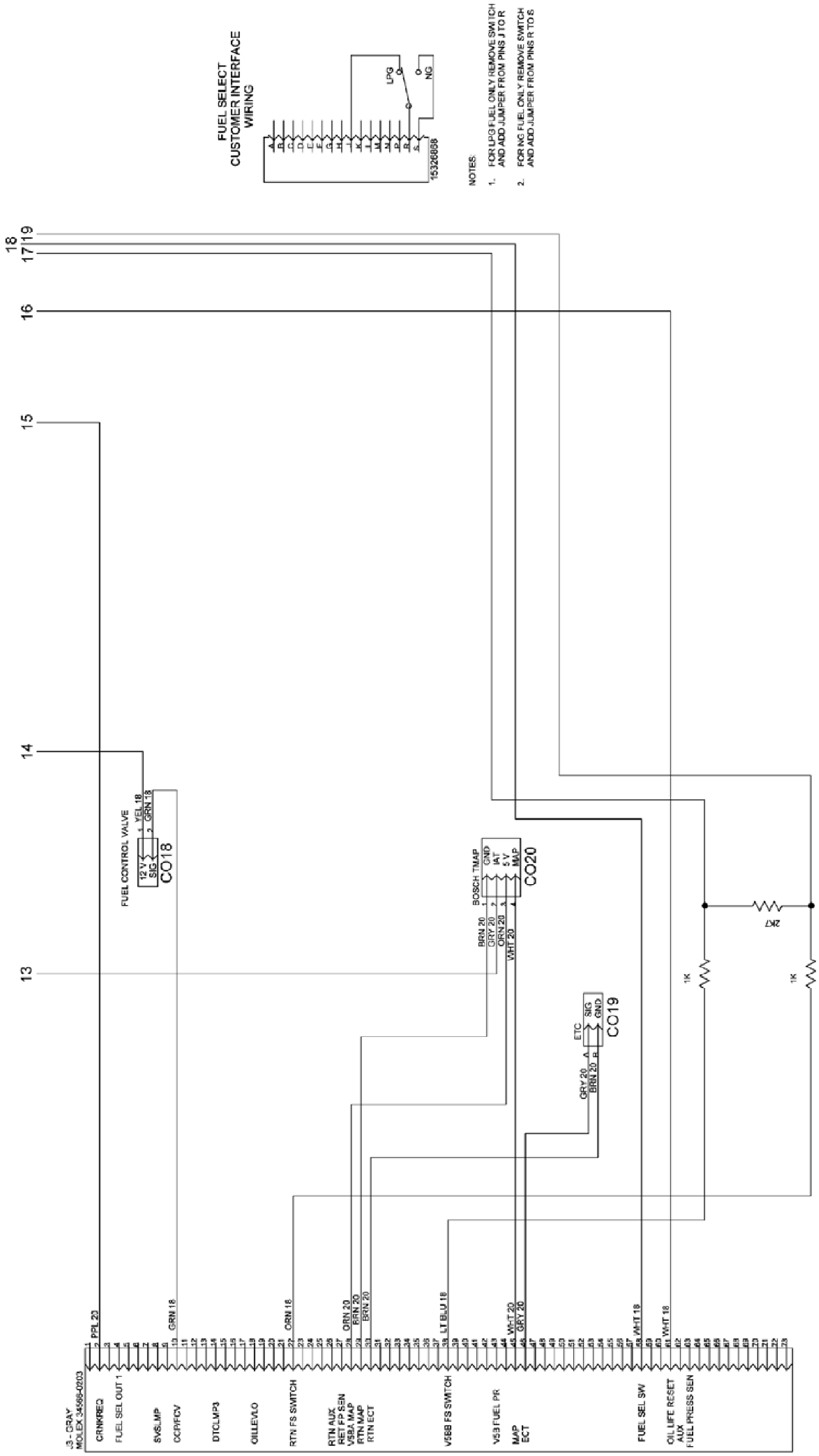
6.2L Stationary Power Generation Engine Wire Harness Schematic



6.2L Stationary Power Generation Engine Wire Harness Schematic



6.2L Stationary Power Generation Engine Wire Harness Schematic



Engine Wire Harness Repair

ON-ENGINE SERVICE
WIRE HARNESS REPAIR

The ECM harness electrically connects the ECM to a various components in both the engine and passenger compartments.

Wire harnesses should be replaced with proper part number harnesses. When wires are spliced into a harness, use wire with high temperature insulation only.

Low current and voltage levels are used in the system, so it is important that the best possible bond at all wire splices be made by soldering the splices.

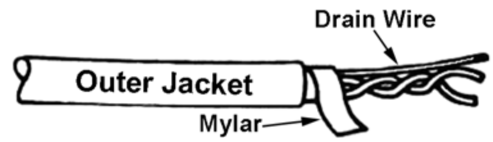
CONNECTORS AND TERMINALS

Use care when probing a connector or replacing terminals in them to prevent shorting opposite terminals and damage certain components. Always use jumper wires between connectors, for circuit checking. Do not probe through the Weather-Pack seals with oversized wire probes. Use tachometer adapter J 35812 (or equivalent) which provides an easy hook up of the tach lead. The connector test adapter kit J 35616 (or equivalent), contains an assortment of flexible connectors used to probe terminals during diagnosis. Fuse remover and test tool BT 8616, or equivalent, is used for removing a fuse and to adapt fuse holder, with a meter, for diagnosis. Do not solder oxygen sensor wire terminals as these wire ends are used for the sensors oxygen reference.

Open circuits are often difficult to locate by sight due to dirt, oxidation, or terminal misalignment. Merely wiggling a connector on a sensor, or in the wiring harness, may correct the open circuit condition. This should always be considered, when an open circuit, or failed sensor is indicated. Intermittent problems may also be caused by oxidized or loose connections.

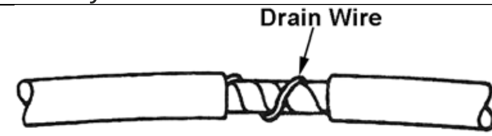
Before making a connector repair, be certain of the type of connector. Weather-Pack and Compact Three connectors look similar, but are serviced differently.

REPAIRING TWISTED/SHIELDED CABLE

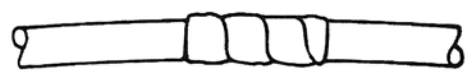


1. Remove outer jacket
2. Unwrap aluminum/Mylar tape. Do not remove Mylar.

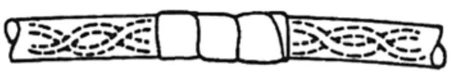
3. Untwist conductors, strip insulation as necessary.



4. Splice wire using splice clips and rosin core solder. Wrap each splice to insulate
5. Wrap with Mylar and drain wire (uninsulated) wire.

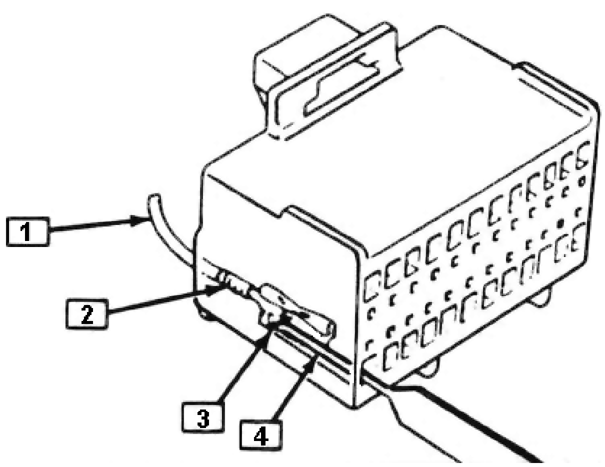


6. Tape over entire juncture and secure.

REPAIRING TWISTED LEADS
 1. Locate Damaged Wire.
2. Remove insulation as required.
 3. Splice two wires together using splice clips and rosin core solder.
 4. Cover splice with tape to insulated from other wires.
5. Retwist as before and tape with electrical tape and hold in place.

MICRO-PACK

Refer to Figure 2 and repair procedure for replacement of a Micro-Pack terminal.

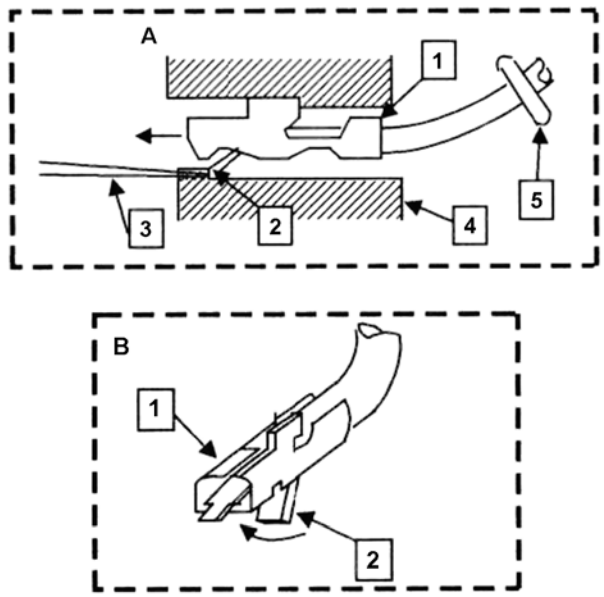


Micropack Connector

1. Cable
2. Terminal
3. Locking Tang
4. Tool J33095/BT8234-A

METRI-PACK

Some connectors use terminals called Metri-Pack Series 150. They are also called "Pull-To-Seat" terminals because of the method of installation. The wire is inserted through the seal and connector, the terminal is crimped on the wire and then pulled back into the connector to seat it in place.



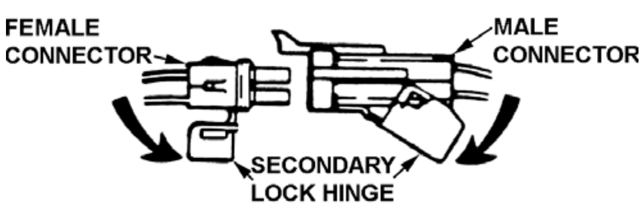
Metri-Pack Series 150 Terminal Removal

1. Slide the seal back on the wire.
2. Insert tool BT-8518, or J 35689, or equivalent, as shown in insert "A" and "B" to release the terminal locking tab (2).
3. Push the wire and terminal out through the connector. If reusing the terminal, reshape the locking tab (2).

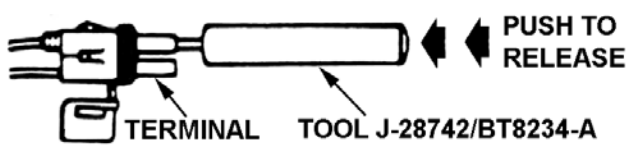
WEATHER-PACK

A Weather-Pack connector can be identified by a rubber seal, at the rear of the connector. The connector is used in the engine compartment to protect against moisture and dirt that may oxidize and/or corrode the terminals. Given the low voltage and current levels found in the electronic system, this protection is necessary to ensure a good connection.

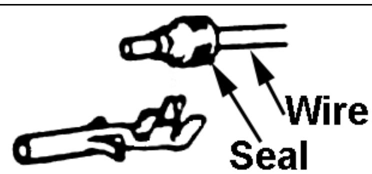
WEATHER-PACK TERMINAL REPAIR



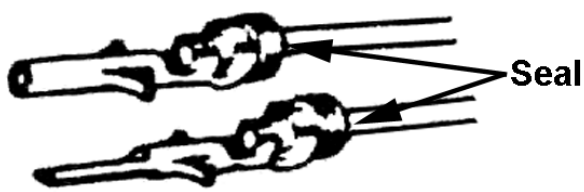
1. Open secondary lock hinge on connector.



2. Remove terminal using tool.



3. Cut wire immediately behind cable seal



4. Replace terminal.
   a. Slip new seal onto wire
   b. Strip 5 mm (.2”) of insulation from wire.
   c. Crimp terminal over wire and seal.
5. Push terminal and connector and engage locking tangs.
6. Close secondary lock hinge.

Use tool J M28742, or BT8234-A or equivalent to remove the pin and sleeve terminals. If the removal is attempted with an ordinary pick, there is a good chance that the terminal will be bent, or deformed. Unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

Verify that the connectors are properly seated and all of the sealing rings in place, when connecting leads. The hinge type flap provides a backup or secondary locking feature for the connector. They are used to improve the connector reliability by retaining the terminals, if the small terminal lock tabs are not positioned properly.

Weather-Pack connections cannot be replaced with standard connections. Additional instructions are provided with Weather-Pack connector and terminal packages.

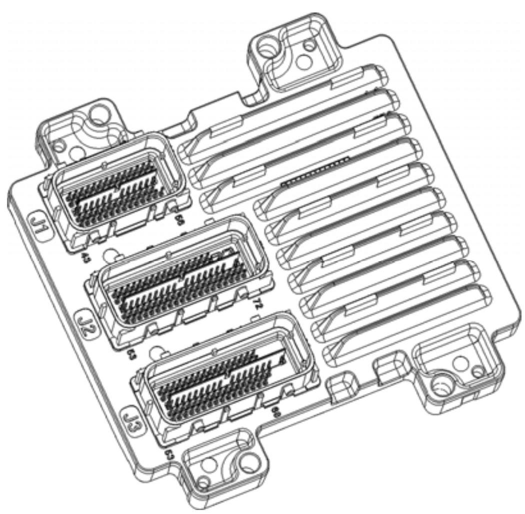
Servicing the Fuel System

I. ENGINE CONTROL MODULE (ECM)

This procedure relates to removal and installation of the ECM--see Diagnostic Scan Tool for accessing ECM software or reflash instructions.

REMOVAL PROCEDURE

1. Disconnect Negative battery cable.
2. Unlock the connectors, unplug the Wire Harness from the ECM and remove.
3. Remove four Bolts and Spacers mounting the ECM to the Bracket.



ECM

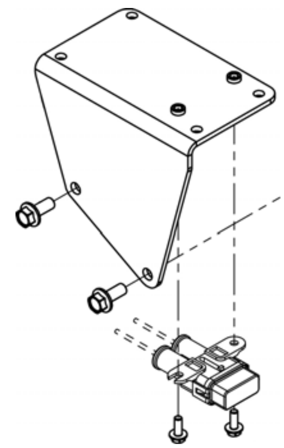
INSTALLATION PROCEDURE

IMPORTANT
The calibration number may be found by connecting the DST.

1. Mount ECM on Bracket with four Screws, Washers and Spacers**. Torque to 7-9 ft.lbs. (9.5-12.2 Nm)**.
2. Plug connectors into the ECM and push locks into place.
3. Reconnect the negative battery cable.
4. Install the Diagnostic Service Tool.
5. Start engine and let run until it reaches normal operating temperature.
6. Check for any DTC codes and clear.
7. Verify engine is in closed loop and no MIL light is present.
8. If a DTC code is found, refer to the Electrical Section for further diagnosis.

II. ECM BRACKET

REMOVAL PROCEDURE



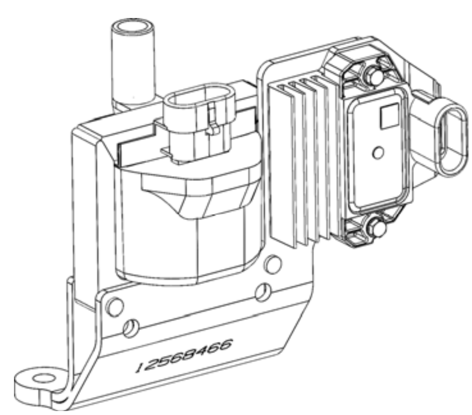
ECM Bracket and its mounting screws

1. Remove the ECM. Refer to *I. ENGINE CONTROL MODULE (ECM).*
2. Remove the screws that secure the Maxifuse
3. Remove the two screws that secure the Bracket.

INSTALLATION PROCEDURE

1. Mount the bracket with screws. Apply Loctite 567 (or equivalent high-temp thread locker/sealer to the threads) **and torque to 20.9 ft.lbs. (28.3 Nm).**
2. Apply Loctite 567 (or equivalent high-temp thread locker/sealer) to the threads of the two screws and install the Maxifuse. **Torque to 7-9 ft.lbs. (9.5-12.2 Nm).**
3. Mount the ECM. Refer to *I. ENGINE CONTROL MODULE (ECM).*

III. IGNITION COIL/MODULE



Ignition Control Module & Coil

REMOVAL

1. Disconnect negative battery cable.
2. Remove all electrical connections to the Ignition Coil/Module Assembly.
3. Remove the two screws securing the Ignition Coil/Module Assembly and remove the Ignition Coil.

INSTALLATION

1. Place Ignition Coil/Module on the bracket.
2. Thread in two screws and **Torque to 20.8 ft.lbs. (28.3 Nm).**
3. Connect electrical connectors to the Ignition Coil.
4. Reattach negative battery cable.
5. Start the engine and check for proper operation in all throttle ranges. If a DTC code is found, refer to the Electrical Section for further diagnosis.

IV. ENGINE WIRE HARNESS REPLACEMENT

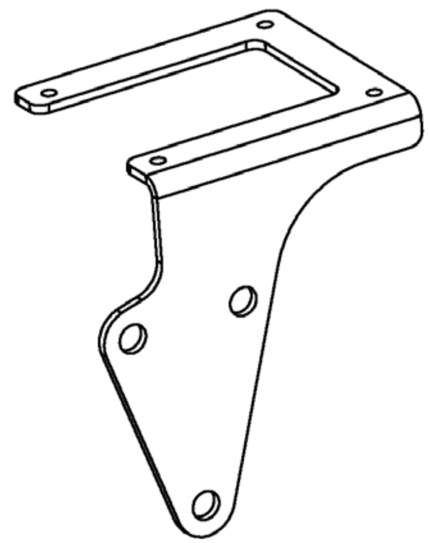
1. Disconnect negative battery cable.
2. Lay out the new wire harness, noting the location, type of connectors, and identifying markings. Take special note of identical or similar connectors to avoid crossing connections during installation. Note the routing of the existing wire harness in and around the engine and the engine. Refer to the Electrical Schematic.

CAUTION

Ensure that all connections are made to the correct locations on the engine and its components. Crossing connections may cause poor engine performance, a MIL warning and/or permanent damage to the ECM.

3. Remove all wire harness connectors on the engine.
4. Remove all clips and brackets holding the wire harness and remove harness from engine.
5. Lay the new wire harness over the engine and route each end to its connection. Verify that all connectors match prior to installation.
6. Connect all connectors and ring terminals.
7. Install all clips and brackets to hold down the harness.
8. Reconnect negative battery cable.
9. Start the engine.
10. If a DTC code is found, refer to the Electrical Section for further diagnosis.

V. FUSE BOX BRACKET



The Fuse Box Bracket

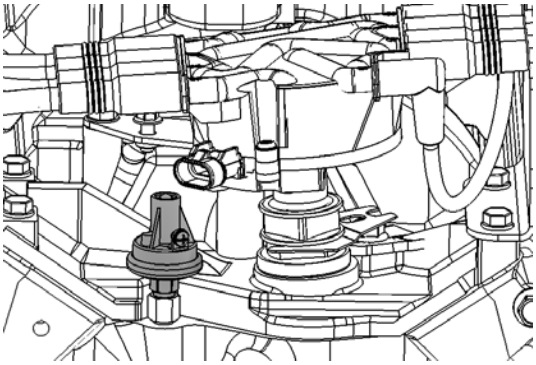
REMOVAL PROCEDURE

1. Disconnect negative battery cable.
2. Remove four Screws securing the Fuse Box to the Bracket.
3. Remove two Screws securing the bracket, engine hanger and spacers.

INSTALLATION PROCEDURE

1. Insert screws through bracket, engine hanger and spacers, then into cylinder head. **Torque to 20.8 ft.lbs. (28.3Nm).**
2. Place Fuse Box on top of Bracket and thread Screws with washers into the Bracket. **Torque to 20.8 ft.lbs. (28.3 Nm).**
3. Reconnect to negative battery cable. Start engine.
4. If a DTC code is found, refer to the Electrical Section for further diagnosis.

VI. OIL PRESSURE SENDER



The Oil Pressure Sender, shown installed near the Distributor.

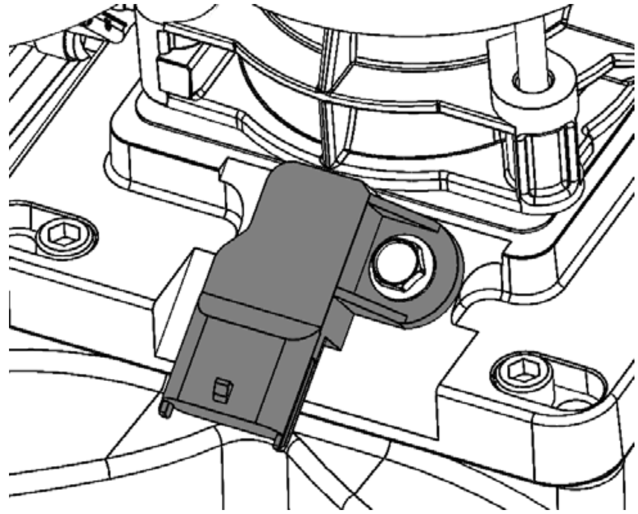
REMOVAL PROCEDURE

1. Disconnect the negative battery cable.
2. Locate the Oil Pressure Sender on the top of the engine next to the distributor.
3. Remove electrical connection from Oil Pressure Sender.
4. Using a wrench, hold the brass adapter (to prevent from turning) and turn the Sender counter-clockwise and remove. Do not remove the brass adapter from the engine block (unless it is to be replaced).

INSTALLATION PROCEDURE

1. Apply Loctite 567 (or equivalent high-temp thread locker/sealer) to the threads on the Oil Pressure Sender.
2. Install Oil Pressure Sender. **Torque the Sender and Brass Adapter until both are tight**.
3. Attach electrical connector.
4. Reconnect negative battery cable.
5. Start the engine and let run until it reaches normal operating temperature. Check for oil leaks around sensor. If leaks are found, repair as necessary.
6. If a DTC code is found, refer to the Electrical Section for further diagnosis.

VII. TEMPERATURE MANIFOLD PRESSURE SENSOR (TMAP)



The TMAP, shown mounted on the Throttle Body Adapter next to the Throttle Body.

