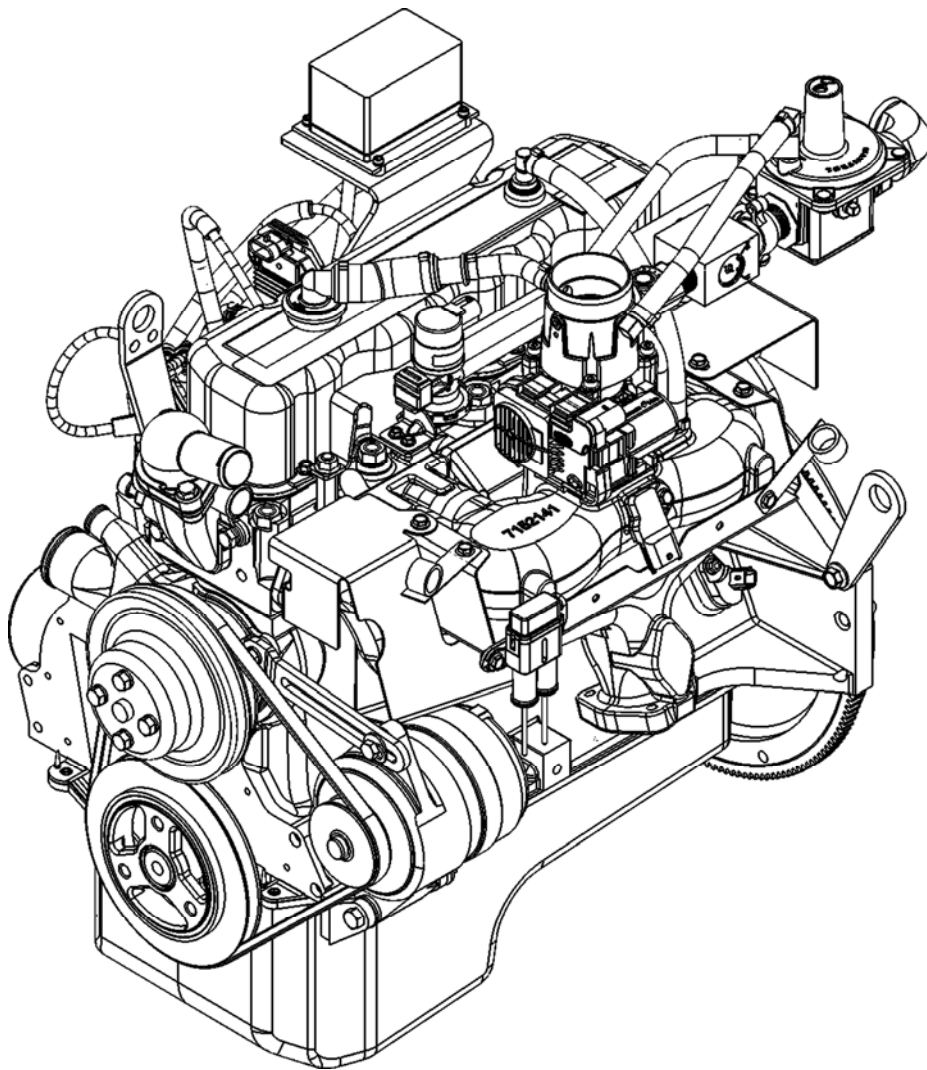

IMPCO

2011 3.0L GM Engine

Emission Certified Natural Gas/Propane Fuel System for Stationary Power Generation

Venturi Series With Fuel Selector



Service Manual

Revision B/September, 2011

IMPCO

2011 3.0L GM Engine Emission Certified Natural Gas/Propane Fuel System for Stationary Power Generation

Including Labor Time Guide

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General Information



GENERAL INFORMATION

INTRODUCTION

This service manual supplement has been developed to provide the service technician with the basic understanding of the IMPCO certified fuel and emission systems for the 3.0L 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 3.0L Engine is an inline four cylinder 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 3.0L stationary engine features a low pressure single point fuel delivery system along with the Delphi MEFI5 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 ECU 60 times per engine revolution 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.



GENERAL INFORMATION

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°F (-20°C) to 221°F (105°C). Low temperature starting characteristics: Unassisted start: 0°F (-18°C). Assisted start (block heater active): -20°F (-29°C). High temperature starting characteristics: Unassisted start: 104°F (40°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 3.0L 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.



GENERAL INFORMATION

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/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 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**

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.

**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.



WARNING

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 be inactive for long periods of time. It is recommended, that the engine be started at least 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.

V-BELT SYSTEM

V-belts should be checked and/or replaced 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 GM Dexcool 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

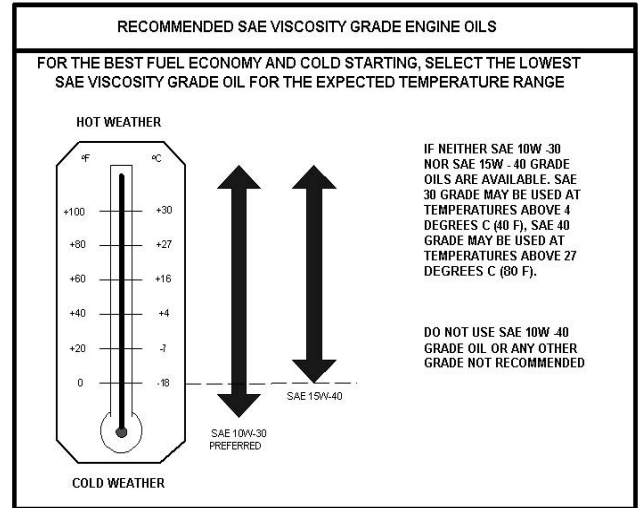
The engine's electrical system incorporates computers to control various related components. The electrical system connections and ground circuits require good connections. Follow the recommended maintenance schedule in this section to maintain optimum performance. When inspecting the electrical system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