REMOVAL PROCEDURE

1. Disconnect the negative battery cable.
2. Locate the TMAP Sensor on the Throttle Body Adapter.
3. Disconnect electrical connector from the TMAP.
4. Remove the retaining Screw.
5. Remove TMAP Sensor by pulling straight up with a slight rocking motion.

INSTALLATION PROCEDURE

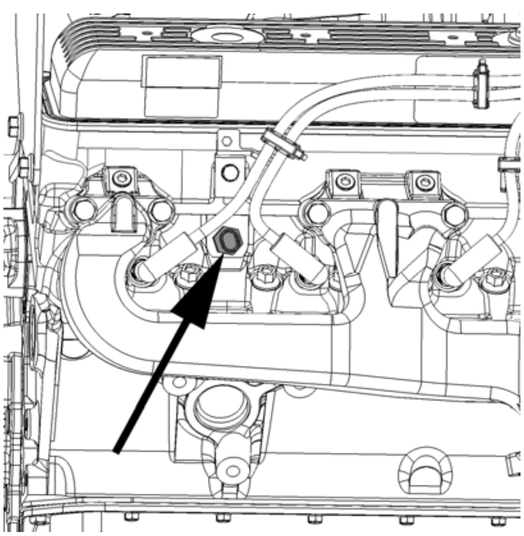
1. Lightly apply Vaseline or petroleum jelly to the O-ring on the TMAP.

CAUTION

Contamination of the HEGO sensor can result from the use of an inappropriate RTV sealer or silicone spray products. Do not use silicone sprays or hoses which are assembled using silicone lubricants. Always use "oxygen sensor safe" RTV sealant for repair procedures. Silicon contamination will cause a high but false HEGO signal voltage (rich exhaust indication). The ECM will then reduce the amount of fuel delivery to the engine, causing a severe performance problem. If silicone contamination is suspected, remove and visually inspect the sensor element. If contaminated, the portion of the sensor exposed to the exhaust stream will have a white powdery coating. Always be sure to eliminate the cause of contamination before replacing the sensor.

2. Install the TMAP and secure with Retaining Screw. **Torque to 7.3 ft.lbs. (9.9 Nm).**
3. Reconnect electrical connector.
4. Reconnect the negative battery cable.
5. Start engine and run until it reaches normal operating temperature.
6. Check for MIL illumination. If a DTC code is found, refer to the Electrical Section for further diagnosis.

VIII. ENGINE COOLANT TEMPERATURE SENSOR (ECT)



The ECT Mounts above the Exhaust Manifold on the left side of the engine.

REMOVAL PROCEDURE

1. Disconnect the negative battery cable.
2. Drain the coolant.
3. Locate the ECT on the side of the engine.
4. Remove electrical connector from the ECT.
5. Unscrew the Sensor from the engine.

WARNING

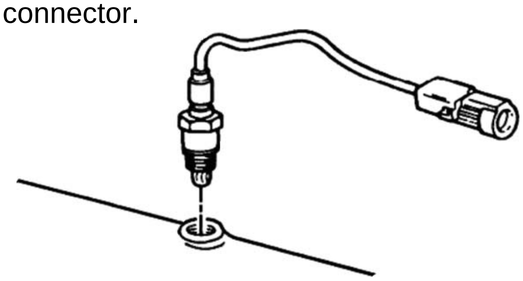
The coolant may be hot. Use caution when removing hose(s) to prevent contact.

INSTALLATION PROCEDURE

1. Apply a light coat of Loctite 567 or equivalent pipe thread sealant on the threads of the ECT.
2. Install the ECT into the engine **and torque until tight**.
3. Connect the ECT electrical connector.
4. Refill the coolant.
5. Reconnect the negative battery cable.
6. Start the engine and let run until it reaches normal operating temperature and verify correct operation. Check for leaks. If leaks are found, repair as necessary.
7. If a DTC code is found, refer to the Electrical Section for further diagnosis.
8. Allow the engine to cool, check coolant level and add coolant if necessary.

IX. HEATED EXHAUST GAS OXYGEN SENSOR (HEGO)

1. Disconnect Negative battery cable.
2. Locate the Oxygen Sensor.
3. Disconnect the Oxygen sensor electrical connector.



HEGO and Fitting

4. Using an Oxygen Sensor socket, remove the Oxygen Sensor.

INSTALLATION PROCEDURE

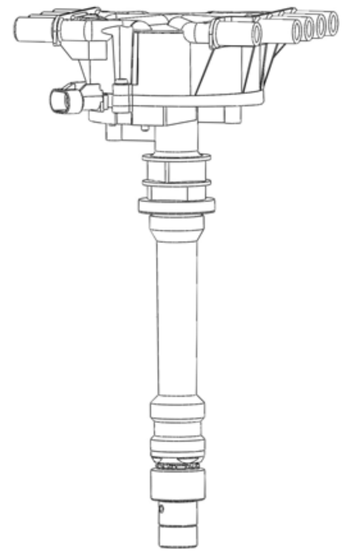
CAUTION

Contamination of the HEGO sensor can result from the use of an inappropriate RTV sealer or silicone spray products. Do not use silicone sprays or hoses which are assembled using silicone lubricants. Always use “oxygen sensor safe” RTV sealant for repair procedures. Silicon contamination will cause a high but false HEGO signal voltage (rich exhaust indication). The ECM will then reduce the amount of fuel delivery to the engine, causing a severe performance problem. If silicone contamination is suspected, remove and visually inspect the sensor element. If contaminated, the portion of the sensor exposed to the exhaust stream will have a white powdery coating. Always be sure to eliminate the cause of contamination before replacing the sensor.

IMPORTANT
Before installing the Oxygen sensor lubricate threads with anti-seize compound GM P/N 5613695 or equivalent. Avoid contaminating sensor tip with compound.

1. Install Oxygen Sensor **Torque to (30 ft. lbs.) 41 Nm**.
2. Reconnect electrical connector to the Oxygen Sensor.
3. Reconnect the negative battery cable.
4. Start the engine and let run until it reaches normal operating temperature and is in closed loop.
5. If a DTC code is found, refer to the Electrical Section for further diagnosis.

X. DISTRIBUTOR



The Distributor

REMOVAL PROCEDURE

1. Disconnect negative battery cable.
2. Mark each Spark Plug wire with its corresponding cylinder or position on the Distributor Cap.
3. Remove Spark Plug wires from Distributor Cap by pulling and twisting each Spark Plug wire boot ½ turn.
4. Remove Ignition Coil wire.
5. Remove the electrical connector from the base of the Distributor.
6. Remove the two Screws that hold the Distributor Cap to the housing and remove cap.
7. Using a grease pencil or similar marking tool, mark the location of the Rotor on the distributor housing and engine.
8. Remove the Distributor hold down bolt.
9. Carefully remove the Distributor, noting the final position of the Rotor in the housing. Using a grease pencil or similar marking tool, mark the location of the rotor on the Distributor housing.

IMPORTANT
Do not engage the starter, or change the positions of the cam or crankshaft, timing gears or any other internal engine components while the distributor is removed. Any change in the position of these components will alter the timing.

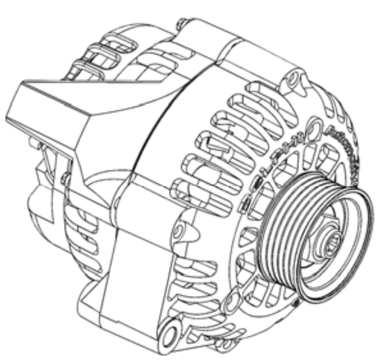
INSTALLATION PROCEDURE

1. Align the Rotor with the second mark made on the Distributor housing (the location of the rotor when it was removed) and place into the engine in line with the mark on the intake manifold. If the Rotor does not return to the position of the first mark, remove and repeat procedure.
2. Install the Distributor hold down or mounting clam Bolt and **tighten to 33.1 ft.lbs (45 Nm)**. Verify that the rotor remains in line with the first mark.
3. Install Distributor Cap.

IMPORTANT
Do not reuse old Distributor Cap Screws. Use new Screws only.

4. Connect the electrical connection to the base of the Distributor.
5. Connect Spark Plug wires to the Distributor Cap verifying that each is connected to the correct Plug. Note that the firing order is 1-8-4-3-6-5-7-2. Refer to the Appendix.
6. Connect Ignition Coil wire to the Distributor Cap.
7. Reconnect negative battery cable.
8. Start engine and run through all throttle ranges and under load to ensure normal operation.
9. Using the DST, clear DTC information from the ECM.
10. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XI. ALTERNATOR



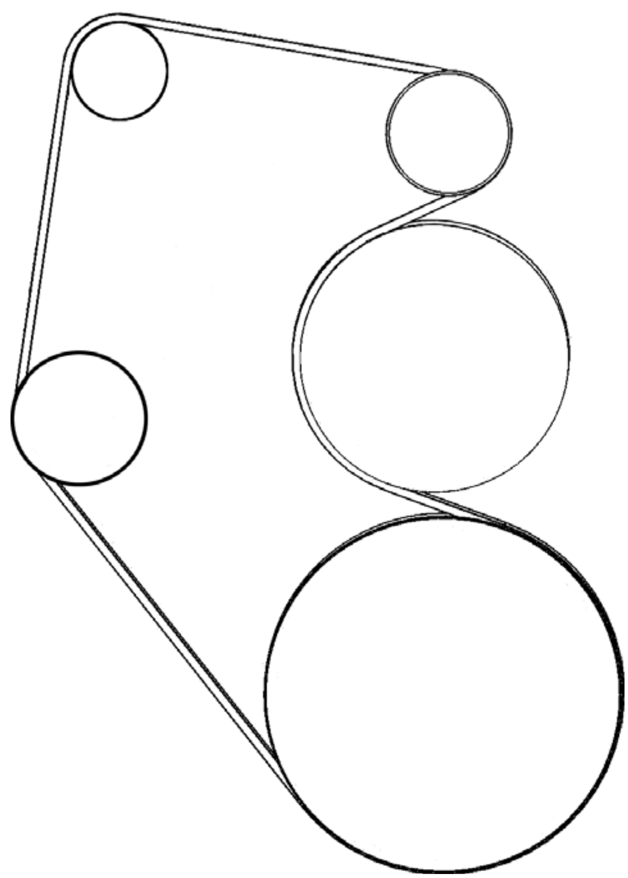
REMOVAL PROCEDURE

1. Disconnect the negative battery cable
2. Remove the Serpentine Belt. Refer to *XII. Serpentine Belt.*
3. Remove the two Bolts securing the Alternator and sleeves.
4. Remove the electrical connections from the Alternator.
5. Remove Alternator.

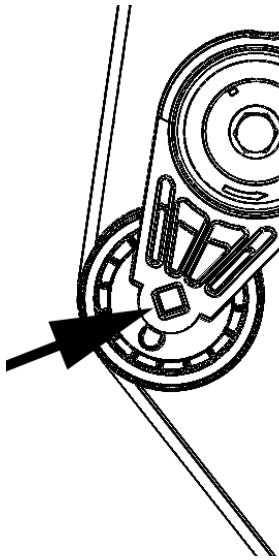
INSTALLATION PROCEDURE

1. Connect electrical connections to the Alternator. Tighten the output terminal nut **to 12 ft.lbs (17 Nm).**
2. Insert two Bolts securing the Alternator and **toque to 37 ft.lbs (50 Nm).**
3. Replace Serpentine Belt. Refer to *XII. Serpentine Belt.*
4. Reconnect the negative battery cable.
5. Start engine and check for MIL. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XII. SERPENTINE BELT



The Serpentine Belt routing of the 6.2L engine.



The Tensioner and the 3/8" socket as shown by the arrow.

REMOVAL PROCEDURE

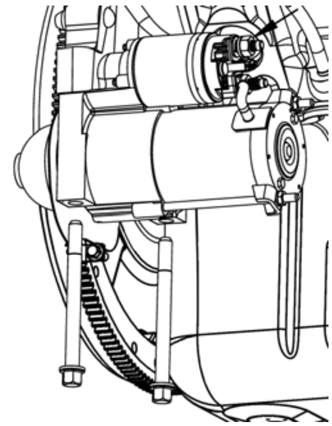
1. Insert a 3/8" socket wrench or breaker bar into the tensioner arm. Rotate the arm counter-clockwise, slowly release the tension on the tensioner and slide the Belt off the tensioner pulley.
2. Remove the Belt.

XIII. STARTER

INSTALLATION PROCEDURE

1. Place the Serpentine Belt over the pulleys (see illustration for routing) except the tensioner Pulley.
2. Using a 3/8" socket wrench or breaker bar, rotate the tensioner counterclockwise and slip the Belt over the Pulley on the tensioner.
3. Verify the Belt is properly placed on the all Pulleys.

REMOVAL



Removal of the Starter Bolts and Electrical Connection.

1. Remove the two Bolts securing the Starter and remove Starter.
2. Remove the wire connected to the solenoid on top of the Starter (as noted in the arrow in the illustration).

INSTALLATION PROCEDURE

1. Connect the wire to the solenoid and secure with nut. **Torque to 17 in.lb. (1.9 Nm).**
2. Secure the starter with the two bolts and **torque to 37 ft.lb (50 Nm)**.

XIV. CAMSHAFT POSITION SENSOR

REMOVAL PROCEDURE

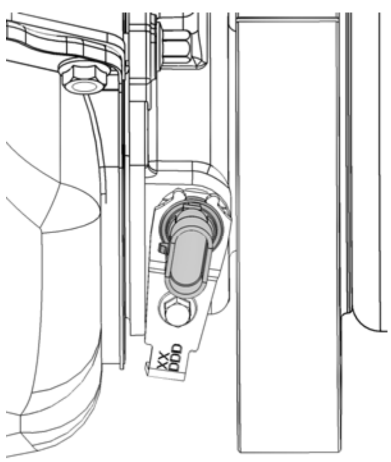
1. Disconnect negative battery cable.
2. Label Spark Plug Wires with matching Distributor Cap number and remove by pulling and twisting each spark plug wire boot ½ turn.
3. Remove Ignition Coil wire.
4. Remove the electrical connector from the base of the Distributor.
5. Remove the two Screws that hold the Distributor Cap to the housing and remove Cap.
6. Remove the Rotor Screws.
7. Turn the engine crankshaft to align the square slot in the reluctor wheel with the Cam Sensor.
8. Remove the two screws securing the Camshaft Sensor
9. Remove the Camshaft Sensor from the Distributor.

INSTALLATION PROCEDURE

IMPORTANT
Do no not reuse the old Distributor Cap, Rotor or Cam Sensor Screws.

1. Mount Camshaft Sensor on Distributor and secure with new Screws. **Torque to 19 in. lbs. (2.2 Nm).**
2. Install the Rotor on the reluctor wheel and secure with new Rotor Screws. **Torque to 18 in. lbs. (2.0 Nm).**
3. Install new Rotor Cap and secure with new Screws. **Torque to 21 in. lbs. (2.4 Nm)**.
4. Connect the Camshaft sensor harness connector.
5. Connect the Spark Plug wires and Ignition Coil Wire.

XV. CRANKSHAFT SENSOR (CKP)



The Crank Sensor (CKP) is located on the right side of the engine, between the flywheel and oil pan.

REMOVAL PROCEDURE

1. Remove electrical connector.
2. Remove bolt securing the sensor and remove sensor and bracket.
3. Remove sensor by pulling off bracket.

INSTALLATION PROCEDURE

1. Insert sensor into clip of bracket.
2. Attach electrical connector.
3. Insert bolt into hole in bracket and insert assembly into the engine. Secure with bolt and **torque to 6.7 ft.lbs. (9Nm).**
4. Start engine and check for MIL. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XVI. CRANKSHAFT SENSOR RELUCTOR RING

REMOVAL PROCEDURE

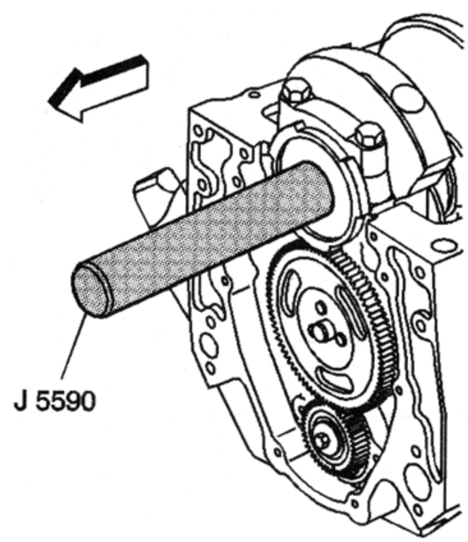
1. Disconnect negative battery cable.
2. Remove front engine cover assembly.
3. Slide the Crankshaft Sensor Reluctor Ring off the crankshaft.

INSTALLATION PROCEDURE

1. Align the keyway on the CKP Sensor Reluctor Ring and crankshaft and install the CKP Sensor Reluctor Ring.

IMPORTANT
The CKP Sensor Reluctor Ring is dish shaped. The dish must face the front engine cover.

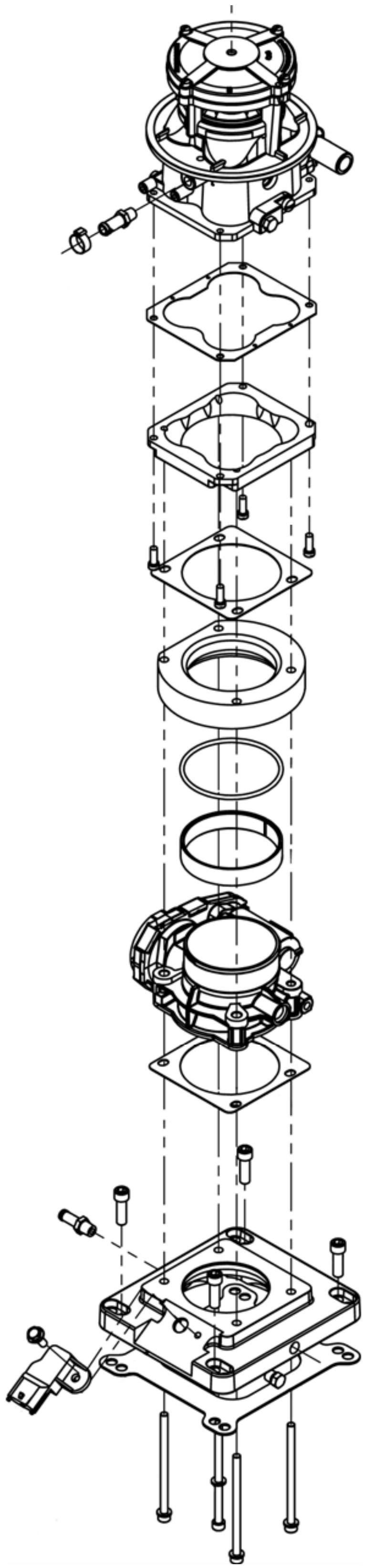
2. Use tool J 5590 to push the CKP Sensor Reluctor Ring until it is firmly seated against the crankshaft sprocket.



CKP Sensor Reluctor Ring Installation using tool J 5590. Engine is shown upside down.

3. Install the front engine cover assembly.

XVII. MIXER/ADAPTER/THROTTLE BODY ASSY



The Mixer, Throttle Body, Adapter and Related Gaskets and hardware.

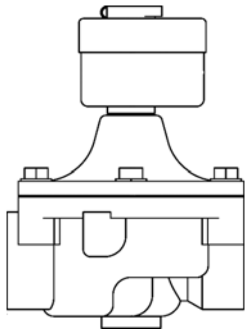
REMOVAL PROCEDURE

1. Relieve the fuel system pressure. Refer to *XXII. FUEL SYSTEM PRESSURE RELIEF.*
2. Disconnect the negative battery cable.
3. Remove the air intake hose from the Mixer.
4. Remove PCV hose from Mixer.
5. Remove electrical connection from Throttle Body.
6. Remove MAP sensor connector.
7. Remove the four screws holding the adapter plate to the intake manifold and remove as an assembly.
8. Unscrew from pipe leading to regulator.
9. Remove four screws securing the Adapter, Throttle Body and Mixer. Disassemble components.
10. Place tape or a clean cloth over the intake to prevent items from falling inside the engine.
11. Map sensor need only be removed if the adapter is replaced.

INSTALLATION PROCEDURE

1. Clean all components using a safety solvent.
2. Lubricate O-ring with Vaseline.
3. Place ring, O-ring, Adapter and gasket on top of Throttle Body as shown in the illustration.
4. Place the Throttle Body assembly on top of the Adapter plate. Align holes and insert four screws and finger tighten. Ensure all components are aligned correctly, **then tighten to 12.5ft.lbs (7 Nm.)**
5. Place a sparing amount of pipe thread sealer on the fuel delivery pipe and insert pipe from Regulator into the Mixer. Torque until tight, then continue turning until the proper clock positions are met.
6. Place the Mixer assembly and gasket on top of the Intake manifold and secure with four screws and **torque to 12.5ft.lbs (7 Nm.)**
7. Connect the PCV hose.
8. Connect electrical connector to the Throttle Body.
9. Connect electrical connector to the MAP sensor.
10. Connect negative battery cable.
11. Open fuel supply valve.

XVIII. SHUT-OFF VALVES



One of the two Gas Vapor Shut-off Valves (Actual Valve may be different from one pictured above).

REMOVAL PROCEDURE

WARNING

Residual vapor pressure will be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

1. Relieve the fuel system pressure. Refer to *XXII. FUEL SYSTEM PRESSURE RELIEF.*
2. Disconnect the negative battery cable.
3. Disconnect both of the Shut-Off Valve electrical connectors.
4. Disconnect the fuel inlet line.
5. Remove the Fuel Pipe and Shut-off Valve assembly.
6. Disassemble the Fuel Pipe assembly and remove the Shut-off valves.

INSTALLATION PROCEDURE

1. Add Loctite 567 or equivalent thread sealer to all male pipe threads, including the Elbow, Hose Adapter, Fuel Inlet Fittings, etc.
2. Connect elbow and brass fittings, making sure that the Elbow has the correct orientation to the Shut-Off Valves.
3. Connect Elbow, Shut-Off Valves and Fuel Pipes together. **Torque 2 turns past finger tight**, then continue if necessary, until each component is aligned to its proper clock position.
4. Connect electrical connectors to the Shut-off Valves.
5. Connect the fuel inlet line to the Shut-Off Valve assembly.
6. Reconnect negative battery cable.
7. Open the fuel supply valve.
8. Turn Ignition to the ON position for several seconds, then turn back to OFF. Check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
9. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
10. If a DTC code is found, refer to the Electrical Section for further diagnosis

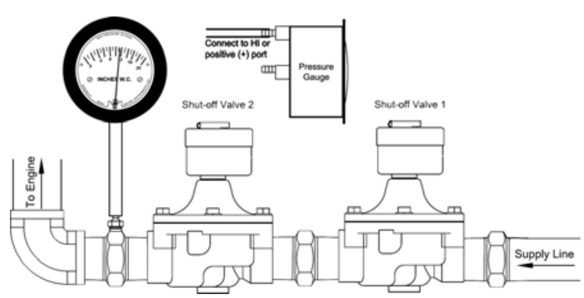
XIX. FUEL SUPPLY PRESSURE TEST

1. Turn the fuel supply valve to OFF and relieve the system fuel pressure. Refer to *XXII. FUEL PRESSURE RELIEF*.
2. Remove the plug on the Test Port Fitting between the Manual Supply Valve and the first Shut-off Valve.

WARNING

Residual vapor pressure will be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

3. Install the test port fitting into the supply line and torque until tight.
4. Zero and/or calibrate the 0-20” W.C. gauge, then attach the hose to the test port fitting. Note that the test port fitting, hose and gauge are included with test kit, ITK-1-IND.
5. Slowly turn the Fuel Supply Valve ON and note the pressure on the gauge. The pressure should not exceed 13.85” W.C.



The Shut-off Valves with the Pressure Gauge Attached to the Test Port (Actual Valves may be different from ones pictured above).

6. Turn the Manual Supply Valve to OFF.
7. Remove the gauge, hose and test port fitting.

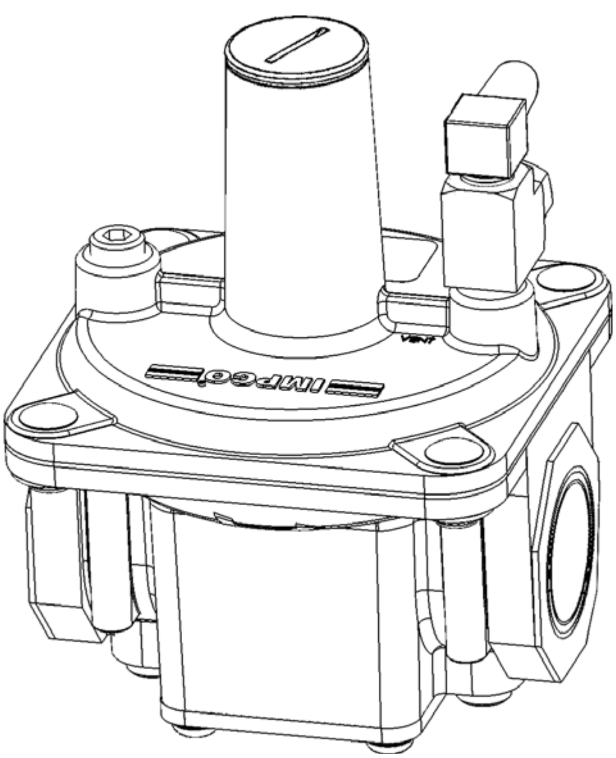
WARNING

Residual vapor pressure will be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

8. Apply Loctite 567 to the test port plug and insert into the test port. Torque until tight.
9. Refer to *XVIII. SHUT-OFF VALVES* and *Minimum and Maximum Recommended Inlet Pressure Specifications* for additional information, testing of the Shut-off Valves and testing fuel pressure from other test ports.

XX. REGULATOR

Important: Once installed, the tamper resistant cap is not serviceable and cannot be removed.



The Regulator

REMOVAL PROCEDURE

1. Turn off the fuel supply valve and relieve the fuel system pressure. Refer to *XXII. FUEL SYSTEM PRESSURE RELIEF.*
2. Disconnect Negative battery cable.
3. Disconnect hoses attached to the brass T-fitting on the Regulator.
4. Remove the Fuel Hose Clamp and Hose from the Elbow nearest the Regulator.
5. Remove Clamp supporting the Pipe that leads to the Regulator.

Remove the Mixer Adapter, Fuel Pipes and Regulator together as an assembly. Refer to *XVII. MIXER/ADAPTER/THROTTLE BODY ASSY*

6. Remove the Fuel Pipe or Elbow attached to the Regulator at the juncture between the Fuel Pipe and Regulator.

NOTE: Be sure to spin the Regulator on the pipe. Do not put any side pressure on the Regulator or Pipe that may strip or damage any of the threads.

7. Remove the straight Fuel Pipe assembly using care not to damage the threads with any side-ways pressure.
8. Remove the 90-degree nylon Elbow, the brass Hose Barb and the brass T-fitting on top of the Regulator.

INSTALLATION PROCEDURE

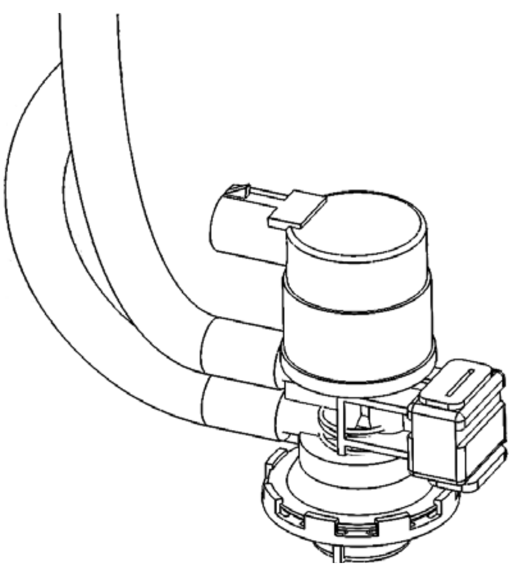
1. Place Loctite 567 or equivalent thread sealer on the male threads of the Fuel Pipes.
2. Assemble the Fuel Pipe and Elbow in the Regulator and **torque until tight**.

NOTE: Insert the fuel pipe end of the Regulator and Fuel Pipe assembly into the Mixer and **torque until tight**, then continue to turn so the Regulator and Mixer are in the same clock position. Be sure to spin the Regulator on the pipe and not put any side pressure on the Regulator.

3. Place the assembly on top the Throttle Body. Refer to *XVII. MIXER/ADAPTER/THROTTLE BODY ASSY*
4. Secure Fuel Pipe to bracket with the Regulator Support Clamp and torque the Clamp Screw to **20.8 ft.lbs. (28.3 Nm).**
5. Place the Elbow on the Fuel Pipe and turn to tight, then continue to turn until it is positioned in line with the Fuel Hose.
6. Place Loctite 567 or equivalent thread sealer on threads of the Hose Barb. Insert into

Elbow and **torque until tight.**
7. Place Loctite 567 or equivalent thread sealer on the threads of the Brass T-fitting and insert into the top of the Regulator. **Torque until tight**, then continue turning until the T-fitting is pointed towards the engine.
8. Place Loctite 567 or equivalent thread sealer on the threads of the Vacuum Hose Barb adapter. Insert into the brass T-fitting and **torque until tight.**
9. Place Loctite 567 or equivalent thread sealer on the male threads of the nylon elbow, then insert into the brass T. **Torque until tight**, then continue to turn until it points to the Fuel Control Valve.
10. Place Loctite 567 or equivalent thread sealer on the male threads of the nylon elbow, then insert into brass T. **Torque until tight**.
11. Reconnect Vacuum Hoses to the barb fittings.
12. Reconnect negative battery cable.
13. Open the fuel supply valve.
14. Turn Ignition to ON and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected make repairs.
15. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs. Verify correct operation in all throttle ranges.
16. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XXI. FUEL CONTROL VALVE



The Fuel Control Valve, Shown with Hoses.

REMOVAL PROCEDURE

1. Disconnect electrical connector
2. Disconnect Vacuum Hoses
3. While rocking the Control Valve back and forth, gently pull the Valve up and remove from the bracket.

INSTALLATION PROCEDURE

1. Press the Fuel Control Valve on the mounting bracket.
2. Connect two vacuum hoses.

NOTE: The lower Hose is attached to the Intake Manifold and the upper Hose is attached to the Regulator.

3. Attach electrical connector.
4. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected make repairs. Verify correct operation in all throttle ranges.
5. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XXII. FUEL SYSTEM PRESSURE RELIEF

1. Close the fuel supply valve.
2. Start and run the engine until the engine stalls from lack of fuel.
3. Turn the ignition switch to OFF.
4. Disconnect the negative battery cable.

WARNING
Never use an open flame of any type to check for Natural Gas or Propane leaks.

IMPORTANT
Always inspect the fuel system for leaks after performing service. Check for leaks at the fittings of the serviced or replaced component. Use a commercially available liquid leak detector or an electronic leak detector. When using both methods, use the electronic leak detector first to avoid contamination by the liquid leak detector.

XXV. FUEL SYSTEM LEAK TEST

1. Use a commercially available liquid leak detector or an electronic leak detector and follow the manufacturer's instructions.

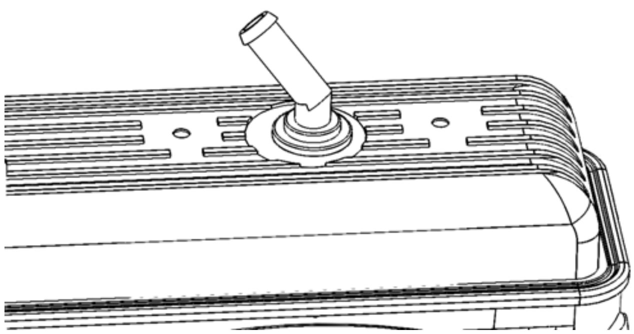
IMPORTANT
When using both methods, use the electronic leak detector first to avoid contamination by the liquid leak detector.

2. If leaks are detected, make repairs

XXIII. FUEL CONTROL SYSTEM CHECK

1. The fuel system can be thoroughly diagnosed by use of the DST tool. See section DIAGNOSTIC SCAN TOOL.

XXIV. CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS



The Elbow Vent, shown mounted on top of the valve cover.

Refer to CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS in the Fuel Symptom Diagnostics Section for additional information.

If an engine is idling rough, inspect for a clogged PCV orifice, a dirty vent filter, air cleaner element, or plugged hose. Replace any faulty items found. Use the following procedure:

1. Remove the PCV hose from the rocker arm cover.
2. Operate the engine with no load.
3. Place your thumb over the end of the hose in order to check for vacuum. If there is no vacuum at the hose end, inspect for plugged hoses and/or clogged or damaged manifold vacuum port.
4. Turn the engine OFF.
5. Inspect the PCV orifice in the valve cover for debris or blockage. Clean with carburetor cleaner as necessary.

XXV. COOLANT HOSE

REMOVAL PROCEDURE

1. Drain coolant.

WARNING

Do not remove the cooling system pressure cap (radiator cap) when the engine is hot. Allow the engine to cool and then remove the cap slowly to allow pressure to vent. Hot coolant under pressure may discharge violently.

WARNING

The coolant may be hot. Use caution when removing hose(s) to prevent contact.

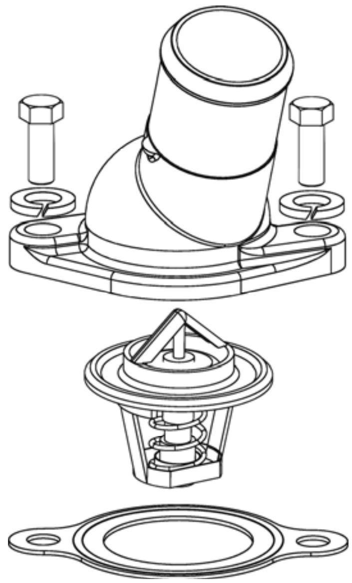
2. Remove Hose Clamps from both ends and remove hose.

INSTALLATION PROCEDURE

IMPORTANT
Coolant hoses are specifically designed for their application. DO NOT use hose material or length other than the OEM specified parts. DO NOT mix the inlet or outlet ends of the Hose when reinstalling.

1. Slide Clamps over each end of the Hose.
2. Place hose over barbs on each end. If necessary, twist or untwist the Hose to ensure it lies in the correct position and is not kinked or twisted.
3. Slide Hose Clamp to a position approximately 1/4” from the end of the Hose and tighten.
4. Refill with coolant.
5. Start engine and let run until it reaches operating temperature.
6. Check for leaks. If leaks are detected, make repairs.
7. Stop engine and allow to cool. Check coolant level and add coolant as necessary.

XXVI. THERMOSTAT, HOUSING & GASKET



An Expanded view of the Thermostat Housing, Thermostat and Gasket.

REMOVAL PROCEDURE

1. Drain Coolant.

WARNING

Do not remove the cooling system pressure cap (radiator cap) when the engine is hot. Allow the engine to cool and then remove the cap slowly to allow pressure to vent. Hot coolant under pressure may discharge violently.

2. Remove Clamp and coolant hose attached to the Thermostat Housing.
3. Remove two Bolts securing the Housing to the Intake Manifold.
4. Remove Thermostat Housing, Thermostat and Gasket.

INSTALLATION PROCEDURE

1. Verify that pieces of the old Gasket are removed that the Gasket sealing surfaces on both the Thermostat Housing and Intake Manifold are clean.
2. Place PipeTite compound on the threads of the Screws, then place the Gasket on the Intake Manifold, followed by the Thermostat and Housing. Align holes and insert Screws and Lock Washers. **Torque Screws to 33 ft.lbs (45 Nm)**.
3. Attach coolant hose and secure with clamp. Refer *XXV. Coolant Hose.*
4. Refill Coolant.
5. Start and run engine until it reaches normal operating temperature.
6. Check for coolant leaks. Repair if leaks are found.
7. Allow engine to cool. Inspect coolant level and add coolant if necessary.

XXVII. FUEL VAPOR HOSE

REMOVAL PROCEDURE

1. Relieve the fuel system pressure. Refer to *XVIII. FUEL SYSTEM PRESSURE RELIEF*.

WARNING

Residual vapor pressure may be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

2. Disconnect negative battery cable.
3. Remove Hose Clamps.
4. Remove Hose from barbs at both ends.

IMPORTANT
Hoses are designed for specific applications. DO NOT use Hose material or length other than specified by the OEM. DO NOT mix the inlet or outlet ends of the Hose when reinstalling.

INSTALLATION PROCEDURE

1. Slide Hose Clamps over each end and towards the middle of the Fuel Hose.
2. Place Fuel Hose over each barb. If necessary, twist or untwist the Hose to ensure it lies in the correct position and is not kinked or twisted.
3. Slide each Hose Clamp to a position approximately 1/4” from the end of the Hose and tighten.

CAUTION

Contamination of the HEGO sensor can result from the use of an inappropriate RTV sealer or silicone spray products. Do not use silicone sprays or hoses which are assembled using silicone lubricants. Always use "oxygen sensor safe" RTV sealant for repair procedures. Silicon contamination will cause a high but false HEGO signal voltage (rich exhaust indication). The ECM will then reduce the amount of fuel delivery to the engine, causing a severe performance problem. If silicone contamination is suspected, remove and visually inspect the sensor element. If contaminated, the portion of the sensor exposed to the exhaust stream will have a white powdery coating. Always be sure to eliminate the cause of contamination before replacing the sensor.

4. Reconnect negative battery cable. Open the fuel supply valve.
5. Turn Ignition to the ON position for several seconds, then turn back to OFF. Check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
6. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
7. If a DTC code is found, refer to the Electrical Section for further diagnosis

XXVIII. FUEL VAPOR PIPE

REMOVAL PROCEDURE

1. Relieve the fuel system pressure. Refer to *XVIII. FUEL SYSTEM PRESSURE RELIEF*.

WARNING

Residual vapor pressure may be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

2. Disconnect negative battery cable. Remove the Fuel Vapor Hose connecting to the Fuel Pipe Assembly. Refer to *XXVII.FUEL VAPOR HOSE.*
3. Remove the Regulator support clamp from the Fuel Pipe.
4. Remove the Fuel Pipe from the Regulator.

NOTE: Be sure to spin the Pipe on the Regulator. Do not put any side pressure on the Regulator or Pipe that may strip or damage any of the threads.

5. Remove the Elbow and Hose Barb from the Pipe if necessary.

INSTALLATION PROCEDURE

6. Place Loctite 567 or equivalent thread sealer on all male threads to be assembled.
7. Thread the Elbow on to the Pipe (if Elbow was removed).
8. Insert opposite end of pipe into Regulator and **torque until tight**. Continue turning until the Elbow is positioned so that it points away from the engine.
9. Reconnect negative battery cable. Open the fuel supply valve.
10. Turn Ignition to the ON position for several seconds, then turn back to OFF. Check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
11. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
12. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XXIX. VACUUM HOSE

REMOVAL PROCEDURE

1. Remove the Vacuum Line from each fitting.

INSTALLATION PROCEDURE

IMPORTANT
DO NOT use a hose other than the OEM specified part.

1. Reinstall the Vacuum Hose to each fitting and secure with clamp, if used originally. If necessary, twist or untwist the Hose to ensure it lies in the correct position and is not kinked or twisted.

2. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected make repairs.

XXX. OETIKER CAMPS

A Used or Compressed Oetiker Hose Clamp

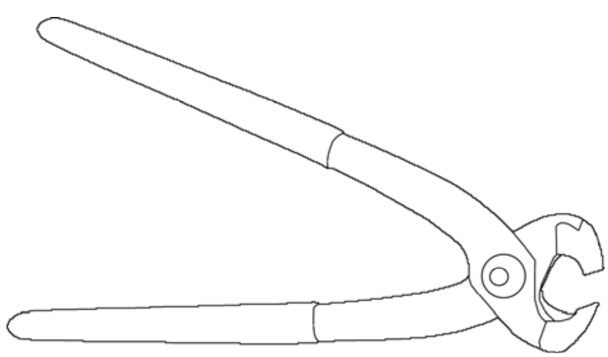
IMPORTANT
Oetiker Clamps can be used only once. Once removed, they can no longer be reused and should be discarded.

REMOVAL PROCEDURE

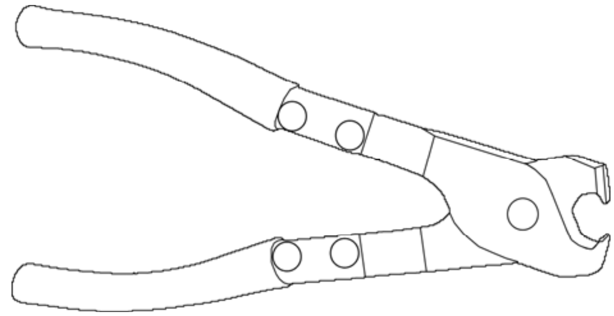
1. Place the pincer jaws or diagonal wire cutters across the ear (the crimped part of the clamp, shown on the top of the clamp above) and cut through it.
2. Remove Clamp and discard.

INSTALLATION PROCEDURE

Two Oetiker pliers exist: one standard and one for use when space is restricted:



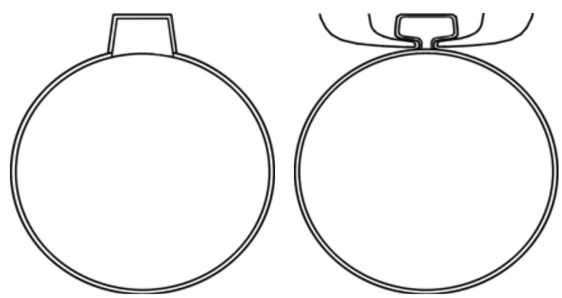
Standard Oetiker Pliers



Side Jaw Oetiker Pinchers

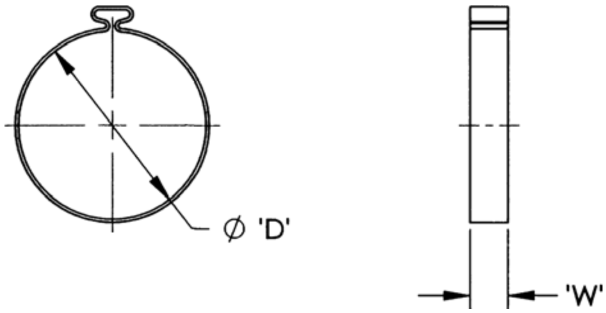
Only use recommended tools to close Oetiker Clamp ears. The ears of the clamp should be closed with a uniform force, sufficient to pinch the two sides of the ear together while applying enough compression on the hose to keep it snug on the barb without crushing. The deformation of the clamp ear provides the means to inspect the clamp (see illustration in Step 1 below).

1. Using the correct tool, crimp the ear so that the clamp is fully closed. Verify the clamp and the hose are both tight and secure on the barb.



The Oetiker Clamp on the left is shown end view as new and uncompressed and the one on the right is shown compressed using the Oetiker pliers.

2. Always inspect the hose for leaks after servicing any hoses. Run engine until normal operating temperature is reached and check for leaks using a commercially available liquid leak detector or an electronic leak detector. When using both methods, use the electronic leak detector first to avoid contamination by the liquid leak detector.



IMPCO PART NO.	BAND WIDTH DIM 'W'(mm)	CLAMP RANGE DIA. 'D' (mm)
C2-51552-05-105	5	8.8 -10.5
C2-51552-05-113	5	9.6 -11 .3
C2-51552-07-123	7	9.8 -12.3
C2-51552-07-133	7	10.8 -13.3
C2-51552-07-140	7	11 .5 -14.0
C2-51552-07-157	7	13.2 -16.2
C2-51552-07-170	7	14.5-17.0
C2-51552-07-185	7	15.3 -18.5
C2-51552-07-198	7	16.6 -19.8
C2-51552-07-210	7	17.8 -21 .0
C2-51552-07-241	7	20.9 -24.1
C2-51552-07-256	7	22.4 -25.6
C2-51552-07-271	7	23.9 -27.1
C2-51552-07-286	7	25.4 -28.6
C2-S1552-07-301	7	26.9 -30.1
C2-51552-07-346	7	31.4 -34.6
C2-51552-07-361	7	32.9 -36.1

Table listing IMPCO P/N and Clamp size.