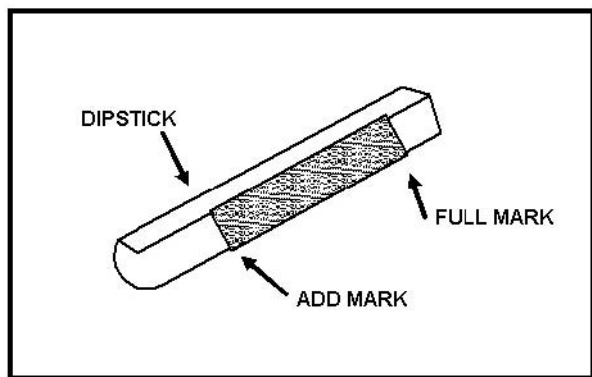
Synthetic oils have been available for use in industrial engines for a relatively long period of time and may offer advantages in cold and hot temperatures. However, it is not known if synthetic oils provide operational or economic benefits over conventional petroleum-based oils in industrial engines. 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 damage, 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 and responsible manner.

FUEL SYSTEM INSPECTION AND MAINTENANCE

NATURAL GAS/PROPANE FUEL SYSTEM

The 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.

VENTURI/THROTTLE CONTROL DEVICE MAINTENANCE AND INSPECTION

IMPORTANT:

The Venturi and Throttle Body components have been specifically designed and calibrated to meet the fuel system requirements of the engine.

When inspecting the Venturi and Throttle Body, check for the following items:

- Leaks at all fittings.
- Ensure the Venturi and Throttle Body are securely mounted.
- Inspect Air cleaner element according to the Recommended Maintenance Schedule found in this section.

NOTE: A dirty air cleaner may significantly alter the Venturi performance.

- Inspect air inlet hose connection and clamp. Also inspect inlet hose for cracking, splitting or chafing. Replace if any of these conditions exist.
- 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. Clean and/or 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.