XXXI. REGULATOR PRESSURE CHECK

1. Relieve the fuel system pressure. Refer to *XVIII. FUEL SYSTEM PRESSURE RELIEF.*

WARNING

Residual vapor pressure will be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

2. Remove the Primary Pressure Test Plug on the Regulator and insert the Test Plug.
3. Zero and/or calibrate the test Pressure Gauge, then connect to the Test Plug.
4. Open the fuel supply valve.
5. Reconnect negative battery cable.
6. Turn ignition to ON and note value on gauge.
7. Turn Ignition OFF.
8. Relieve the fuel system pressure. Refer to *XVIII. FUEL SYSTEM PRESSURE RELIEF.*
9. Remove gauge.
10. Apply Loctite 567 equivalent thread sealer to male threads on the test port plug and Replace. **Torque to tight.**
11. Open the fuel supply valve.
12. Turn ignition to ON and check for leaks at the inlet and outlet fittings using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.

XXXII. INTAKE MANIFOLD AND/OR GASKET

1. Drain coolant.

WARNING

Do not remove the cooling system pressure cap (radiator cap) when the engine is hot. Allow the engine to cool and then remove the cap slowly to allow pressure to vent. Hot coolant under pressure may discharge violently.

2. Remove ECM. Refer to *I. ENGINE CONTROL MODULE (ECM).*
3. Remove ECM bracket. Refer to *II. ECM BRACKET.*
4. Remove Distributor. Refer to X*. DISTRIBUTOR.*
5. Remove Ignition Coil. Refer to *III. IGNITION COIL/MODULE.*
6. Remove Fuel Control Valve. Refer to *XXI. FUEL CONTROL VALVE.*
7. Remove Oil Pressure Sender. Refer to *VI.OIL PRESSURE SENDER.*
8. Remove PCV Hose. Refer to *XXIX. VACUUM HOSE.*
9. Remove Clamp securing the Fuel Hose to the Fuel Pipe and remove the Hose.

NOTE: If only the Intake Manifold Gaskets are to be replaced, skip to Step 14.

10. Remove the Regulator Support Clamp securing the Fuel Pipe.
11. Remove the Throttle Body and Throttle Body Adapter. Refer to *XVII. MIXER ADAPTER/THROTTLE BODY.*
12. Remove Coolant Hose Clamp and Hose from Thermostat Housing. Refer t*o XXV.*

COOLANT HOSE.

13. Remove Thermostat Housing, Thermostat and Gasket. Refer to *XXVI. THERMOSTAT, HOUSING & GASKET.*
14. Remove 8 Bolts securing the Intake Manifold and remove the Manifold and Regulator Bracket.
15. Remove all Gaskets from the engine and Intake Manifold.

NOTE: Once the Intake Manifold is removed, place tape, a clean cloth or other protective covering over the engine and ports in the cylinder heads to prevent debris from falling in, possibly causing permanent engine damage.

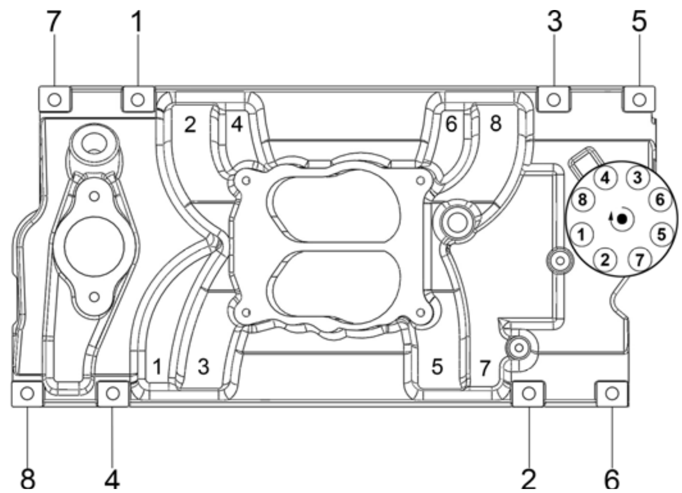
INSTALLATION PROCEDURE

1. Clean the Intake Manifold and inspect for the following:

    - Damage to the gasket sealing surfaces.
    - Restricted cooling system passages
    - Cracks or damage.
    - Damage to threaded bolt holes.

2. Replace the Gaskets on the engine and cylinder head. Use RTV in accordance to the OEM's specifications.
3. Place Intake Manifold on engine.
4. Finger tighten each of the 8 bolts securing the Intake Manifold and install the Fuel Pipe Bracket under Bolts listed as 3 and 5 below.

IMPORTANT: Proper Intake Manifold fastener tightening sequence and toque is critical. Always follow the tightening sequence and torque the intake manifold bolts using the three step method.



Top View of the Intake Manifold with the Bolt Tightening Sequence Numbered.

Torque each bolt in the order shown above in three passes:

First pass, **torque each bolt in sequence to 27 in.lb (3 Nm).**
Second pass **torque each bolt in sequence to 106 in.lb (12 Nm).**
Third pass **torque each bolt in sequence to 11 ft.lb (15 Nm).**

4. Install Thermostat Housing, Thermostat and Gasket. Refer to *XXVI. THERMOSTAT, HOUSING & GASKET*.
5. Connect Coolant Hose to Thermostat Housing and secure with Clamp. Refer to *XXV. COOLANT HOSE.*
6. Add Throttle Body and Throttle Body Adapter (if removed). Refer to *XVII. MIXER ADAPTER/THROTTLE BODY*.
7. Tighten the Regulator Support Clamp securing the Fuel Pipe to the Regulator Support Bracket (if removed).
8. Install the Ignition Coil. Refer to *III. IGNITION COIL/MODULE.*
9. Install Fuel Control Valve. Refer to *XXI. FUEL CONTROL VALVE.*
10. Install the PCV Hose and Regulator Hoses. Refer to *XXIX. VACUUM HOSE*.
11. Install the Oil Pressure Sender. Refer to *VI.OIL PRESSURE SENDER.*
12. Install distributor. Refer to X. *DISTRIBUTOR.*
13. Install the ECM bracket. Refer to *II. ECM BRACKET.*
14. Install the ECM. Refer to *I. ENGINE CONTROL MODULE (ECM).*

15. Fill coolant.
16. Connect negative battery cable.
17. Turn ignition to ON and check for fuel leaks using a commercial leak detector. If leaks are found, repair.
18. Start engine and check for leaks around the Intake Manifold, Thermostat housing, Oil Sensor and all other serviced fittings and components. If leaks are found, repair as necessary.
19. Check for MIL. If a DTC code is found, refer to the Electrical Section for further diagnosis.
20. Allow engine to cool and add coolant if necessary.

XXXIII. EXHAUST MANIFOLDS

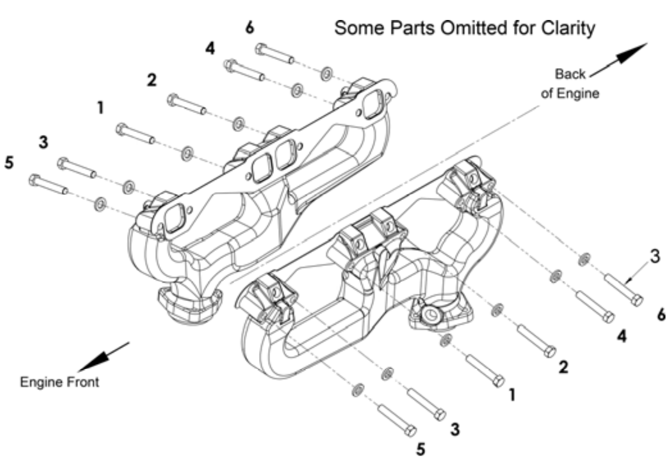
REMOVAL PROCEDURE

WARNING

Allow engine and exhaust manifolds to cool prior to any maintenance or other contact to prevent burns.

1. Remove the HEGO. Refer to *IX. HEATED*
2. *EXHAUST GAS OXYGEN SENSOR (HEGO).*
3. Remove the three Screws that secure the exhaust pipe to the Exhaust Manifold.
4. Remove Spark Plug Wires from Spark Plugs as necessary to gain access to the Exhaust Manifold.
5. Remove six bolts that secure the Exhaust Manifold to the engine and remove the Manifold and Gaskets. Repeat for opposite side.

INSTALLATION PROCEDURE



Expanded View of the Exhaust Manifold Assembly, showing bolt tightening sequence.

1. Verify that all of the sealing surfaces of the Exhaust Manifold are clean and smooth.
2. Place one Bolt and Washer in each of outside or the farthest Bolt Holes on each end of the Exhaust Manifold.
3. Place the Exhaust Manifold Gasket, Spacer and the second Gasket onto the Exhaust Manifold Bolts.
4. While holding each end of the Exhaust Manifold keeping the bolts from backing out, mate the exhaust Manifold, Gaskets and Spacer up the side of the engine and thread in the Bolts one at a time.
5. Insert the remaining four Bolts and finger tighten each, then **torque to 11 ft.lbs (15 Nm)**. Making one more pass, re-torque each to **22 ft. lbs (30 Nm)**.
6. Repeat Steps 1-5 for the other Exhaust Manifold (if both Manifolds are replaced).
7. Attach the Manifolds to the Exhaust Pipe and secure each with Bolts.
8. Start engine and run until it reaches normal operating temperature. Verify engine is in closed loop and no MIL light is present.
9. If a DTC code is found, refer to the Electrical Section for further diagnosis.

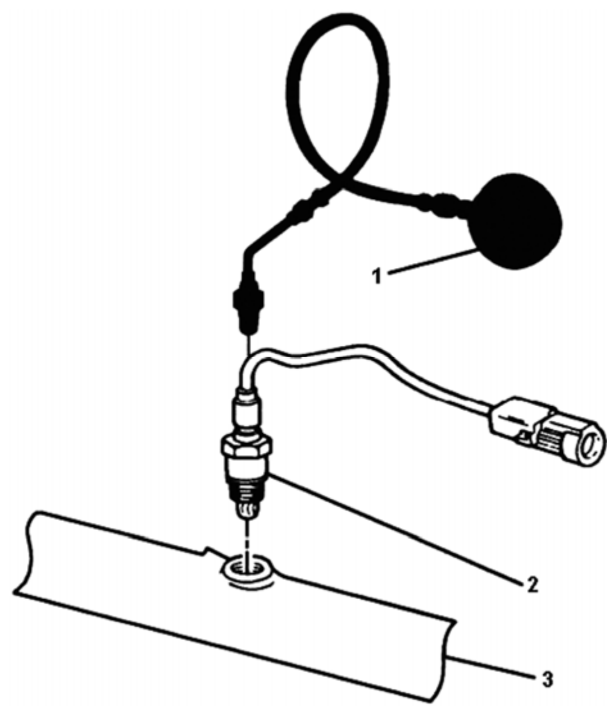
XXXIV. RESTRICTED EXHAUST SYSTEM DIAGNOSIS

TEST PROCEDURE

1. Carefully remove the HEGO.
2. Install Exhaust Back Pressure Test Gauge (J35314-A) in place of the HEGO.
3. Run the engine speed to1,800 RPM with no more than 25% load and observe gauge. Reading should not exceed 13.8 kPa (2 psi).
4. If the back pressure at either speed exceeds specification, a restricted exhaust system is indicated.
5. Inspect the entire exhaust system for a collapsed pipe, heat distress or possible internal damage.
6. If there are no obvious reasons for the excessive back pressure.
7. Once the problem is identified and corrected, start the engine and run until normal operating temperature is reached. Connect DST and look for closed loop operation as

shown by switching of the HEGO.

8. If a DTC code is found, refer to the Electrical Section for further diagnosis.



1. Back Pressure Gauge
2. Heated Exhaust Gas Oxygen Sensor (HEGO).
3. Exhaust Pipe/Muffler

Exhaust Back Pressure Test

XXXV. OIL DIPSTICK

REMOVAL PROCEDURE

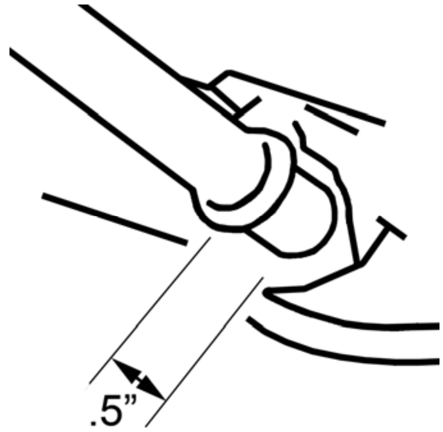
1. Remove the Oil Level Indicator (Dip Stick) from Tube.
2. Remove Bolt on Exhaust Manifold securing the Clamp.
3. Remove Oil Level Indicator Tube by rocking back and forth while pulling it from the engine.

WARNING

Engine oil will be hot. Use protective gloves to prevent burns. Engine oil contains chemicals which may be harmful to your health. Avoid skin contact.

INSTALLATION PROCEDURE

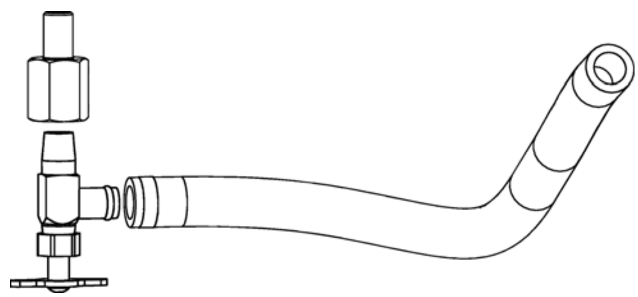
1. Add GM 10953480 sealant around the end of the Dipstick Tube and insert into the engine until the bead on the Tube is within ½” (13mm) of the engine.



The Oil Tube is inserted until the bead comes to within ½” of the engine.

2. Fasten the Tube to the side of the engine using the clamp. Tighten the Exhaust Manifold bolt to **22 ft. lbs (30 Nm)**.
3. Install the Dipstick or Oil Level Indicator into the Oil Tube.
4. Run engine until normal operating temperature is reached, then check for oil leaks.
5. Repair if leaks are found.

XXXVI. OIL DRAIN VALVE REMOVAL



A Drain Valve mounted underneath the Oil Pan.

WARNING

Engine oil will be hot. Use protective gloves to prevent burns. Engine oil contains chemicals which may be harmful to your health. Avoid skin contact.

1. Drain Oil. Refer to *Changing the Oil* in the General Information section.
2. Remove Hose Clamp and Hose from Drain Valve.
3. Remove Drain Valve and Adapter together by turning the Adapter counterclockwise.
4. Remove Valve from Adapter.
5. Catch any oil dripping from the oil pan and any other oil spilled and dispose of oil in a safe manner.

INSTALLATION PROCEDURE

1. Apply Loctite 567 to the male threads of the Valve and Adapter.
2. Thread Valve into Adapter and **torque until tight.**
3. Thread Valve and Adapter assembly into the oil pan and **torque until tight**. Continue turning the Valve until it reaches the correct clock position.
4. Place clamp over the oil hose and secure approximately ¼" from the end of the hose.
5. Refill oil. Refer to *Changing the Oil* in the General Information section.
6. Start engine and run until it reaches normal operating temperature. Check for leaks. If leaks are found, make repairs.

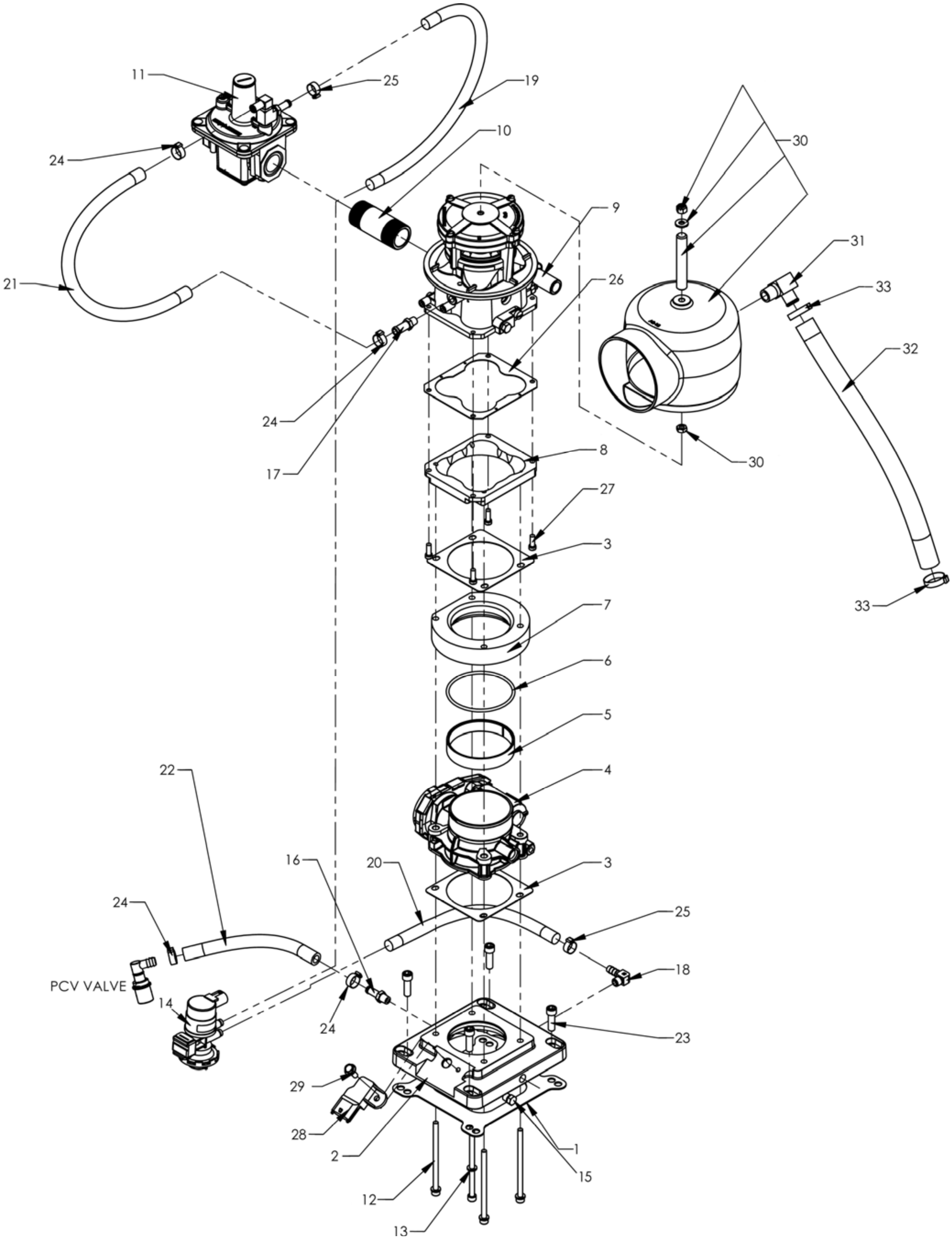
XXXVII. Fuel Selection

The IMPCO GM 6.2L Stationary Power Generating engine is easily configurable for use with either natural gas (NG) or LPG. System configuration for LPG or NG requires an electrical setting for the ECM to insure proper fuel and spark timing is supplied to the engine. ***The pressure regulator is pre-set at the factory for NG, so when using NG no mechanical adjustment is required.***

Atoggle switch, mounted under a panel needs to be switched to change the fuel type. Refer to the OEM instructions for changing the fuel.