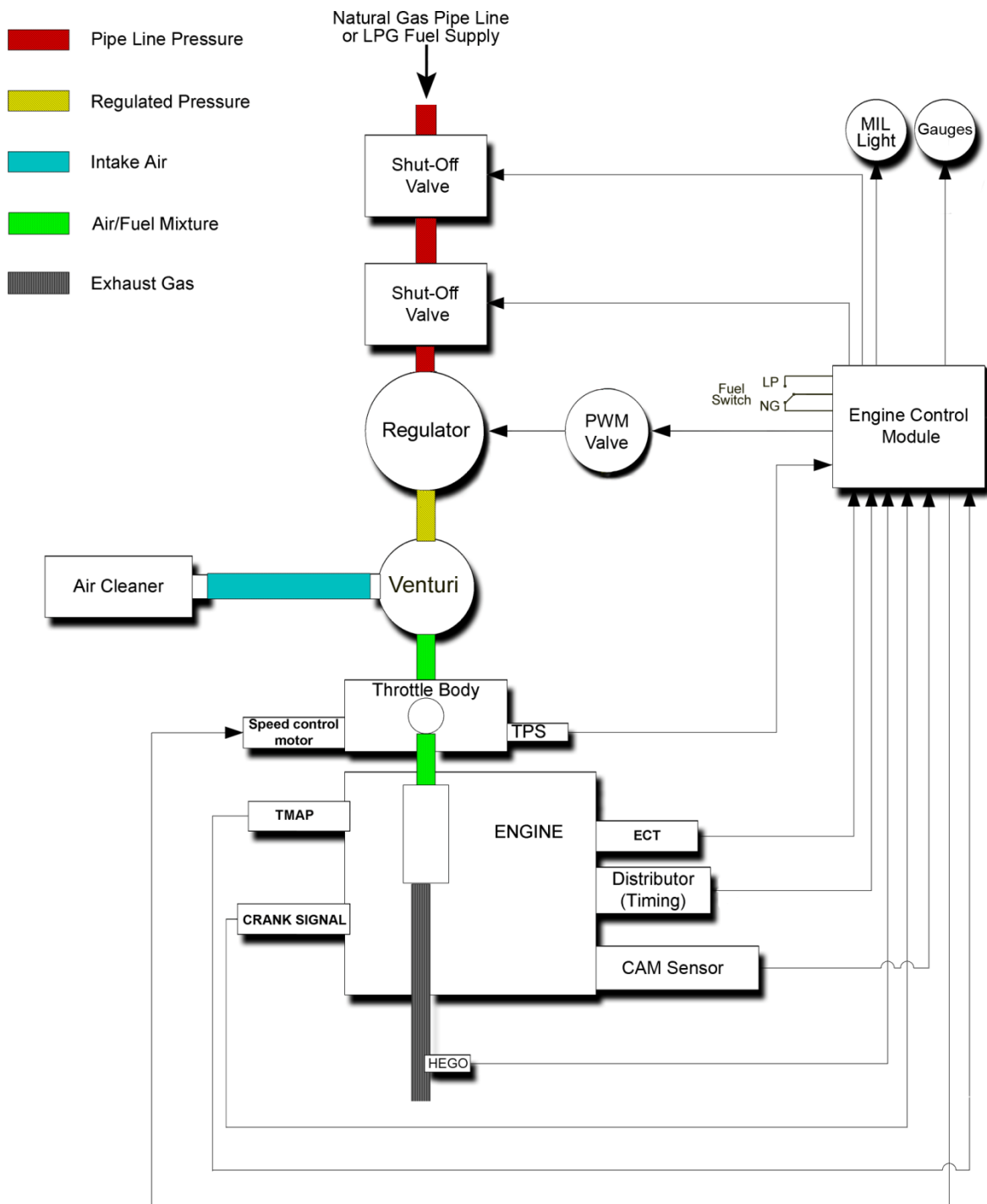
CERTIFIED EMERGENCY STATIONARY ENGINE MAINTENANCE REQUIREMENTS

For maintenance or other work that is not 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									
	Prior To Each Use	1000	1500	2000	2500	3000	3500	4000	4500	5000
General Maintenance Section										
Visual check for fluid leaks	X									
Check engine oil level	X									
Check coolant level	X									
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--GM 6277M specification (Dexcool) 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 LPG 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		

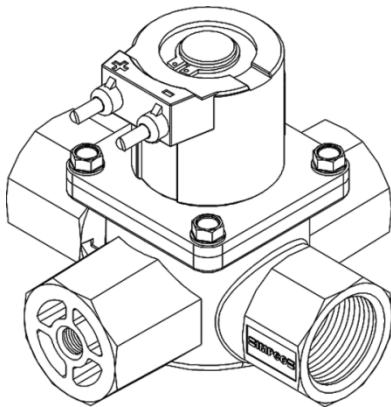
*A "day" is any 24 hour period in which the engine was run, if only for a few minutes. Not to be confused with calendar days

Natural Gas/Propane Fuel System



DESCRIPTION AND OPERATION OF THE FUEL SYSTEMS

FUEL SHUT-OFF VALVES

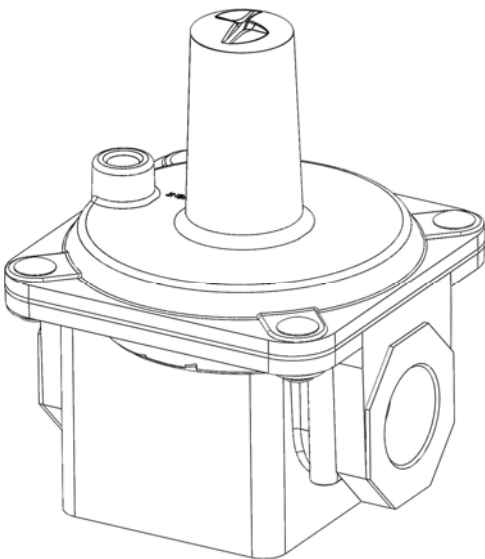


Shut-off Valve

Two low pressure 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 Gas fuel to flow through the valve. The valve opens during cranking and engine run cycles. Voltage to the Shut-Off Valves is controlled by the engine control module (ECM).

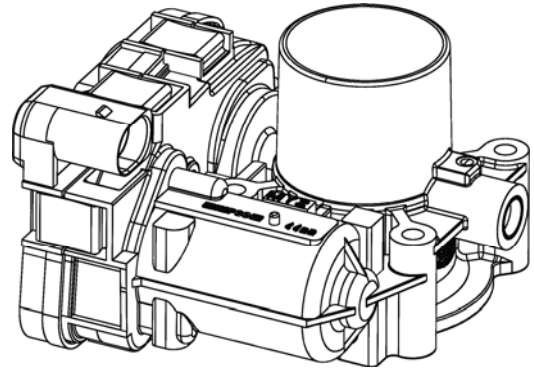
FUEL PRESSURE REGULATOR

The Fuel Pressure Regulator regulates pressure of Fuel vapor to the Venturi.



Regulator

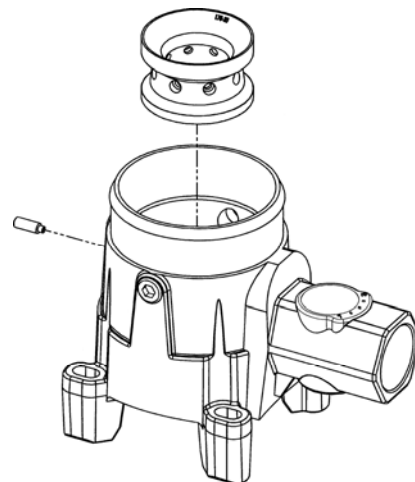
THROTTLE CONTROL DEVICE



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.

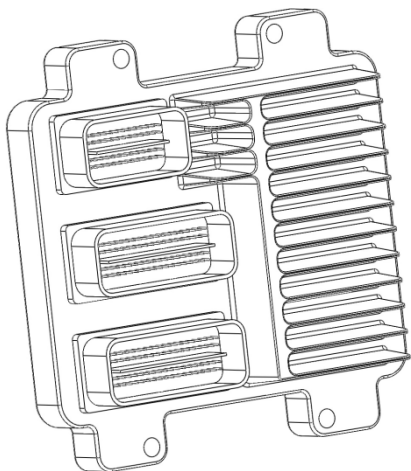
VENTURI



Venturi and Adapter

The Venturi rests on top of the Throttle Body and mixes the air and fuel. Air passing through the throat of the Venturi creates a low pressure (vacuum), drawing fuel through holes in the Venturi and into the throat of the Venturi Adapter. The amount of fuel delivered to the Venturi is monitored by the ECM and can be modified by signals to the Fuel Control Valve. A Power Valve is used to adjust high speed mixture and is preset and not adjustable in the field.

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.

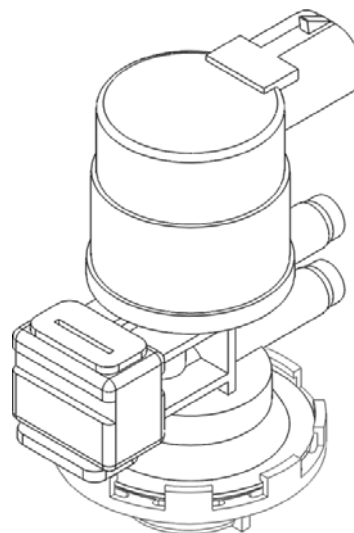


Engine Control Module (ECM) Inputs & Outputs

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 Venturi.

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 then 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.



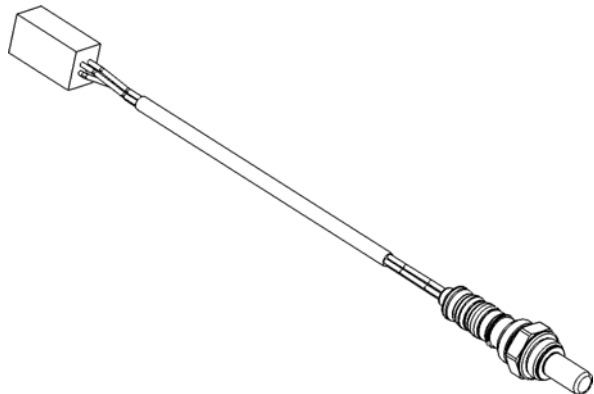
Fuel Control Valve

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 Venturi.

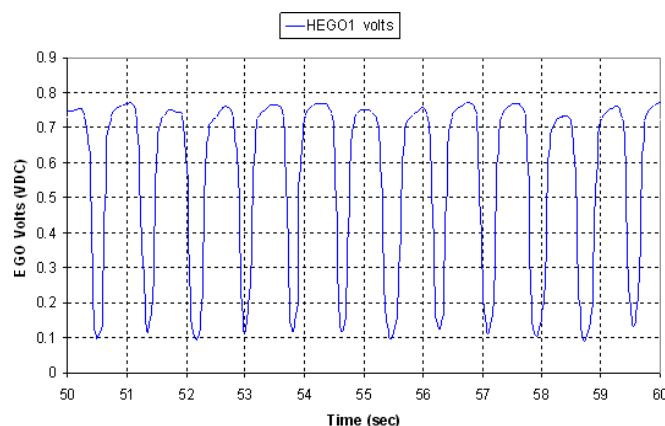
HEATED EXHAUST GAS OXYGEN SENSOR

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



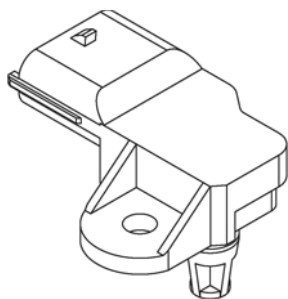
CAUTION

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:

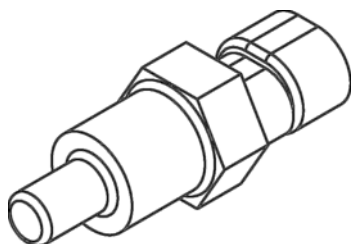
- 1) A variable resistor used to monitor the difference in pressure between the intake manifold and outside or atmospheric pressure. The ECM monitors the resistance of the sensor to determine engine load (the vacuum drops when the engine is under load or at wide open throttle). When the engine is under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

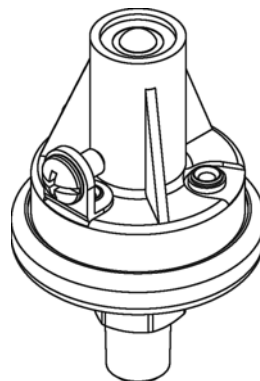
The Engine Coolant Temperature sensor or ECT is a variable resistance thermistor that changes resistance as the engine's coolant temperature changes. The sensor's resistance is monitored by the ECM to determine a cold start condition and to regulate various fuel and emission control functions via a closed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



Coolant Temperature Sensor

OIL PRESSURE SENDER

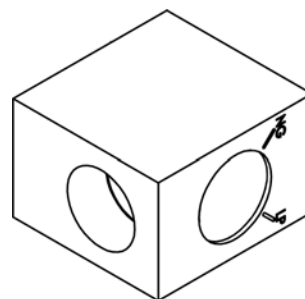
The Engine Oil Pressure Sender is designed to ensure adequate lubrication throughout the engine. It provides a pressure value and is monitored by the ECM. If the pressure drops, a MIL will occur.