Service Parts Manual

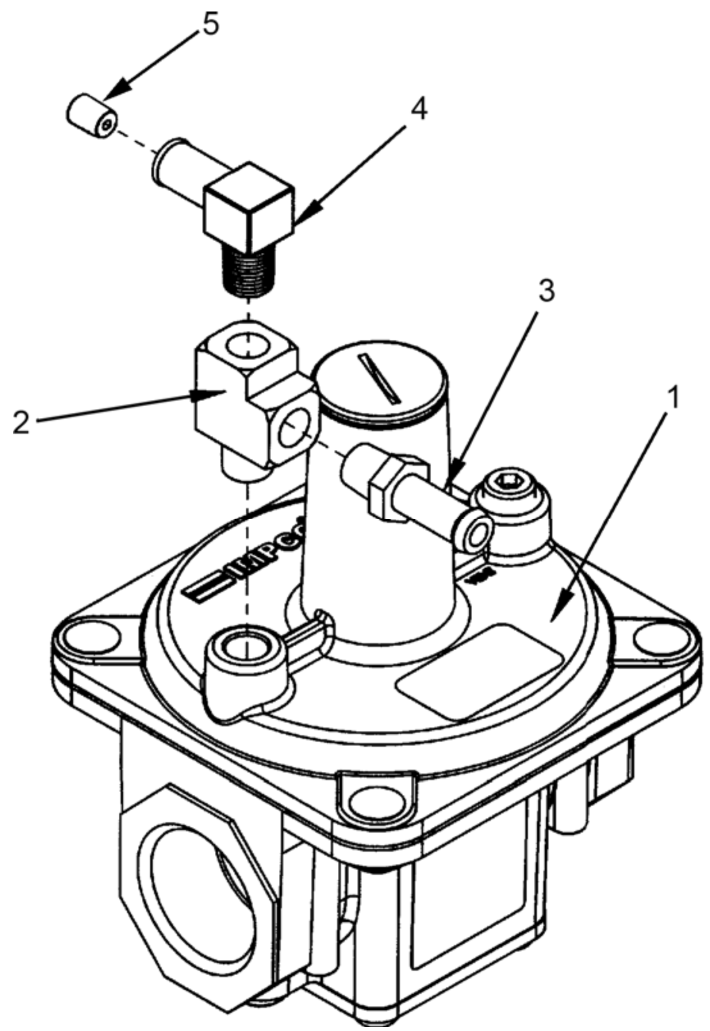
MIXER, THROTTLE BODY ASSEMBLY & MAP SENSOR



MIXER, THROTTLE BODY ASSEMBLY & MAP SENSOR

Item #	Description	Qty	Part Number
1	Gasket, 2116 1m, 5.7-6.2l	1	B001-1041
2	Adapter, Dual Bore -72mm ETB	1	B001-1011
3	GASKET, BOSCH 72mm ETB	2	B001-0961
4	GM Throttle Body	1	12616995
5	Sleeve, Plastic, Bosch 72mm	1	B001-0041
6	O-Ring, Nitrile,2-234, 0.139 X 03.0 ID	1	B001-1101
7	Adapter, Mixer To 72mm ETB	1	B001-0011
8	Adapter, 425 Mixer	1	B001-0031
9	Mixer Asm, 425 Series	1	CT425M-30155-003
10	Nipple, SCH 80 x l" X 3"LG BLACK	1	B001-1051
11	Regulator, Straight thru W/Fts	1	MD-53171-001
12	Screw, Socket Cap M6 x 100mm	4	S1-50237-A021-06100
13	Washer, Split Lock, M6	4	W1-1988-001
14	Valve, Regulator Control	1	V3-51777-001
15	Plug, 1/8 NPT	1	P3-13
16	Ftg1/8" MNPT X 5/16" Hose Br	1	15928-1
17	Fitting,1/8 NPT 3/8 Hose Brass	1	2H-103B
18	Fitting, 1/8 NPT 5/16hs 90el Br	1	F4-15269
19	Hose, 5/16" ID Fuel/Oil Bulk 396mm	1.3 FT	H1-19231-003-0396
20	Hose, 5/16" ID Fuel/Oil Bulk 265mm	.87 FT	H1-19231-003-0265
21	Hose, 3/8" ID Fuel/Oil Bulk 396mm	1.3 FT	H1-19231-004-0396
22	Hose, 3/8" ID Fuel/Oil Bulk 177mm	.58 FT	H1-19231-004-0177
23	BOLT SCHD, 5/16-18 x 1" GR 8	4	90268100
24	Ear Clamp, Stepless, 14.5 17.0	4	C2-51552-07-170
25	Ear Clamp, Stepless 13.2-15.7	2	C2-51552-07-157
26	Gasket, A3-35 Adapter	1	G1-74
27	Screw, 12-24 Slotted, Fillister .64in	4	S1-19
28	Sensor, TMAP Bosch	1	E146601
29	Screw, Hex Flange M6-10x16mm	1	S1-30871-02-0616
30	Adapt Asm 425 4 In Hose	1	B001-1091
31	Fitting, Water 3/8” NPT X 5/8 Hose 90	1	F4-17
32	Hose, Id 5/8” Fuel/Oil Bulk 244mm	1.13FT	H1-19231-006-0344
33	Ear Clamp, Stepless, 20.9-24.1	2	C2-51552-07-241

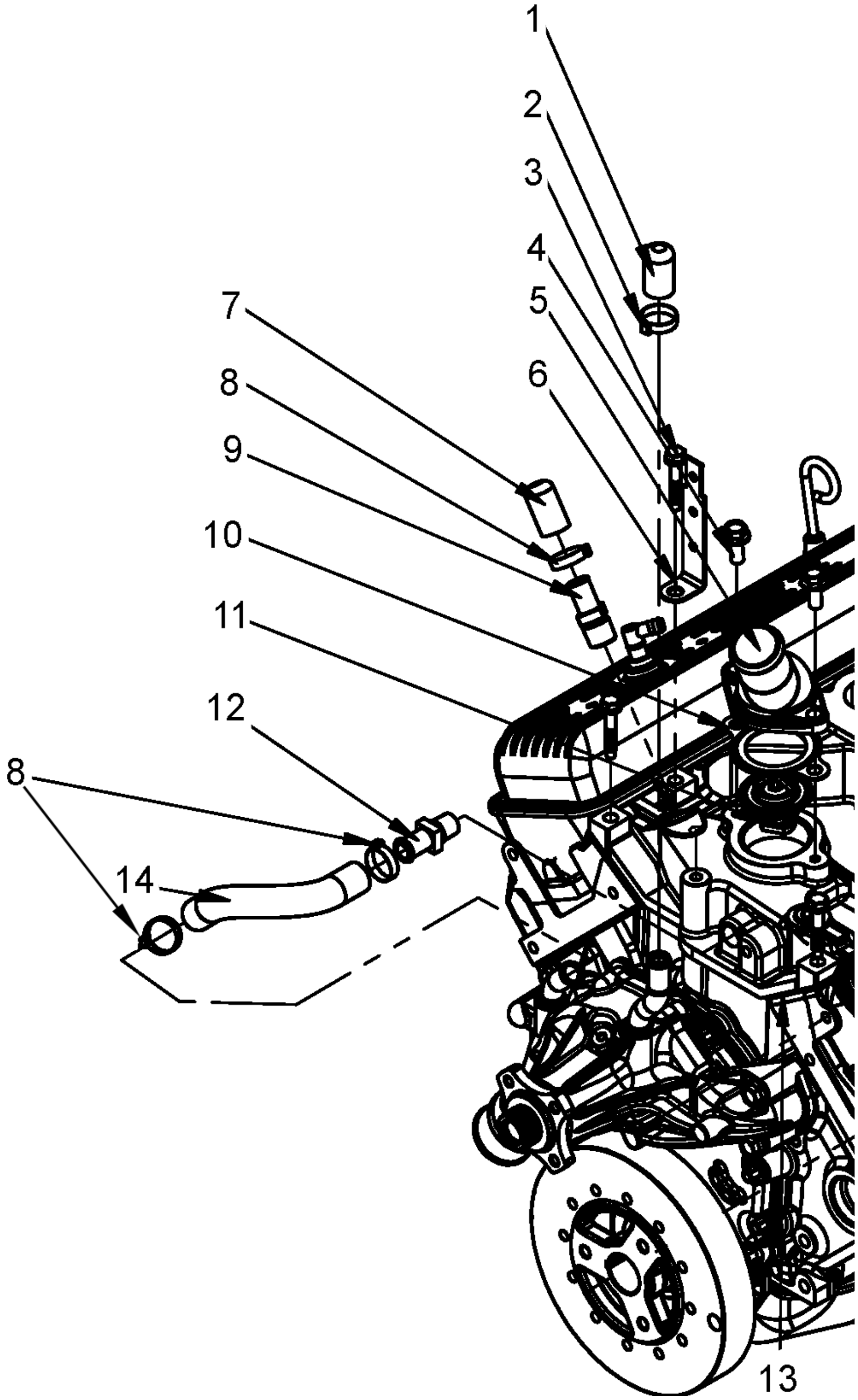
REGULATOR



REGULATOR

Item#	Description	Qty.	Part Number
1	Regulator, Straight-thru Low Pressure	1	IMP-52905-002
2	Fitting 1/8 NPT Street	1	3750X2
3	Fitting 1/8 NPT 5/16 Hose Brass	1	15928-1
4	Fitting, 90 Deg 1/8 NPT x 3/8	1	F4-12
5	Jet, Fee Back Bleed 0.80	1	B001-0711

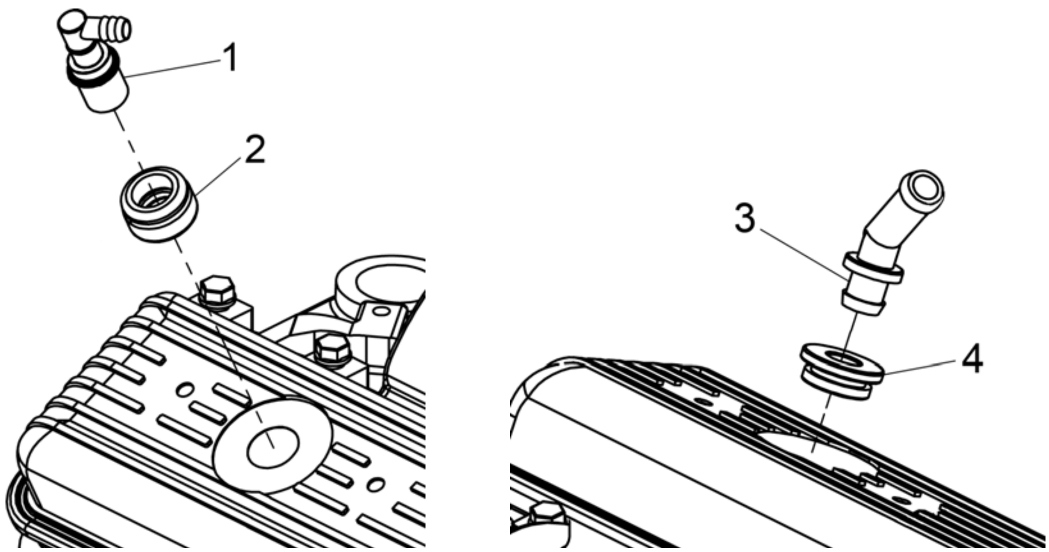
THERMOSTAT & WATER HOSES



THERMOSTAT & WATER HOSES

Item #	Description	Qty	Part Number
1	Cap, 5/8 Rubber Plug	1	7110790
2	Clamp, Ear Oetiker 024.1-706R	3	C2-51552-07-241
3	Bolt, 5/16-18 x 1-3/4”	3	7150960
4	Screw, Hex Flange 3/8-16 x 7/8	5	90325088
5	Thermostat Housing	1	7141970
6	Bracket, FCV Mount	1	B4-52048-001
7	Cap, 5/8 Rubber Plug	1	7110790
8	Clamp, Ear Oetiker 024.1-706R	3	C2-51552-07-241
9	Fitting, ½ NPT 5/8 Hs Nip Nylon	1	F4-16
10	Gasket, Thermostat Housing	1	7140310
11	Thermostat 180 degree	1	7142690
12	Fitting, 3/8 NPT 5/8 Hs Nip Nylon	1	F4-18
13	Gasket, Intake Manifold	1	See Manifolds
14	Hose, Coolant 5/8 Dia (177mm)	1	H1-50866-001-0177

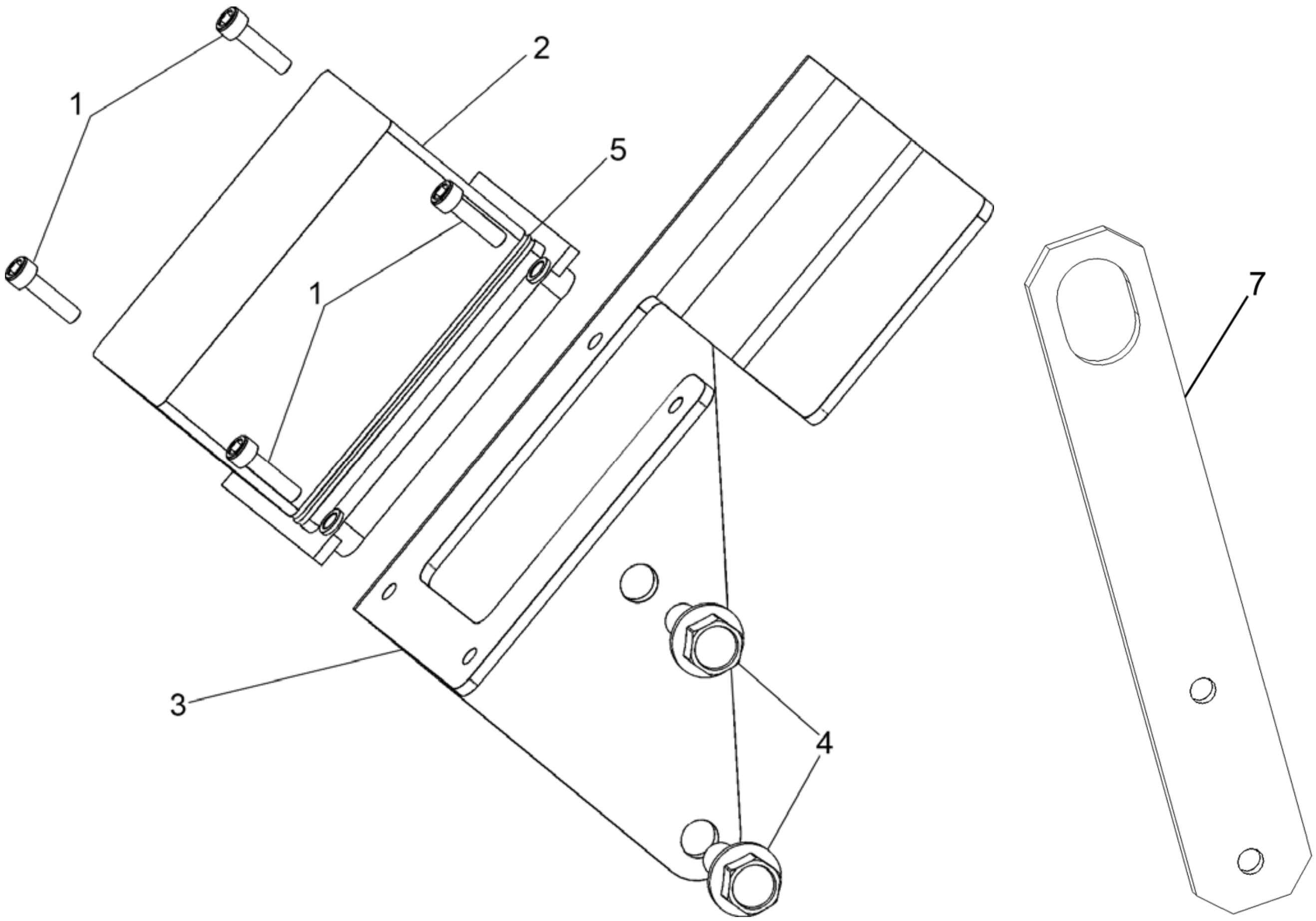
PCV-CRANKCASE VALVE & ELBOWS



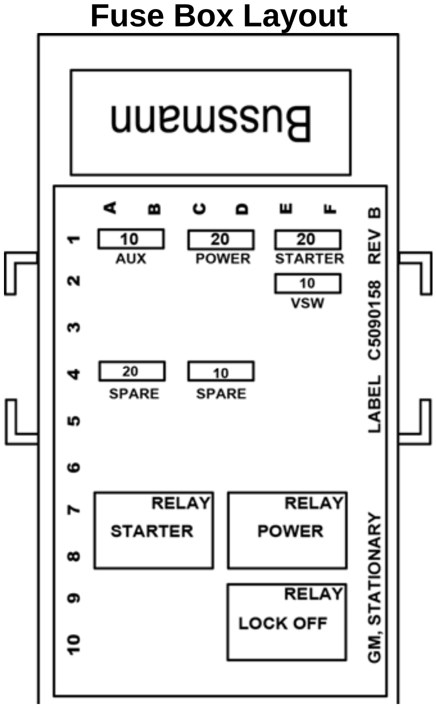
PCV-CRANKCASE VALVE & ELBOWS

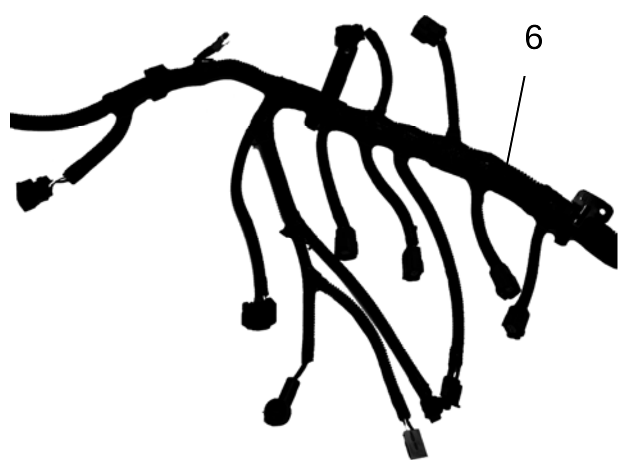
Item #	Description	Qty	Part Number
1	PCV	1	7120010
2	Gasket, PCV	1	7120140
3	Vent, Elbow	1	1104594
4	Grommet, Elbow	1	98214

HARNESS, FUSE BOX & BRACKET



Fuse Box Layout

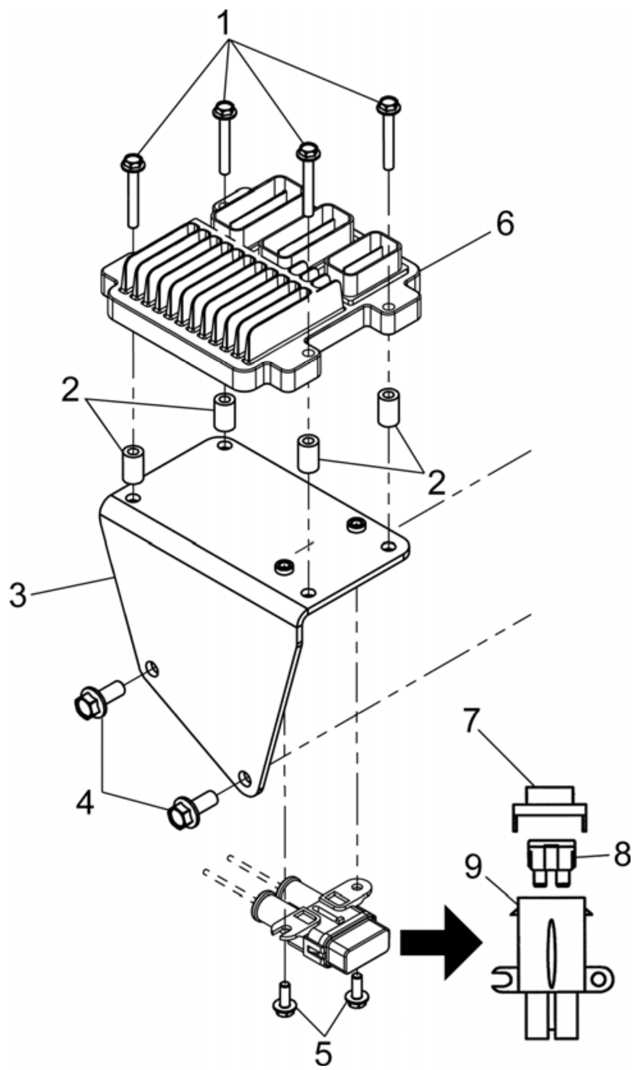




FUSE BOX & BRACKET

Item #	Description	Qty	Part Number	Manufacturer Part Number
1	Screw, Hex	4	S1-30295-0416	
2	Fuse Box Cover	1	C1-52520-001	
3	Bracket, Fuse Box	1	B4-51727-001	
4	Bolt	2	90325150	
5	Seal	1	S3-52522-001	
6	Wire Harness	1	B001-0591	
7	Hanger	1	B4-51471-001	
Power Relay	Power Relay	1	3011CCR1U0112V DC	
Starter Relay	Starter Relay	1	3011CCR1U0112V DC	
VSW 10A Fuse	10A Minifuse	1	914584	914584
AUX 10A Fuse	10A Minifuse	1	914584	914584
Power 20A Fuse	20A Minifuse	1	7381270	Littelfuse 297020
Starter 20A Fuse	20A Minifuse	1	7381270	Littelfuse 297020

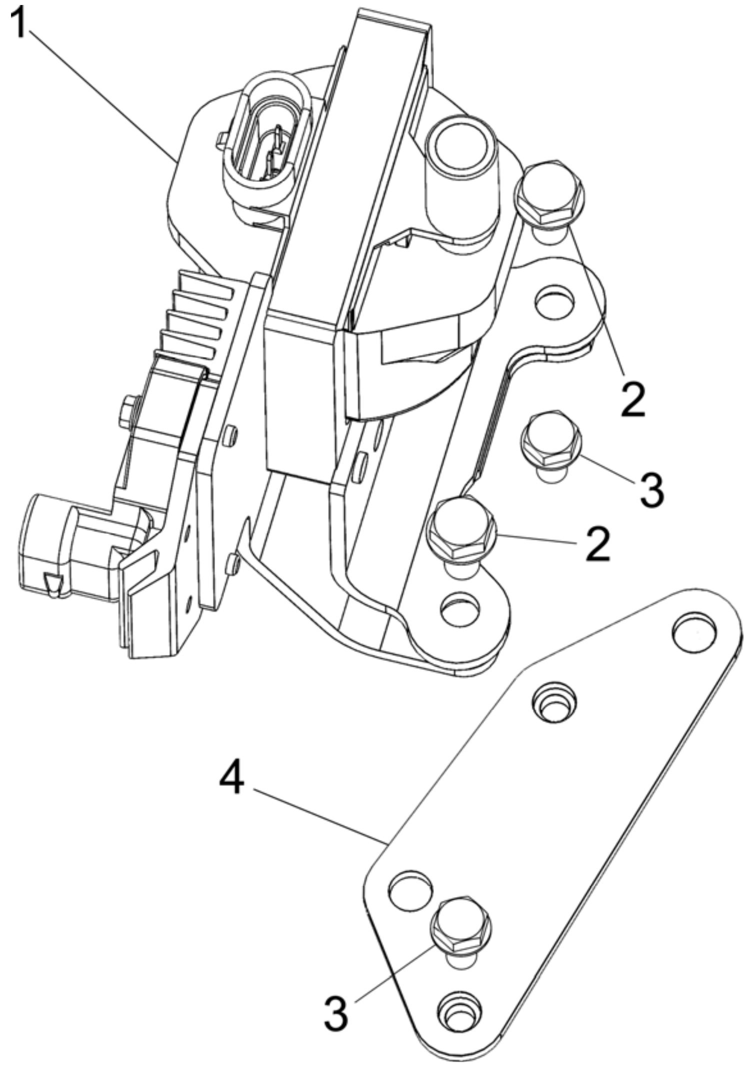
ENGINE CONTROL MODULE & BRACKET



ENGINE CONTROL MODULE & BRACKET

Item #	Description	Qty	Part Number	Manufacturer P/N
1	Screw, Hex Head	4	S1-30871-02-0645	
2	Spacer, 12.7 OD x 6.6 ID x 20	4	S3-50626-001	
3	Bracket, MEFI 6	1	B4-51673-001	
4	Screw, Hex Flange 3/8 -16 x 7/8	2	90325088	
5	Screw, Hex Flange M6-1.0x16mm	2	S1-30871-02-0616	
6	ECM, MEFI 6	1	6452900	
7	Cover	1		Littelfuse 1520007Z
8	Fuse 70A	1	1054112	Littelfuse 299070
9	Fuse Holder	1		Littelfuse 1520004Z

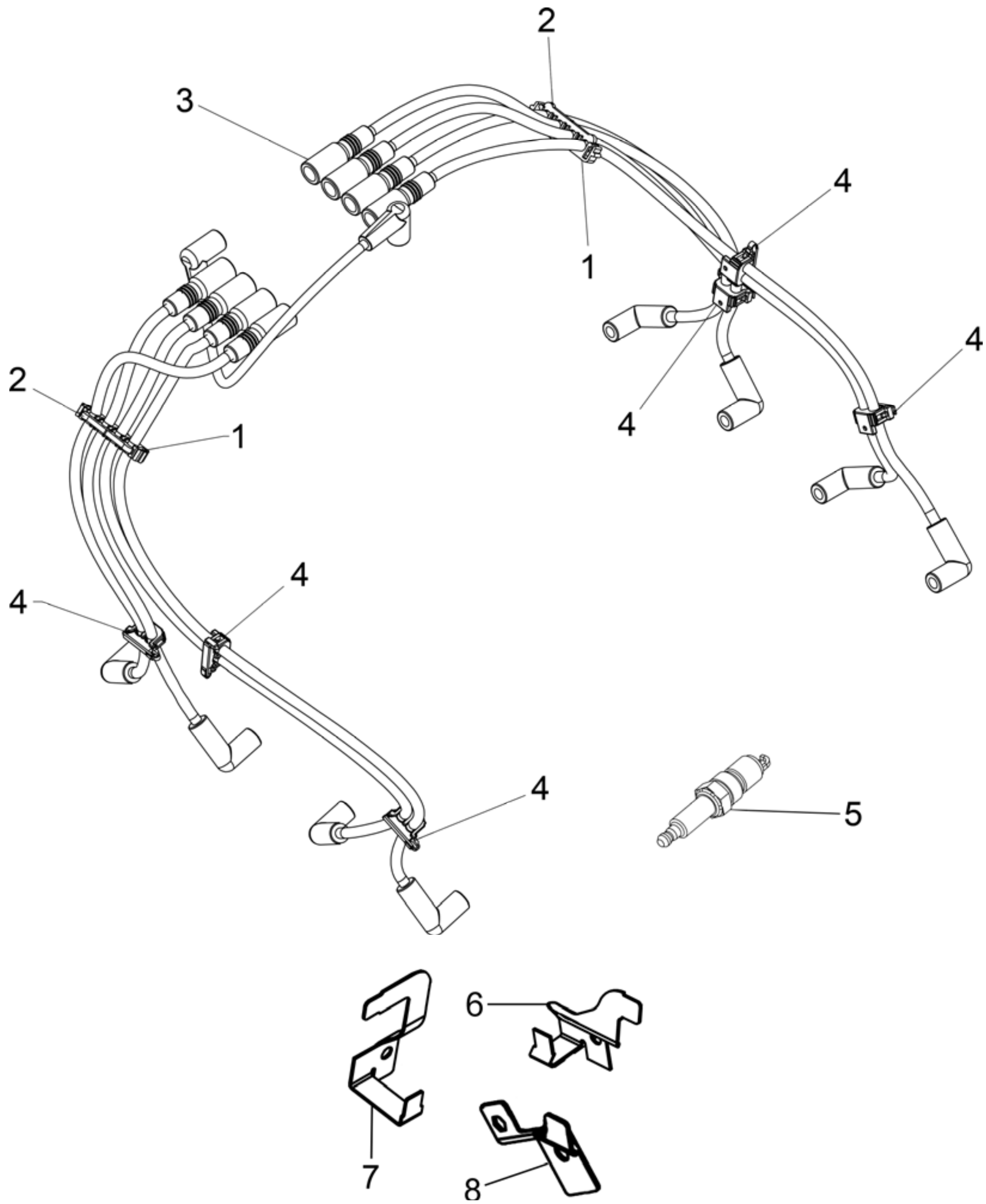
IGNITION COIL



IGNITION COIL

Item #	Description	Qty.	Part Number
1	Ignition Coil	1	7245470
2	Screw, Hex Flange M6-1. X 16mm	2	M2-51772-001
3	Bolt, 5/16 x 18 x 5/8”	2	90225063
4	Bracket, Coil	1	B4-51755-001

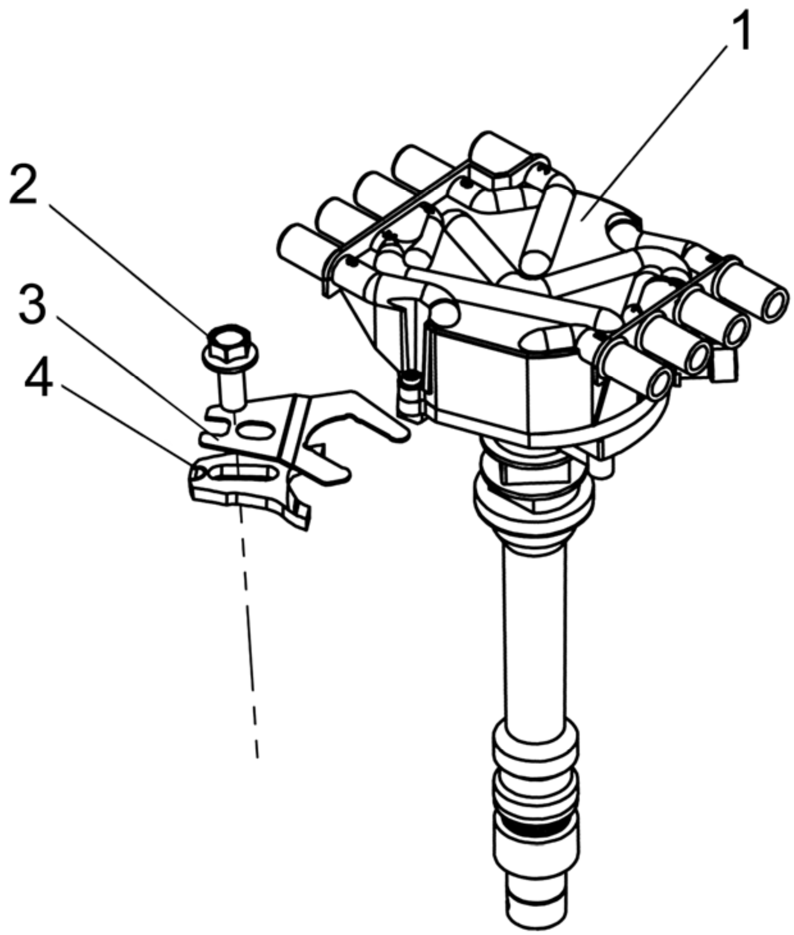
SPARK PLUG WIRES



SPARK PLUG WIRES

Item #	Description	Qty	Part Number
1	Cover, Cable Clip*	1	7242950
2	Separator, Cable Clip 4-Way*	2	88891792
3	Wire Set, Plug-Coil 4-Way*	1	AW-51754-001
4	Separator, Ign Wire 2-Way*	6	7240050
5	Spark Plug, R42	8	78092
6	Bracket, Support, Plug Sire LFT	1	B4-51913-001
7	Bracket, Support, Plug Sire RT	1	B4-51914-001
8	Bracket, Support, Plug Sire MID	1	B4-51915-001
	*Spark Plug Wire Set (Includes 1-4)	1	MD-51753-001

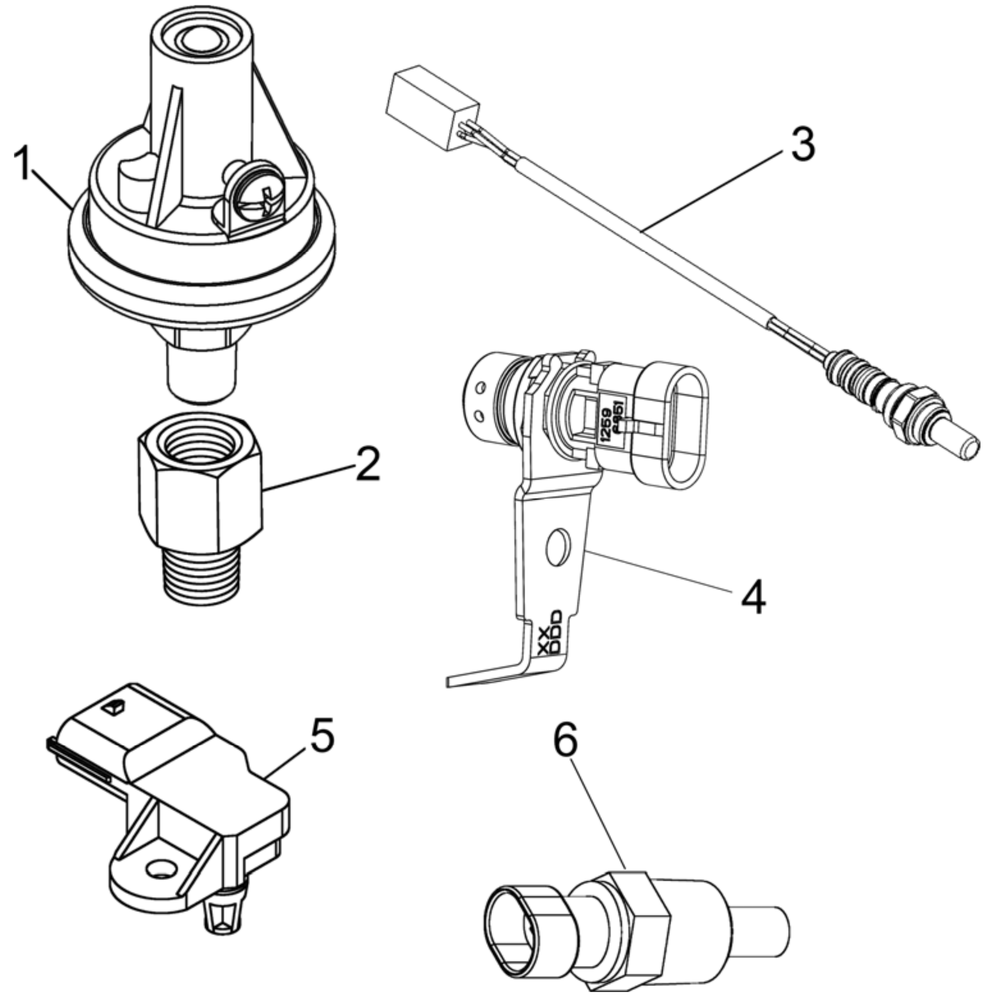
DISTRIBUTOR



DISTRIBUTOR

Item#	Description	Qty.	Part Number	GM Part Number
1	Distributor Assy (Complete)	1	B005-0101	94672691
2	Screw, Hex Flange 3/8-16 x 7/8	1	90325088	14091544
3	Yoke, Dist. Align	1	7245490	
4	Clamp, Distributor	1	7240300	10096197
Not Shown	Cap Distributor	1		10452459
Not Shown	Rotor, Distributor	1	7245224	10452457
Not Shown	Camshaft Sensor	1	7245370	10485432

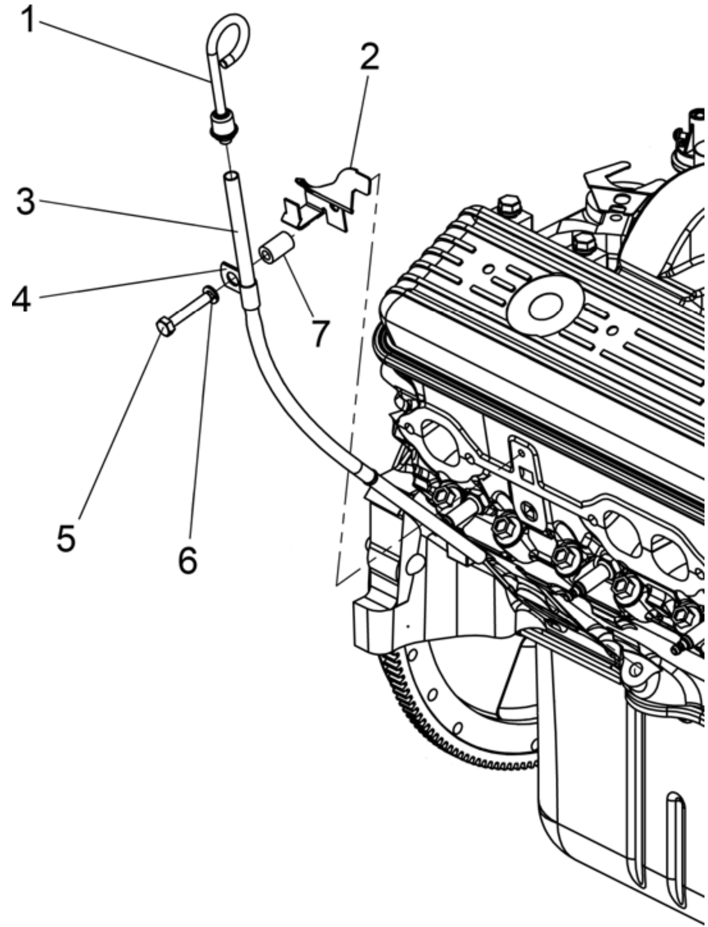
SENSORS



SENSORS

Item #	Description	Qty	IMPCO Part Number	GM Part Number
1	Switch, Oil Pressure	1	S10-50352-001	
2	Nipple, Extension	1	7242360	
3	HEGO Sensor	1	S8-50234-001	
4	Crankshaft Sensor	1	7180590	12596851
5	Sensor, TMAP	1	See Mixer and Throttle Body Assy	
6	Coolant Temp Sensor	1	7144790	

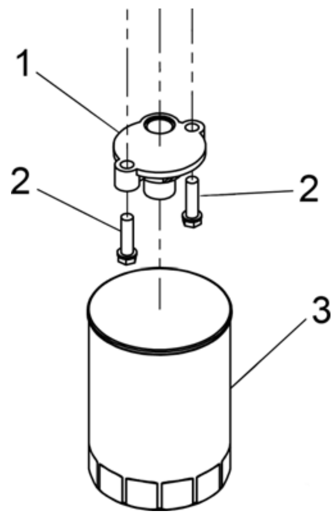
OIL LEVEL GAUGE



OIL LEVEL GAUGE

Item #	Description	Qty	Part Number
1	Oil Level Indicator (Dipstick)	1	7100270
2	Bracket, Support Plug Wire	1	B4-51913-001
3	Tube, Dipstick	1	7100680
4	Clamp 3/8”	1	7100290
5	¼-20 ” Bolt Grade 5	1	90105150
6	Washer Lock ¼”	1	93100000
7	Spacer, 12.7 OD 6.6 ID x 20 LG	1	S3-50626-001

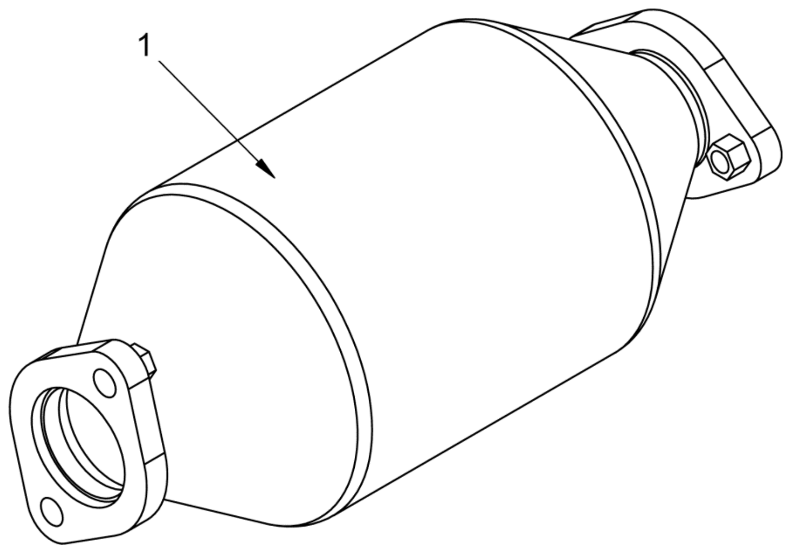
OIL FILTER & ADAPTER



OIL FILTER & ADAPTER

Item #	Description	Qty	Part Number
1	Adapter, Oil Assy	1	7110730
2	Bolt, Oil Fill Adapter	2	7110720
3	Filter, Oil PF218	1	7110950

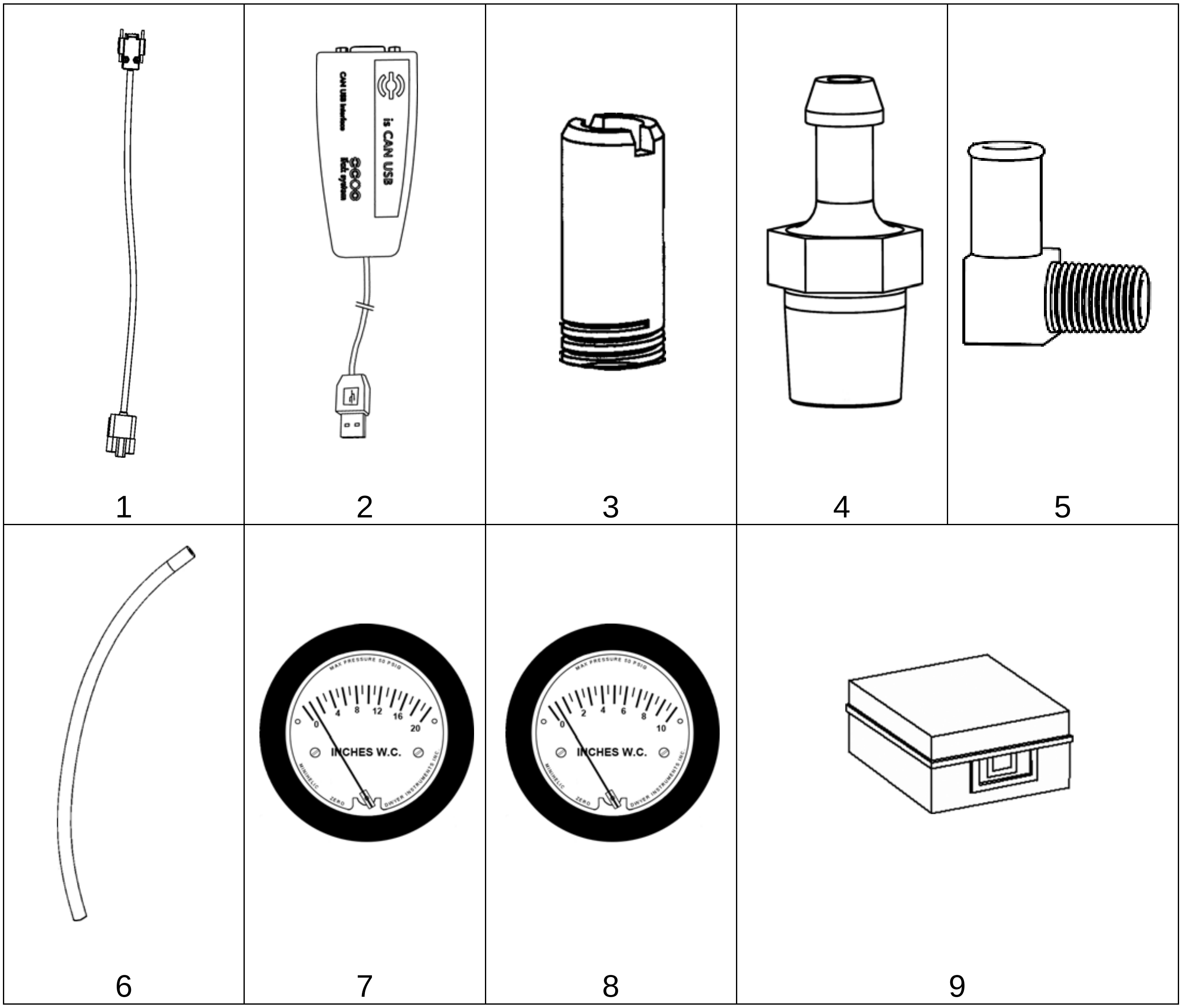
CATALYTIC CONVERTER

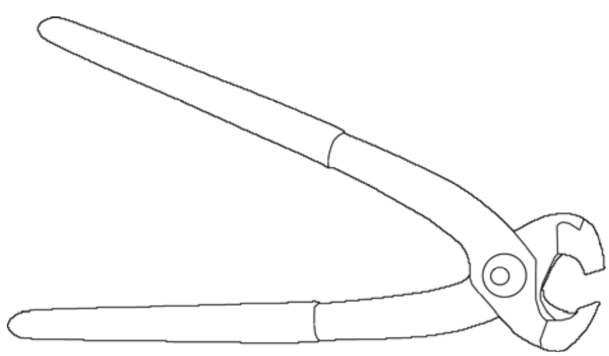


CATALYTIC CONVERTER

Item #	Description	Qty	Part Number
1	Catalyst	1	C12-51126-057

IMPCO ITK-1-IND TOOL KIT & ACCESSORIES





Standard Oetiker Pliers, IMPCO P/N 14100037 (not included in ITK-1-IND)

IMPCO ITK-1-IND TOOL KIT & ACCESSORIES

Item #	Description	Qty.	Part Number
1	Wire Harness CAN BUS Adapter	1	1534008
2	ASM, CAN USB Dongle	1	ISCAN-USB
3	Fitting, ¼ Unf ¼ Hs Vac Nip	1	F4-2
4	Fitting, 1/8 NPT 3/16 Hs Nip Brs	2	F4-4
5	Fitting, 1/8 NPT ¼ Hs Elbow Nylon	2	F4-8
6	Hose, 3/16" ID Vacuum Bulk	8’	H1-11
7	Test Kt-Gauge 0-20" w.c. (2-5020)	1	TG-020
8	Test Kt-Gauge 0-10" w.c. 2-5010)	1	TG-010
9	Case Plastic 12” x 8” x 3.5”	1	C9-25849-003

Labor Time Guide

INTRODUCTION

This Guide provides the labor times for repairs and service operations covered under warranty for IMPCO Technologies Engine Systems Division fuel systems.

The warranty reimbursement for the labor operations can be calculated when used in conjunction with the IMPCO Policy & Procedures Manual.