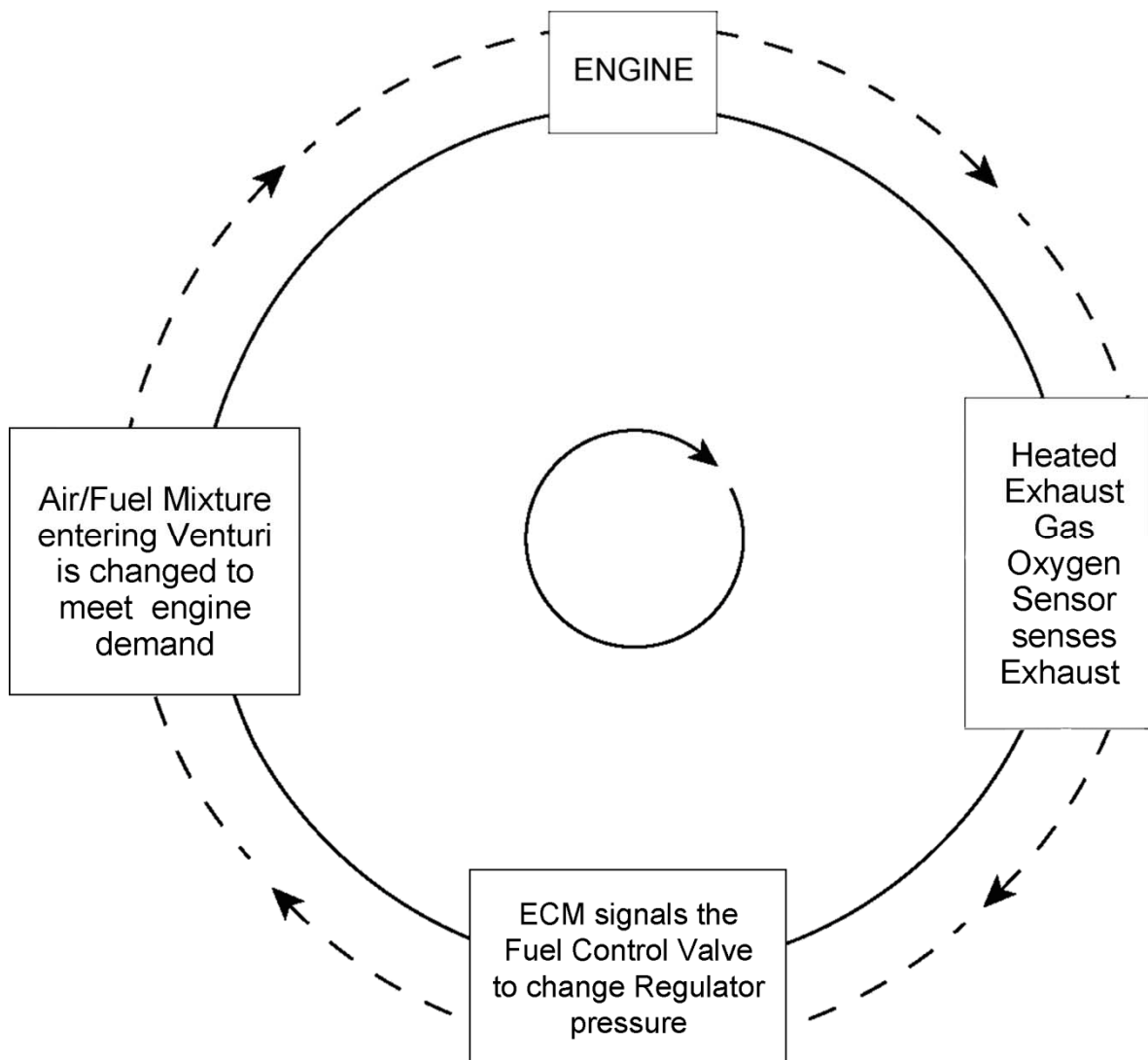
Oil Pressure Sender

FUEL SELECTOR SWITCH

A Fuel Selector Switch is necessary to properly adjust the vapor fuel flow and compensate for the differences between Natural Gas and LPG vapor. It has two settings: NG for Natural Gas and LP for LPG. The switch is adjusted at the factory and is not user serviceable.



Fuel Selector Switch (shown with expansion plug installed)



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

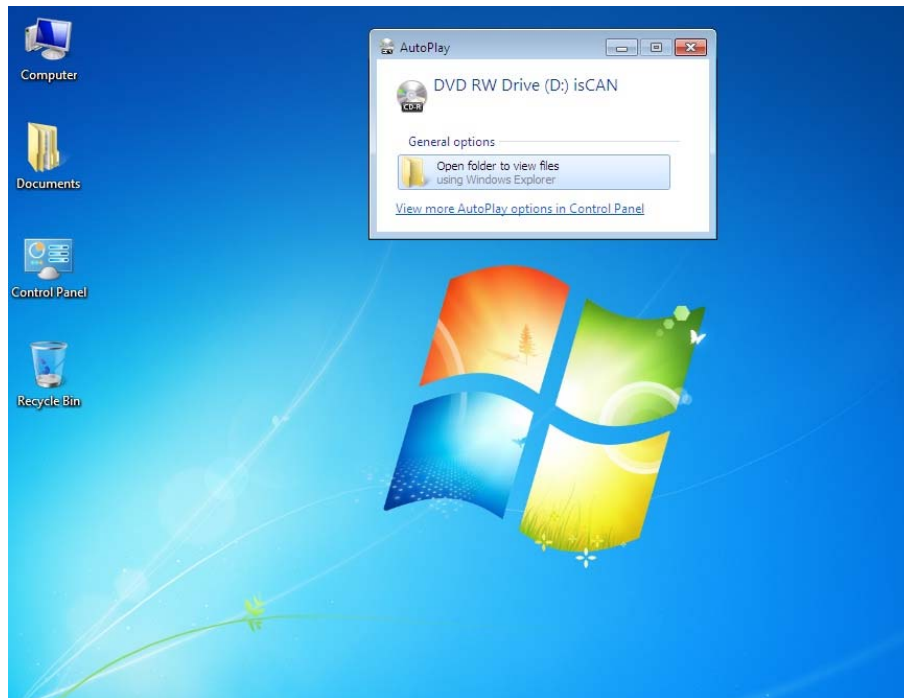
Additional:

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

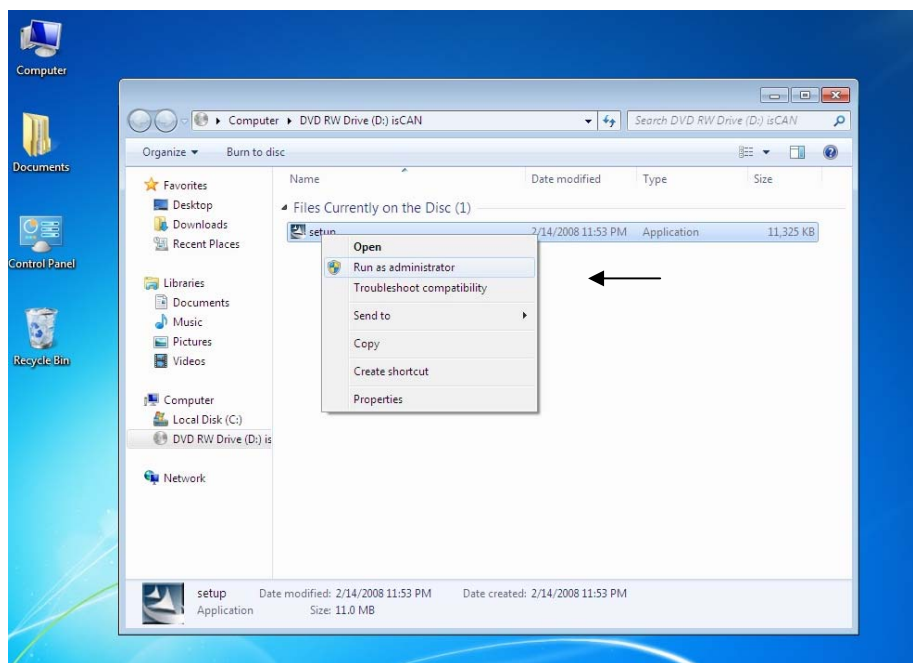
Examples and snapshots used in this manual are based off of the initial DST tool release as of August, 2010 using the Windows 7 operating system. This tool is used for multiple fuel systems and is frequently updated. Snapshot illustrations may vary depending on the installed operating system and changes 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:

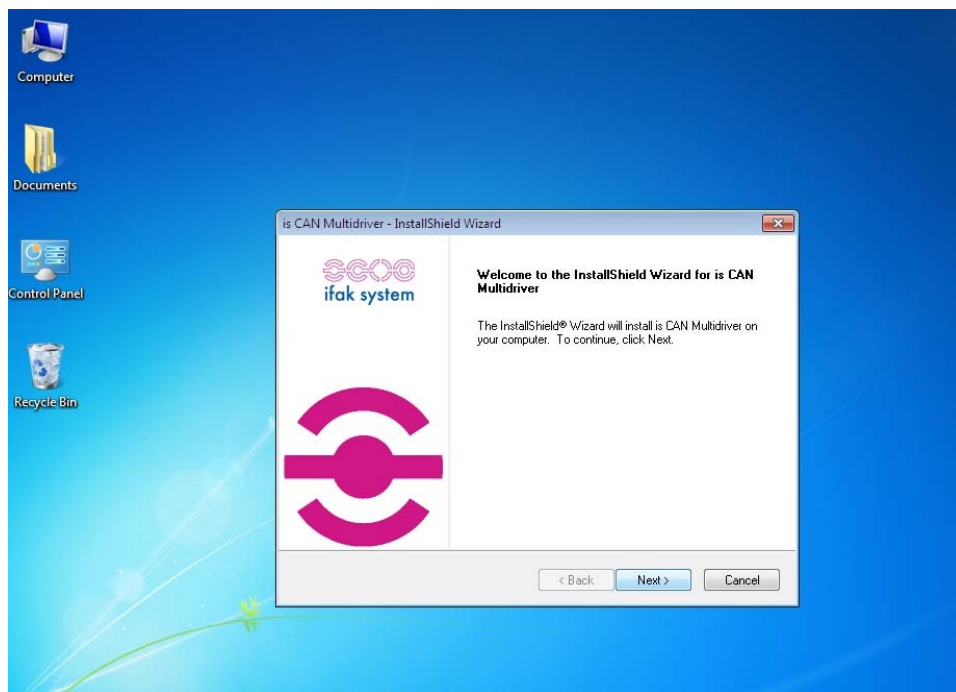
NOTE: Close any open applications prior to installing the DST.