The labor times published in this Guide identify labor operations and labor times required to perform a repair, replacement and/or adjustment operation. These times represent those of an average technician in a typical dealership using standard hand tools, equipment and some Special Service Tools. They are not intended to be used as retail labor rates.

LABOR TIME STUDY DEVELOPMENT

GENERAL

The labor times published in this Guide were developed by IMPCO using genuine IMPCO parts and procedures listed in the IMPCO Service Manual. They include the actual time required to perform the operation and diagnose the system or component failure. All operations also include a standard allowance for “access time” to locate the engine, move it to a safe and suitable work area, access the engine, use of Special Service Tools and time to open packaged parts. The times also provide for operation variables but do not include time to remove and/or replace non-IMPCO components and accessories.

TOOLS

The labor time studies were based on the use of standard hand tools and Special Service Tools. No power-operated tools were used. The labor times were developed by general technicians following procedures described in the Service Manual Supplement, Service Publications and good shop practices. The times were calculated using an engine mounted on a stand.

TIME ALLOWANCES

The labor times include the removal, disassembly, cleaning, re-assembly, installation and/or adjustment of the affected component or assembly. Any cleaning time is limited to the installation or replacement of components (such as mating surfaces) and does not include cleaning other areas of the engine contaminated by failure of the component (e.g. coolant sprayed inside the engine compartment). Labor operations that require more than one technician are adjusted to represent the total time for all technicians.

GLOSSARY OF TERMS

OPERATION DESCRIPTION

The Operation Description identifies the repair to be performed and may include sub-headings such as: *ADD* conditions, *NOTES*, *INCLUDES* and other information. This information is essential for both the technician and warranty claim processing personnel to properly complete a warranty claim for accurate cost recovery.

FAILED PART / CAUSAL PART

The Failed or Causal Part is the part that caused the repair and/or replacement of other parts. The technician must identify the part as defective (i.e., one that exhibits a flaw or manufacturer’s defect in material or workmanship). The Causal Part **must be tagged** for warranty failure analysis identification prior to returning it to IMPCO Technologies.

TROUBLE CODES / CONDITION CODING

Each failed or causal part must be coded to identify the manufacturer’s defect of the part as accurately as possible (see Trouble Code chart). The code selected by the repairing technician identifies the manufacturer’s defect and/or workmanship condition qualifying the repair for warranty coverage.

ADD CONDITIONS

Add Conditions may be required to complete or supplement a labor operation and are included in the Add sections under the Labor Operation Description. If an ADD is performed, the allowed labor time for the ADD must be recorded on the shop repair order under the Operation Number.

REPLACE

Replace is used when the part or assembly is subject to replacement only. This includes the transfer of attached components from the original part to the new part, the installation of the new part and any inspection, adjustment, or required cleaning or lubrication operations.

R&R OR REPLACE

R&R refers to a part or assembly that is removed and re-installed after the part has been aligned, adjusted, repaired as a separate operation or removed for a sublet repair. Replace means the part or assembly can be replaced with a new (or exchanged) part or assembly (see the Replace paragraph above).

INCLUDES

The INCLUDES which follow some of the Labor Descriptions are provided to assist in determining whether or not certain items or functions are included within the operation (these are not all encompassing to simplify the use of this Guide). Examples include:

- Fuel System Evacuation
- Leak Check
- Cooling system drain and refill

Refer to the IMPCO Service Manual Supplement or use the Request for Review Form to question and/or recommend changes.

CUSTOMER PROBLEM ANALYSIS

It is the duty of the service technician to translate the customer's complaint into a specific symptom. Examples include: stalling, hesitation, surges, engine cranks but will not start, etc. Symptoms also include readily apparent failures to the senses of sight, touch, sound and smell, such as leaking coolant line or cracked casting.

SYMPTOM DIAGNOSIS

Symptom Diagnosis is the process used to determine the source of the problem and is the responsibility of both the technician and dealership management. Symptom Diagnosis is complete when the cause of failure has been identified.

REPAIR DIAGNOSIS

These are the checks, tests and measurements required to identify the cause of a failure and/or failed part. Examples include:

- Cleaning and inspection of all parts.
- Use of test equipment.
- Use of common instruments such as an ohmmeter, volt-amp meter, a leak detector or a cooling system pressure tester that may be required by IMPCO Service Manual Supplement procedures.

Repair Diagnosis is the responsibility of the technician.

LABOR OPERATION NUMBER

A Labor Operation Number is assigned to the labor performed and must be recorded on the warranty claim. The Labor Operation Number can be found in this Guide or IMPCO Technical Service Bulletins.

OVERLAPPING LABOR

Overlapping labor is labor time is where two operations include the same repair Steps. Overlapping time is not compensated; therefore, the repeated labor time must be deducted from the second labor operation so that the total time entered is less than the sum of the combined labor times.

DUPLICATE LABOR

Duplicate Labor is the same labor charged twice, either to two different cost recovery sources, or overlapping labor charged to the same or different cost recovery sources. Duplicate Labor is not eligible for compensation unless authorized by IMPCO.

STRAIGHT TIME

Straight Time is applicable only when a labor operation is required and no labor operation description or operation number exists in this Guide. All Straight Time is governed by **Policy "A"** and is subject to review and approval by IMPCO before payment is reimbursed. Precise labor Step documentation indexed to time is required and must be recorded on the shop repair order to identify and justify this expense. Prior approval may be obtained by contacting IMPCO Technical Assistance 1-866-473-2851.

ADDITIONAL OR OTHER LABOR

Additional or Other Labor may be required when unusual or abnormal conditions are encountered. This time must be identified as such and follow the same time recording and labor Step documentation as Straight Time. Warranty compensation for all additional time falls under **Policy "A"** and is subject to review and approval by IMPCO before payment is reimbursed. Prior approval may be obtained by contacting IMPCO Technical Assistance at 1-866-473-2851.

POLICY CODES

Certain IMPCO Policy Codes apply to the Generic Labor Operations listed on page 7. Policy codes and descriptions are:

Policy "A" – Is subject to review by IMPCO before reimbursement.
Policy "B" – Will require approval from IMPCO before expense is incurred
Policy "S" – Sublet of work to a facility outside the normal OEM dealer network, and requires approval from IMPCO prior to incurring the expense

All prior approvals may be obtained by contacting IMPCO Technical Assistance at 1-866-473-2851.

NORMAL & ADDITIONAL DIAGNOSTICS

Normal repair diagnosis time is included in all labor time operations. Additional Diagnostics is time that is necessary to complete a satisfactory diagnosis that beyond the normal time allowed. This time must be identified as Additional Diagnostics and follow the same time recording and labor Step documentation as Straight Time.

It is the responsibility of qualified dealership supervisory personnel to assist technicians in both customer Problem Analysis and Symptom Diagnosis.

TECHNICAL ASSISTANCE

Service technicians must call the OEM Technical Assistance whenever extensive diagnosis or repair advice is required, or to verify an engine's warranty. OEM Technical Assistance personnel must contact IMPCO Technical Service personnel to obtain authorization for those repairs or additional labor that require prior authorization for warranty compensation. IMPCO Technical Assistance may be contacted at (1-866-473-2851) between the hours of 8:00 a.m. and 5:00 p.m. Pacific Time Monday through Friday except holidays.

COMPLETED WARRANTY CLAIMS

OEMs can choose to submit their electronic forms via an FTP site using the OEM user ID and Passwords (supplied by IMPCO Technical Assistance). The forms may be submitted individually or batched. The claims will be reviewed and approved or declined and the OEM will be notified via an electronic response from the IMPCO warranty administrator. The OEM may then submit an invoice for payment of approved claims to IMPCO for payment of those claims.

TROUBLE CODES

CAUSE OF PROBLEM	CODE	CAUSE OF PROBLEM	CODE
Bent	1A	Worn	4X
Casting defect	1B	Wrong part	4Z
Compression	1C	Paint-acid rain	5A
Broken	1D	Chrome plating defective	5C
Burned	1E	Paint- cracking	5G
Carbon deposit	IF	Paint - peeling	5L
Chipped	1G	Paint - poor repair	5P
Clogged / restricted / blocked	1H	Paint - primer shows through	5R
Collapsed	1J	Poor metal finish	5T
Cracked	1K	Rusted / corroded	5W
Cut	1L	Component - ground	6B
Dented	1M	Component - inoperative	6C
Burrs	1N	Component - intermittent	6D
Discharged	1P	Component - missing	6E
Does not match	1R	Component - open	6F
Condensation / moisture	1W	Component - shorted	6G
Foreign material	1Y	Connector - bent / damaged	6H
Leaks	2C	Connector - corroded	6J
Clearance - excessive	2E	Connector - missing	6L
Clearance - too tight	2F	Connector - disconnected	6M
Improperly cut	2G	Connector - partially connected	6N
Improper installation	2H	Connector - seal damaged	6P
Improperly padded	2J	Lamp (bulb) - improperly installed	6R
Improperly sealed	2K	Lamp (bulb) - defective	6S
Incorrect pressure	2L	Lamp (bulb) - contains moisture	6T
Insufficient lubrication	2N	Overcharged	6U
Insufficient sealant	2P	Socket - broken	6W
Kinked	2S	Socket - corroded	6X
Improper torque	2T	Socket - open	6Y
Loose	2W	Socket - shorted	6Z
Misadjusted / misaligned	3A	Socket / lamp - disconnected	7A
Misrouted	3C	Terminal - backed out	7B
Missing	3D	Terminal - bent or damaged	7C
Not connected	3F	Wire - shorted to ground	7D
Not drilled	3G	Terminal - crimped over insulation	7E
Balance / imbalance	3K	Terminal - not crimped / soldered	7F
Out of calibration	3L	Wire - burned - external heat	7G
Out of round	3M	Wire - burned - internal heat	7H
Poor machining	3N	Wire - chaffed	7J
Poor release	3P	Wire - crossed in connector	7K
Porosity	3R	Wire - cut / broken / open	7L
Punctured	3W	Wire - misrouted	7M
Registers incorrectly	3X	Wire - missing	7N
Ruptured	3Z	Wire - not long enough	7P
Scored	4A	Wire - pinched	7R
Scratched	4B	Wire - ring terminal disconnected	7S
Sheared	4D	Wire - ring terminal loose	7T
Stripped	4G	Electrical interference	7W
Torn	4H	No trouble found	9Z
Warped / wavy	4N	Extended service parts warranty	88
Weak	4Q	Technical service bulletin	93
Weld broken	4R	Special policy	95
Weld omitted	4S	PDI	99
Twisted	4T	Campaign	96

FUEL SYSTEM LABOR OPERATIONS

Engine-Electrical

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
ENGINE CONTROL MODULE (ECM)–REPLACEMENT	**E0050**	0.8
ENGINE CONTROL MODULE (ECM)–REFLASH	**E0057**	0.3
FUSE BOX BRACKET-REPLACE	**E3037**	0.2
ENGINE WIRE HARNESS–REPAIR	**E1015**	0.9
ENGINE WIRE HARNESS–REPLACEMENT	**E2015**	1.5
PLUGS, SPARK–REPLACE ONE	**J4226**	0.4
PLUGS, SPARK–REPLACE ALL	**J4227**	0.7
WIRES, SPARK PLUG--REPLACE ALL	**J4207**	0.3
COIL, IGNITION–REPLACEMENT	**J4340**	0.6
FUEL CONTROL SYSTEM CHECK **INCLUDES:** Connect scan tool or test equipment. Check for trouble codes (DTCs), check HEGO operation, disconnect scan tool or test equipment.	**M1007**	0.3
ELECTRONIC THROTTLE BODY–REPLACEMENT	**M0075**	0.8
THROTTLE BODY/GASKET–REPLACEMENT	**E3012**	0.8
CAP, DISTRIBUTOR–REPLACE	**J4360**	0.2
ROTOR, DISTRIBUTOR–REPLACE	**J4380**	0.2
DISTRIBUTOR ASSEMBLY–REPLACE	**J4530**	0.8

FUEL SYSTEM LABOR OPERATIONS

Engine-Sensors

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
ENGINE OIL PRESSURE SENSOR–REPLACEMENT	**J4590**	0.5
ENGINE COOLANT TEMP SENSOR AND/OR ADAPTER–REPLACE	**J4591**	0.6
CAMSHAFT SENSOR--REPLACEMENT	**E3019**	0.6
CRANK POSITION SENSOR–REPLACEMENT	**J4592**	0.7
TEMP MANIFOLD PRESSURE SENSOR (TMAP)–REPLACEMENT	**F1015**	0.7
HEATED EXHAUST GAS OXYGEN SENSOR (HEGO)–REPLACEMENT	**N1002**	0.8

FUEL SYSTEM LABOR OPERATIONS

Fuel Delivery

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
PRESSURE REGULATOR-REPLACEMENT **INCLUDES:** Transfer of all fittings	**M1001**	0.8
REGULATOR FITTINGS (All)	**M1002**	0.3
BRACKET, REGULATOR MOUNTING–REPLACEMENT	**E3009**	0.5
LEAK CHECK THE FUEL SYSTEM	**G0004**	0.2
FUEL SYSTEM PRESSURE CHECK **INCLUDES:** Connect fuel pressure gauges. Check regulator pressure. Disconnect gauges.	**M1006**	0.3
SHUT-OFF VALVE–REPLACEMENT (EACH)	**F1003**	0.8
MIXER ADAPTER AND/OR GASKET--REPLACE	**F1101**	0.7
THROTTLE BODY AND/OR GASKET	**M0078**	0.8
THROTTLE BODY/INTAKE MANIFOLD ADAPTER AND/OR GASKET-REPLACEMENT	**F1103**	1.0
FUEL CONTROL VALVE	**F1105**	0.4
FUEL CONTROL VALVE BRACKETS-REPLACE	**F1106**	0.2

FUEL SYSTEM LABOR OPERATIONS

Exhaust

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
RESTRICTED EXHAUST SYSTEM DIAGNOSIS	**E3017**	0.3

Hoses

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
COOLANT HOSES–REPLACE ALL **INCLUDES:** Drain & Fill Radiator	**T1001**	0.7
FUEL VAPOR HOSE—REPLACE ALL **INCLUDES**: Replacement of Vapor Hose Port Fittings	**E3048**	0.4
VACUUM LINE-REPLACE ONE **ADD:** Additional Line Replace Allowances. Diagnosis Time: 0.1	**T1002**	0.4 0.1
PCV-INSPECT OR REPLACE	**E3050**	0.3

FUEL SYSTEM LABOR OPERATIONS

Engine-Exterior Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
WATER PUMP AND/OR GASKET-REPLACE	**J3480**	0.7
STARTER–REPLACEMENT	**J4560**	0.6
ALTERNATOR–REPLACEMENT	**J4570**	0.5
DRIVE BELT–REPLACEMENT	**J4571**	0.5
THERMOSTAT, AND/OR GASKET–REPLACEMENT	**J4580**	0.4
FLYWHEEL/HARMONIC BALANCER–REPLACEMENT	**J0720**	0.5
DRIVE BELT IDLER PULLEY–REPLACEMENT **INCLUDES***: R&R drive belt*	**J4573**	0.6
OIL FILL ADAPTER	**E3053**	0.3
WATER PORT	**E3054**	0.3
FUEL CONTROL VALVE	**M065**	0.5
OIL DRAIN VALVE AND/OR TUBE	**E3055**	0.3

FUEL SYSTEM LABOR OPERATIONS

Engine-Manifolds & Cylinder Head Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
INTAKE MANIFOLD AND/OR GASKET-REPLACEMENT	**J0210**	1.0
EXHAUST MANIFOLD REPLACEMENT (EACH SIDE)	**E3018**	1.0
VALVE COVER AND/OR GASKET-REPLACEMENT **INCLUDES:** *R&R intake manifold.*		
Right Side	**J0300**	0.3
Left Side	**J0301**	0.3
Both Sides	**J0307**	0.5
ROCKER ARM–REPLACEMENT **INCLUDES***: R&R intake manifold and rocker cover(s).*		
One Cylinder, Right Side	**J0350**	0.4
ADD: Replace all rocker arms on both sides:		1.2
STUD, VALVE ROCKER ARM BALL REPLACEMENT		
Right Side	**J0380**	0.5
Left Side	**J0381**	0.5
ADD: to replace additional studs		0.3
CYLINDER HEAD GASKET-REPLACEMENT **INCLUDES** *R&R intake manifold, rocker covers(s) and compression test.*		
Right Side	**J0500**	4.0
Left Side	**J0501**	4.0
Both Sides	**J0507**	6.0
CYLINDER HEAD–REPLACEMENT **INCLUDES***: R&R intake manifold, rocker cover(s) and compression test*.		
Right side	**J0510**	5.0
Left side	**J0511**	5.0
Both sides	**J0517**	7.5
VALVE-RECONDITION OR REPLACEMENT		
One cylinder, right side	**J0520**	4.5
One cylinder, left side	**J0521**	4.5
Both sides	**J0527**	7.0
ADD: To recondition all valves		
Either side		1.8
Both sides		3.0
ADD: To ream and fit guides for oversize stems		
One cylinder		0.2
Each additional cylinder		0.1

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
VALVE SPRING, CAP AND/OR SEALS–REPLACEMENT **INCLUDES***: R&R rocker cover(s)*		
Right Side	**J0540**	0.7
Left Side	**J0541**	0.7
Both Sides	**J0547**	1.2
PUSH ROD–REPLACEMENT **INCLUDES***: R&R rocker cover(s)*		
One cylinder, right side	**J0580**	0.4
One cylinder, left side	**J0581**	0.4
Both sides	**J0587**	0.8
ADD: To replace all push rods each side		0.2
LIFTER, VALVE–REPLACEMENT **INCLUDES** *R&R rocker cover(s)*		
One cylinder, right side	**J0620**	1.7
One cylinder. left side	**J0621**	1.7
Both sides	**J0627**	2.0
ADD: To replace all lifters each side		0.4

FUEL SYSTEM LABOR OPERATIONS

Engine–Internal Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
TIMING COVER OIL SEAL–REPLACEMENT **INCLUDES**: *R&R balancer*	**J0750**	0.7
TIMING COVER AND/OR GASKET–REPLACEMENT **INCLUDES:** *R&R balancer*	**J0780**	2.0
TIMING CHAIN–REPLACEMENT **ADD**: Replace crankshaft gear	**J0820**	1.6 0.2
CAMSHAFT TIMING GEAR–REPLACEMENT **ADD:** Replace crankshaft gear	**J0840**	3.9 0.2
CAMSHAFT–REPLACEMENT	**J0850**	6.0
OIL PAN AND/OR GASKET–REPLACEMENT **INCLUDES:** *Fluid replacement*	**J1000**	2.2
PUMP, ENGINE OIL–REPLACEMENT **INCLUDES:** *R&R engine oil pan and fluid replacement*	**J1020**	2.5
SEAL, REAR MAIN BEARING–REPLACEMENT **INCLUDES:** *R&R engine oil pan and fluid, replace lower seal and re-pack upper seal*	**J1120**	2.8
BEARING, CRANKSHAFT MAIN-REPLACE ONE **INCLUDES** *R&R engine oil pan and fluid, and use* of *plastic type gauge* **ADD:** Replace main bearings Each additional (NOT to equal or exceed ALL) All main bearings **ADD:** Replace connecting rod bearings Each additional (NOT to equal or exceed ALL) All rod bearings	**J1150**	3.0 0.5 1.2 0.3 1.2

FUEL SYSTEM LABOR OPERATIONS

Engine–Internal Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
BEARING, CONNECTING ROD–REPLACE ONE **INCLUDES** *R&R engine oil pan and fluid, and use* of *plastic type gauge* **ADD:** Replace connecting rod bearings Each additional (NOT to equal or exceed ALL) All rod bearings	**J1180**	2.9 0.4 2.0
PISTON, ROD AND/OR RINGS–REPLACEMENT **INCLUDES** *R&R all necessary components and use of plastic type gauge* **ADD:** Replace rings only Each piston (NOT to exceed ALL) All pistons **ADD:** To replace connecting rods only Each rod (NOT to exceed ALL) All rods **ADD:** To replace pistons only Each piston (NOT to exceed ALL) All pistons	**J1308**	3.3 0.4 2.2 0.3 1.2 0.4 2.4
PLUG, EXPANSION–REPLACEMENT *Note: Use appropriate labor operation(s) for removal of necessary component(s) to gain access to plug*	**J1600**	0.3
PLUG, OIL GALLERY–REPLACEMENT *Note: Use appropriate labor operation(s) for removal of necessary component(s)*	**J1640**	0.3

ENGINE REPAIR OPERATIONS

Engine–Replacement

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
BLOCK, ENGINE FITTED–REPLACEMENT **INCLUDES** *R& R all components, fluids and accessories* **ADD:** To recondition all valves and guides	**J1800**	9.0 2.6
ENGINE, PARTIAL–REPLACEMENT **INCLUDES** *R& R all components, fluids and accessories* **ADD**: To recondition all valves and guides	**J1820**	7.2 2.6
ENGINE, ASSEMBLY–REPLACEMENT **INCLUDES** *R&R all components, fluids and accessories*	**J1880**	3.5
ENGINE, MOUNTS, FRONT–REPLACEMENT	**J1506**	0.3

MISCELLANEOUS

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
ADDITIONAL DIAGNOSTIC TIME Policy "B" Subject to review by IMPCO Technical Support	**G0001** **Policy "B"**	0.5
FASTENER OR FITTING TIGHTENING	**G0003**	0.1
OPERATION TESTS	**G0006**	0.2
SUBLET TIME Policy "S"* ***Requires Prior Approval By IMPCO Technical Support;**	**G0007** **Policy "S"**	0.0

REQUEST FOR REVIEW OF LABOR TIMES

IMPCO will provide all possible assistance in the development process, the content of individual standards, the means for accomplishing repairs within the times established and the assurance that every effort has been made to maintain the accuracy of these times. IMPCO will review and, if necessary, adjust any allowance that is inconsistent with the time actually being spent on warranty repairs that are within the scope and definitions described in this guide.

Although the same methods of labor time allowance development are applied to every labor time study, the actual time required to make a repair on a like component may vary. Changes to labor times are made based on one or more of the following:

- Design change of the component.
- Design change in other components that affect the accessibility to the repaired component.
- Change in the procedure or method of repair.
- Change in the tools or equipment used to make the repair.
- Final review and verification of times after receiving a Request for Review form.