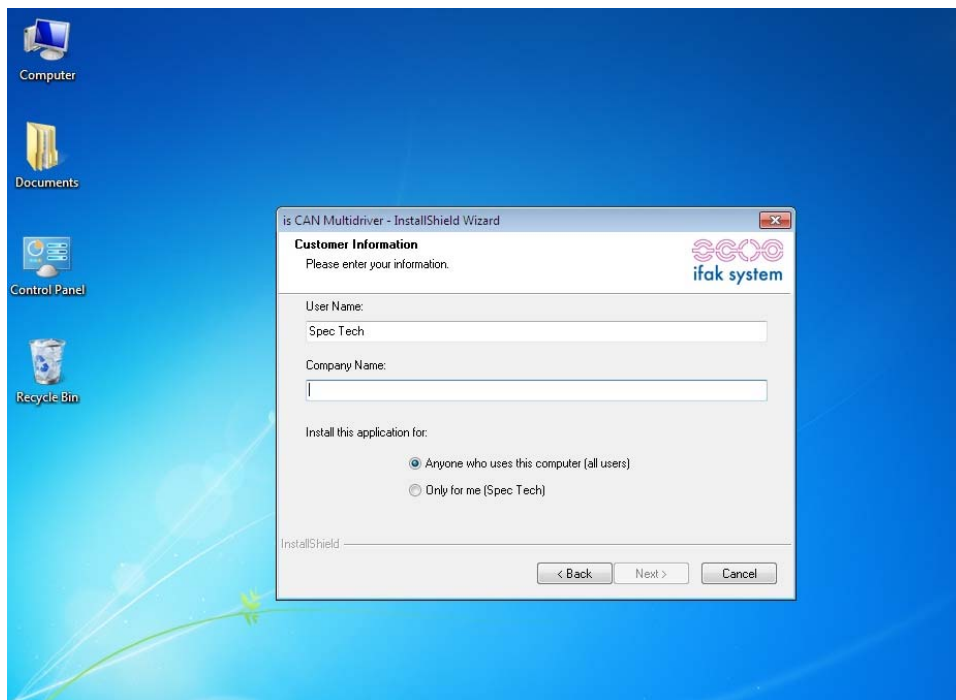
Insert the Ifak CD included with your USB to CAN adapter and open the file folder.



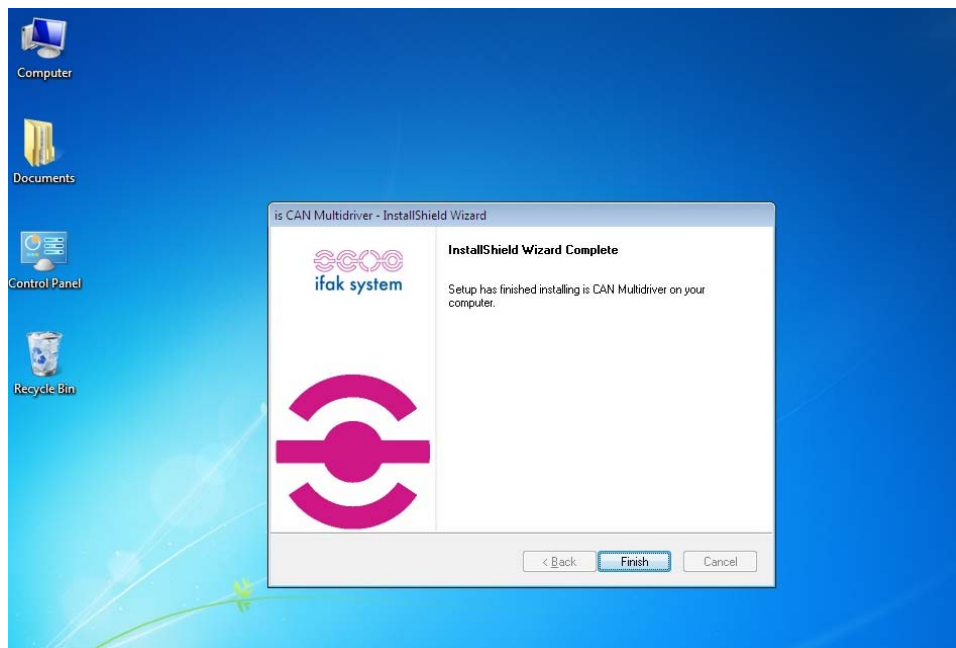
For users with restricted rights using Windows 7 or Windows Vista, select **Run as administrator** as shown above. For all others, select the **Setup** file. You may receive a Windows message asking you to confirm the installation request by an unknown publisher. You must select **Yes** to continue the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



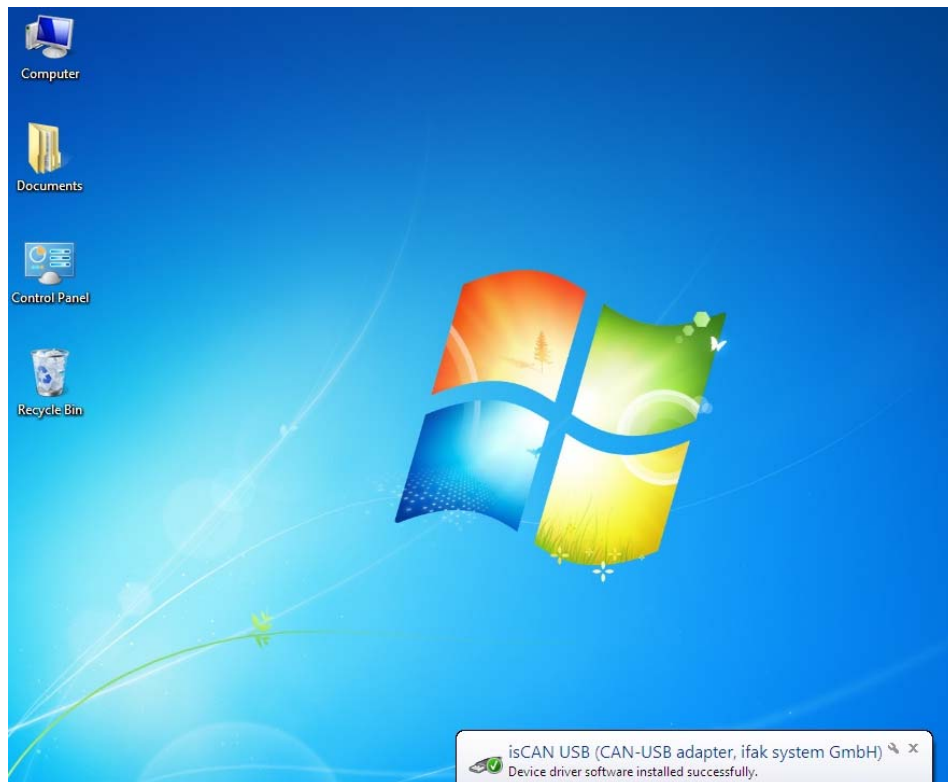
Select the **Next** box to continue with the installation.