Questions and/or suggestions regarding labor operations or time allowances in the Labor Time Guide must be submitted on a Request for Review form. This form is the last page of this guide.

A properly completed form will provide IMPCO detailed information identifying the technician's difficulties in performing a labor operation within the published labor time allowance. When completing this form, it is important that all engine identification data affecting or influencing the operation in question be provided.

OEM RESPONSIBILITIES

Your request for review must include a detailed, Step by Step description of your labor procedure in the space provided. This will allow IMPCO to both understand your concern and potential cause(s) for the variance between your actual time and the published labor time.

When submitting a Request for Review, the following Steps are required:

- Verify that the technician has followed Service Manual Supplement procedure and utilized all necessary equipment and is properly trained.
- Complete the Request for Review Form included in this Guide.
- Use one form for each labor allowance in question (or combination of standards representing one repair job).
- Provide specific performance time for two repairs performed by the same technician to assist in determining average time.
- Identify the technician involved, should it be necessary to review the process.
- Provide comments that may help in identifying the problem area including individual Step times.
- Sign and forward the form to IMPCO.

IMPCO RESPONSIBILITIES

Upon receipt of the Request for Review form, IMPCO will review the procedure and consider changing the labor time. Changes in a labor time will appear as a Warranty Bulletin or the next revision of the Labor Time Guide.

COMPLETING THE REQUEST FOR REVIEW FORM

When completing the request for review form, include a detailed description of each Step, list all components, numbers, type of fasteners, and any Special Service Tools or procedures that are required. Use the Labor Time Study form and include it with the Request for Review sheet on page 18.

When complete, send both forms to:

IMPCO Technologies, Inc.
3030 South Susan Street
Santa Ana, CA. 92704
Attn: Technical Service Labor Time Review

REQUEST FOR REVIEW

Please insure this Request for Review is filled out *completely* so that it can be investigated and processed without delay.

SERVICE FACILITY INFORMATION

Service Facility Name:

Service Facility Address:

City: State: Zip Code

Telephone Number ( ) Fax Number: ( )

OPERATION NUMBER	CURRENT PUBLISHED TIME	SUGGESTED TIME

ENGINE INFORMATION*:*

Model Year Model Line SERIAL#

Mileage ______________________ Engine ________________________

TECHNICIAN INFORMATION:

Technician's Name

Are you certified in this area of repair? ☐ Yes ☐ No

How many times have you performed this repair? ☐ Once ☐ Twice How many?

Is the IMPCO Service Manual Supplement accurate? ☐ Yes ☐ No Describe the inaccuracy:

(Please include any additional inaccuracies and/or suggestions on a separate sheet. We welcome your input.)

Have you attended an IMPCO Technical Training Class for this type of work? ☐ Yes ☐ No

SERVICE MANAGER SIGNATURE*:* *(required)*

Date: (required) ______________________

A detailed, Step by Step labor description is required on the back of this form before a labor time study will be considered for review.

LABOR TIME STUDY FORM

Step	Labor Description	Watch Time (Min/Sec)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
(Attach additional sheets if necessary)		
	Total Repair Time (minutes/seconds)	

Definitions

Air Valve Vacuum (AVV): The vacuum signal taken from below the air valve assembly and above the throttle butterfly valve.

ADP: Adaptive Digital Processor.

Air/Fuel Ratio: The amount or balance of air and fuel in the air fuel mixture that enters the engine.

Analog Voltmeter: A meter that uses a mechanical needle to point to a value on a scale of numbers. It is usually of the low impedance type and used to measure voltage and resistance.

Aromatics: Pertaining to or containing the six-carbon ring characteristic of the benzene series. Found in many petroleum distillates.

Authors: This manual was produced by Bruce Johnson and Steve Lawson of IMPCO's Technical Service Department.

Backfire: Combustion of the air/fuel mixture in the intake or exhaust manifolds. A backfire can occur if the intake or exhaust valves are open when there is a mis-timed ignition spark.

Benzene: An aromatic (C_6H_6). Sometimes blended with gasoline to improve anti-knock value. Benzene is toxic and suspected of causing cancer.

Bi-Fueled: An engine equipped to run on two fuels.

Blow-By: Gases formed by the combustion of fuel and air, which ordinarily should exert pressure only against the piston crown and first compression ring. When rings do not seal, these gases escape or "blow by" the side of the piston into the crankcase.

BTU: British Thermal Unit. A measurement of the amount of heat required to raise the temperature of 1lb. of water 1 degree F.

Butane: An odorless, colorless gas, C_4H_{10} found in Natural Gas and petroleum. One of the five LP gases.

CAFE: Corporate Average Fuel Economy.

CARB: California Air Resources Board.

Carbon Monoxide (CO): A chemical compound of a highly toxic gas that is both odorless and colorless.

Carburetor: An apparatus for supplying an internal-combustion engine a mixture of vaporized fuel and air.

Cathode Ray Tube: A vacuum tube in which cathode rays usually in the form of a slender beam are projected on a fluorescent screen and produce a luminous spot.

CFR: Code of Federal Regulations.

Circuit: A path of conductors through which electricity flows.

Closed Loop Operation: Applies to systems utilizing an oxygen sensor. In this mode of operation, the system uses oxygen sensor information to determine air/fuel ratio. Adjustments are made accordingly and checked by comparing the new oxygen sensor to previous signals. No stored information is used.

CKP: Crankshaft Position Sensor

CMP: Camshaft Position Sensor

CNG: Compressed Natural Gas

Conductor: A material, normally metallic, that permits easy passage of electricity.

Contaminants: Impurities or foreign material present in fuel.

Control Module: One of several informal names for a solid state microcomputer which monitors engine conditions and controls certain engine functions; i.e. air/fuel ratio, injection and ignition time, etc. The formal name and the one used throughout this manual is ECM, or Engine Control Module.

Converter: A fuel system component containing varying stages of fuel pressure regulation combined with a vaporizer.

Cryogen: A refrigerant used to obtain very low temperatures.

Current: The volume or flow of electrons through a conductor. Measured in amperes or amps.

DBW: Drive By Wire

Dedicated Fuel System: A motor fuel system designed to operate on only one fuel type.

Diaphragm: A thin, flexible membrane that separates two chambers. When the pressure in one chamber is lower than in the other chamber, the diaphragm will move toward the side with the low pressure.

Diaphragm Port: The external port located at the fuel inlet assembly and connected to the vacuum chamber above the air valve diaphragm.

DLC: Data Link Connector.

DTC: Diagnostic Trouble Code

DST: Diagnostic Scan Tool.

DVOM: Digital Volt/Ohm Meter**.** A meter that uses a numerical display in place of a gauge and is usually of the high impedance type.

ECT: Engine Coolant Temperature.

ECM: Electronic Control Module

ECOM: A DLC cable supporting CAN and serial communication with a Spectrum II or III ECM.

EFI: Electronic Fuel Injection. A fuel injection system, which uses a microcomputer (ECM) to determine and control the amount of fuel, required by, and injected into, a particular engine.

EGO: Exhaust Gas Oxygen, used to describe a sensor. Also known as "HEGO" (Heat Exhaust Gas Oxygen) sensor, "O_2" or "Oxygen sensor.

EGR: Exhaust Gas Recirculation.

EPA: Environmental Protection Agency: A regulating agency of the Federal government which, among other duties, establishes and enforces automotive emissions standards.

Ethanol: Grain alcohol (C_2H_5OH), generally produced by fermenting starch or sugar.

Evaporative Emissions Controls: An automotive emission control system designed to reduce hydrocarbon emissions by trapping evaporated fuel vapors from the fuel system.

Excess Flow Valve: A check valve that is caused to close by the fuel when the flow exceeds a predetermined rate.

FTV: Fuel Trim Valve.

FFV: Flexible Fuel Engine.

Firing Line: The portion of an oscilloscope pattern that represents the total amount of voltage being expended through the secondary circuit.

FMVSS: Federal Motor Engine Safety Standards.

FPP: Foot Pedal Position Sensor

Fuel Injector: a spring loaded, electromagnetic valve which delivers fuel into the intake manifold, in response to an electrical input from the control module.

Fuel Lock: A solenoid-controlled valve located in the fuel line to stop the flow when the engine stops or the ignition switch is off.

Gasohol: 10 percent ethanol, 90 percent gasoline. Often referred to as E-10.

Gasoline: A motor engine fuel that is a complex blend of hydrocarbons and additives. Typical octane level is 89.

GCP: Spectrum III (90-pin) ECM.

GIC: Generator or Genset Interface Connector.

Greenhouse Effect: A scientific theory suggesting that carbon dioxide from the burning of fossil fuels is causing the atmosphere to trap heat and cause global warming.

HC: Hydrocarbon. An organic chemical compound.

HD 10: A fuel of not less than 80% liquid volume propane and not more than 10% liquid volume propylene.

HD 5: A fuel of not less than 90% liquid volume propane and not more than 5% liquid volume propylene.

HDV: Heavy Duty Engine.

Heavy Ends: A term used to describe the buildup of wax-like impurities that fall out of LPG when vaporized.

HEGO: Heated Exhaust Gas Oxygen, used to describe a sensor. Also known as "EGO" (Exhaust Gas Oxygen sensor), "O_2" or "Oxygen sensor.

Hg: Chemical symbol for the element mercury. Used in reference to a measure of vacuum (inches of Hg).

Histogram: The graphical version of a table which shows what proportion of values fall into specific categories over a specific period of time.

Hydrocarbon: A chemical compound made up of hydrogen and carbon (HC). Gasoline and almost all other fuels are hydrocarbons.

Hydrostatic Relief Valve: A pressure relief device installed in the liquid LPG hose on a LPG fuel system.

IAT: Intake Air Temperature

ICE: Internal Combustion Engine

Ideal Mixture: The air/fuel ratio at which the best compromise of engine performance to exhaust emissions is obtained. Typically 14.7:1.

Ignition Reserve: The difference between available voltage and the required voltage.

ILEV: Inherently Low Emission Engine.

IMPCO: Imperial Machine Products Company.

IMPCO Technologies, Inc. A manufacturer of Natural Gas, LPG and Gasoline fuel systems.

Impedance: A form of opposition of AC electrical current flow (resistance) measured in ohms.

Insulation: A nonconductive material used to cover wires in electrical circuits to prevent the leakage of electricity and to protect the wire from corrosion.

Intercept: An electrical term for a type of splice where the original circuit is interrupted and redirected through another circuit.

ITK: IMPCO Test Kit

Knock: Sound produced when an engine's air/fuel mixture is ignited by something other than the spark plug, such as a hot spot in the combustion chamber. Also caused by a fuel with an octane rating that is too low and/or incorrect ignition timing. Also called detonation or ping.

Lambda Sensor: A feedback device, usually located in the exhaust manifold, which detects the amount of oxygen present in exhaust gases in relation to the surrounding atmosphere. (See HEGO).

LDV: Light Duty Engine.

Lean Mixture: An air to fuel ratio above the stoichiometric ratio; too much air.

LEV: Low Emission Engine.

Limp-in or Limp Home: A mode where the ECM or a component has failed, but the engine remains operational although the engine may operate minimally. This term may also describe the drivability characteristics of a failed computer system.

Liquid Petroleum Gas (LPG): A fuel commonly known as propane consisting mostly of propane (C_3H_8), derived from the liquid components of Natural Gas stripped out before the gas enters the pipeline, and the lightest hydrocarbons produced during petroleum refining. Octane level of LPG is 107.

LNG: Liquefied Natural Gas.

M85: A blend of gasoline and methanol consisting of 85% methanol and 15% gasoline.

Measurements of Pressure: 1 PSI=2.06" Hg (mercury) = 27.72" H_2O (water column). At sea level atmospheric pressure is 29.92" Hg.

Methanol: Known as wood alcohol (CH_3OH), a light, volatile, flammable alcohol commonly made from Natural Gas.

MIL: Malfunction Indicator Lamp.

Misfire: Failure of the air/fuel mixture to ignite during the power stroke.

Mixer: Fuel introduction device that does not include a throttle plate.

MFI: Multiport Fuel Injection. A fuel injection system that uses one injector per cylinder mounted on the engine to spray fuel near the intake valve area of combustion chamber.

MSV: Manual Shut-Off Valve. Refers to the manually operated valve on the LPG tank.

MTBE: Methyl Tertiary Butyl Ether. Oxygenate add to gasoline to reduce harmful emissions and to improve the octane rating.

Multi-fuel System: A motor fuel system designed to operate on two different fuels, such as LPG and gasoline.

Natural Gas: A gas formed naturally from buried organic material, composed of a mixture of hydrocarbons, with methane (CH_4) being the dominant component.

NG: Natural Gas

NGV: Natural Gas Vehicle.

NOX: See Oxides of Nitrogen.

OBD: On Board Diagnostic

Octane Rating: The measurement of the antiknock value of a motor fuel.

OEM: Original Equipment Manufacturer, the engine manufacturer.

Open-Loop: An operational mode during which control module memory information is used to determine air/fuel ratio, injection timing, etc., as opposed to actual oxygen sensor input.

Orifice: A port or passage with a calibrated opening designed to control or limit the amount of flow through it.

Oscilloscope: An instrument that converts voltage and frequency readings into traces on a cathode ray tube (also see Cathode Ray Tube).

Oxides of Nitrogen: Chemical compounds of nitrogen bonded to various amounts of oxygen (NOX). A chief smog forming-agent.

Oxygen Sensor: An automotive fuel system that produces a signal in accordance with the oxygen content of the exhaust gas. (See Lambda Sensor).

Oxygenate: Oxygenates (such as MTBE, ethanol and methanol) added to gasoline to increase the oxygen content and therefore reduce exhaust emissions.

Ozone: A radical oxygen module (O_3) that is found in the upper atmosphere and filters out ultraviolet radiation from the sun. Ground level ozone is formed by NOX, during the formation of photochemical smog.

Particulates: Microscopic pieces of solid or liquid substances such as lead and carbon that are discharged into the atmosphere by internal combustion engines.

Positive Crankcase Ventilation (PCV): An automotive emission control system designed to reduce hydrocarbon emissions by routing crankcase fumes into the intake manifold rather than to the atmosphere.

Power Derate: A mode of reduced engine power output for the purposes of protecting engine components during a failure or malfunction.

Pressure Differential: The differential between atmospheric pressure and intake manifold (referred to as vacuum) pressure.

Pressure Regulator: A device to control the pressure of fuel delivered to the fuel injector(s).

Primary Circuit: The low-voltage or input side of the ignition coil.

Propane: An odorless and colorless gas, C_3H_8, found in Natural Gas and petroleum.

Psia: pounds per square inch absolute.

PTV: Pressure Trim Valve

Reactivity: Refers to the tendency of an HC in the presence of NOX and sunlight to cause a smog-forming reaction. The lighter the HC, the lower reactivity tends to be.

Regulator: An assembly used to reduce and control the pressure of a liquid or vapor.

Resistance: The opposition to the flow of current in an electrical circuit. Measured in ohms.

Rest Pressure: Fuel pressure maintained within the system after engine shutdown.

Rich Mixture: An air to fuel ratio below the stoichiometric ratio; too much fuel.

SAE: Society of Automotive Engineers.

scfh: Standard Cubic Feet per Hour.

Secondary Circuit: The high-voltage output side of the ignition coil.

SEFI or SFI: Sequential Electronic Fuel Injection or Sequential Fuel Injection.

Sensors: Devices that provide the control module with engine information as needed to properly control engine function.

Spark Line: The portion of an oscilloscope pattern that represents the time during which the air/fuel mixture is being burned in the combustion chamber.

Splice: An electrical term for the joining of two or more conductors at a single point.

Stoichiometric Ratio: An ideal fuel/air ratio for combustion in which all of the fuel and most of the oxygen will be burned.

Sulfur Oxides: Chemical compounds where sulfur is bonded to oxygen produced by the combustion of gasoline or any other fuel that contains sulfur. As sulfur oxides combine with water in the atmosphere to form sulfuric acid.

System Pressure: The fuel pressure maintained in the system during normal engine operation.

Tap: An electrical term for a type of splice where the original circuit is not interrupted.

TBI: Throttle Body Injection. Any of several injection systems that have the fuel injector(s) mounted in a centrally located throttle body.

Throttle Body: Controls engine rpm by adjusting the engine manifold vacuum to the mixer. Consists of a housing shaft, throttle liner and butterfly valve.

TLEV: Transitional Low Emission Engine.

TMAP: Combined Air Inlet and Manifold Pressure Sensor.

Toluene: A liquid aromatic hydrocarbon C_7H_8.

TPS: Throttle Position Sensor.

TSB: Technical Service Bulletin.

ULEV: Ultra Low Emission Engine.

USB: Universal Serial Bus. A plug or interface supplied on most personal computers.

Vaporization: A process in which liquid changes states into gas.

Venturi Air Valve Vacuum (VAVV): An amplified air valve vacuum signal coming from the venturi area of the mixer, directly exposed to airflow before the addition of vaporized gas.

Volt/Ohmmeter (VOM): A combination meter used to measure voltage and resistance in an electrical circuit. Available in both analog and digital types. May also referred to as AVOM and DVOM.

Voltage: The electrical pressure that causes current to flow in a circuit. Measured in volts.

Voltage Drop: A lowering of the voltage in a circuit when resistance or electrical load is added.

Voltmeter: A meter that uses a needle to point to a value on a scale of numbers usually of the low impedance type; used to measure voltage and resistance.

VSS: Engine Speed Sensor

w.c.: Water Column. Expressed in inches, water column is a measure of pressure.

Xylene: $C_6H_4\ (CH_3)_2$. Any of three toxic, flammable, and oily isomeric aromatic hydrocarbons that are dimethyl homologues of benzene and usually obtained from petroleum or Natural Gas distillates.

ZEV: Zero Emission Engine.

Appendix

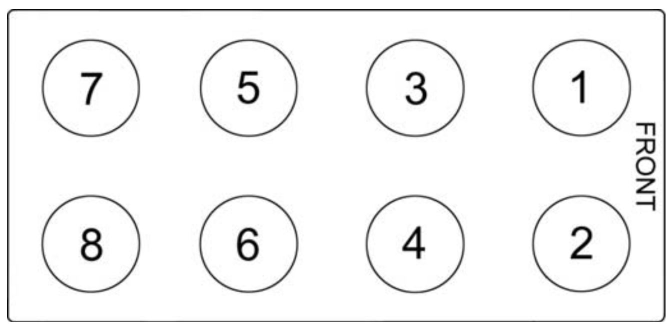
Altitude vs. Barometric Pressure

Altitude Measured In Feet (ft)	Kilopascals (kPa)	Pounds Per Square Inch (PSIA)
14,000	56-64	8.1-9.2
13,000	58-66	8.4-9.6
12,000	61-69	8.8-10.0
11,000	64-72	9.3-10.4
10,000	66-74	9.6-10.7
9,000	69-77	10.0-11.2
8,000	71-79	10.3-11.4
7,000	74-82	10.7-11.9
6,000	77-85	11.2-12.3
5,000	80-88	11.6-12.8
4,000	83-91	12.0-13.2
3,000	87-95	12.6-13.8
2,000	90-98	13.0-14.2
1,000	94-102	13.6-14.8
0	96-104	13.9-15.0
-1,000	101-105	14.6-15.2

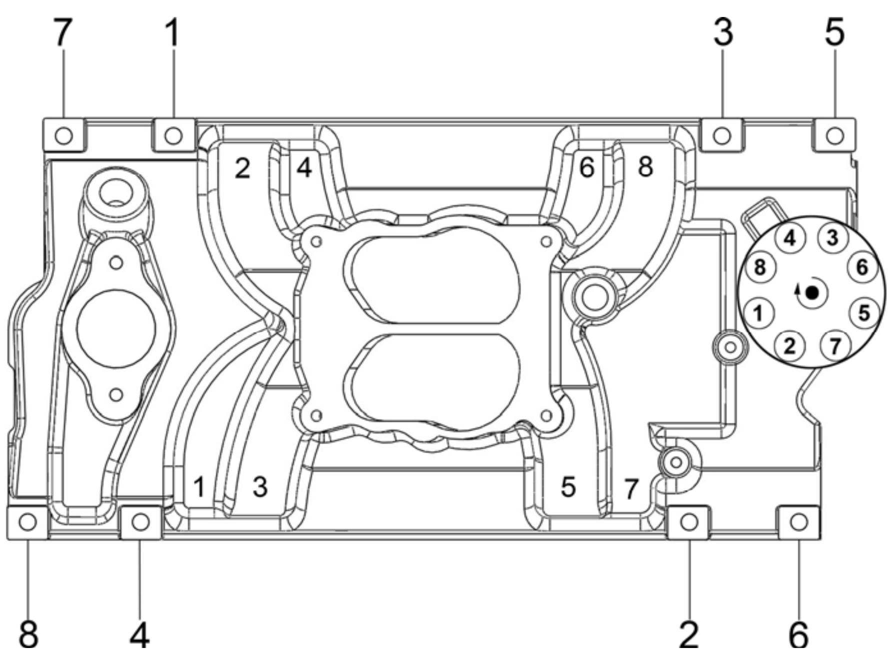
Ignition System Specifications

Firing Order	1-8-4-3-6-5-7-2
Spark Plug Type	R42 (AC Plug)
Spark Plug Gap	.035 in (0.889 mm)
Spark Plug Torque	11 lb ft (15 Nm)
Spark Plug Wire Resistance	1000 Ohms per ft.

GM Engine V-8 Cylinder Layout



The layout of the 5.0 and 6.2L cylinder numbers



Intake Manifold Bolt Tightening Sequence and Distributor Spark Plug Wire Listing by Cylinder Number.

Extended ECT Temperature vs. Resistance

302	150	47
284	140	60
266	130	77
248	120	100
230	110	132
212	100	177
194	90	241
176	80	332
158	70	467
140	60	667
122	50	973
113	45	1188
104	40	1459
95	35	1802
86	30	2238
77	25	2796
68	20	3520
59	15	4450
50	10	5670
41	5	7280
32	0	9420
23	-5	12300
14	-10	16180
5	-15	21450
-4	-20	28680
-22	-30	52700
-40	-40	100700