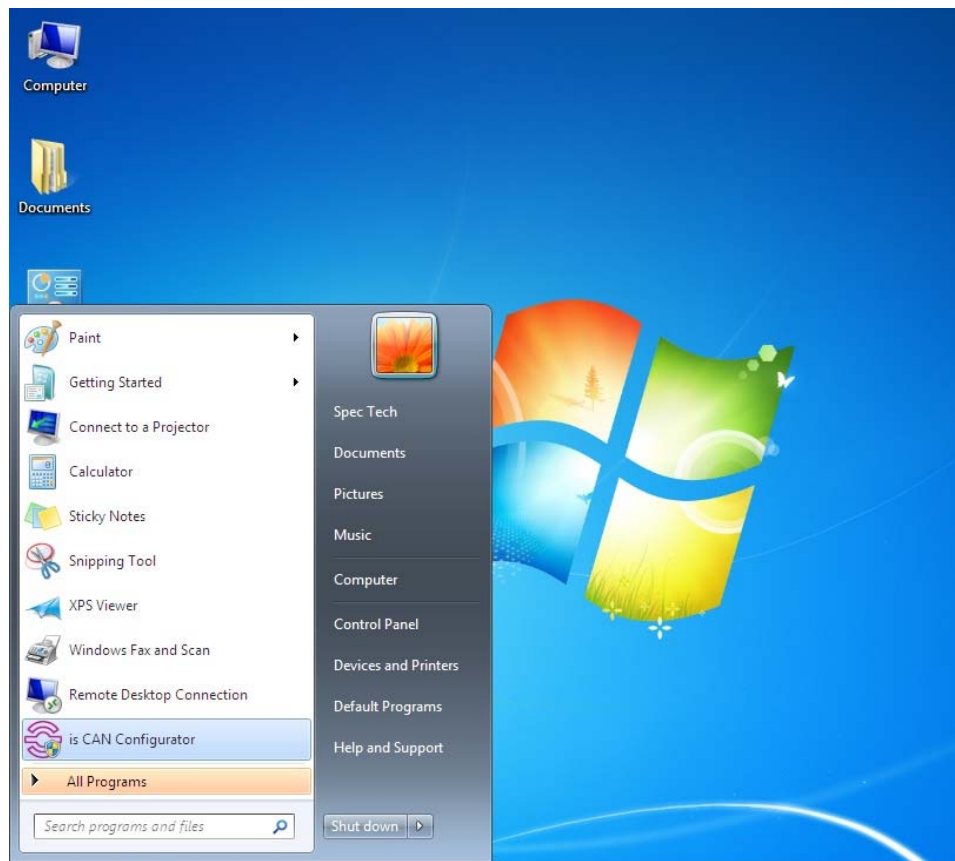
Enter your company name or organization and click the **Next** box. Follow the next steps using the recommended defaults.



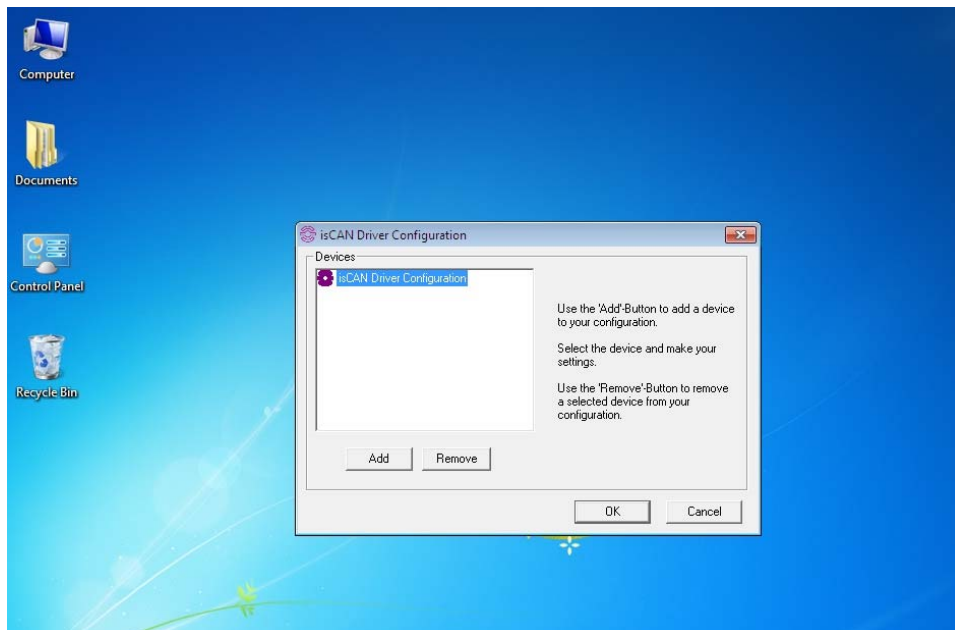
Click the **Finish** box to complete the installation. It is now recommended you re-boot your computer.



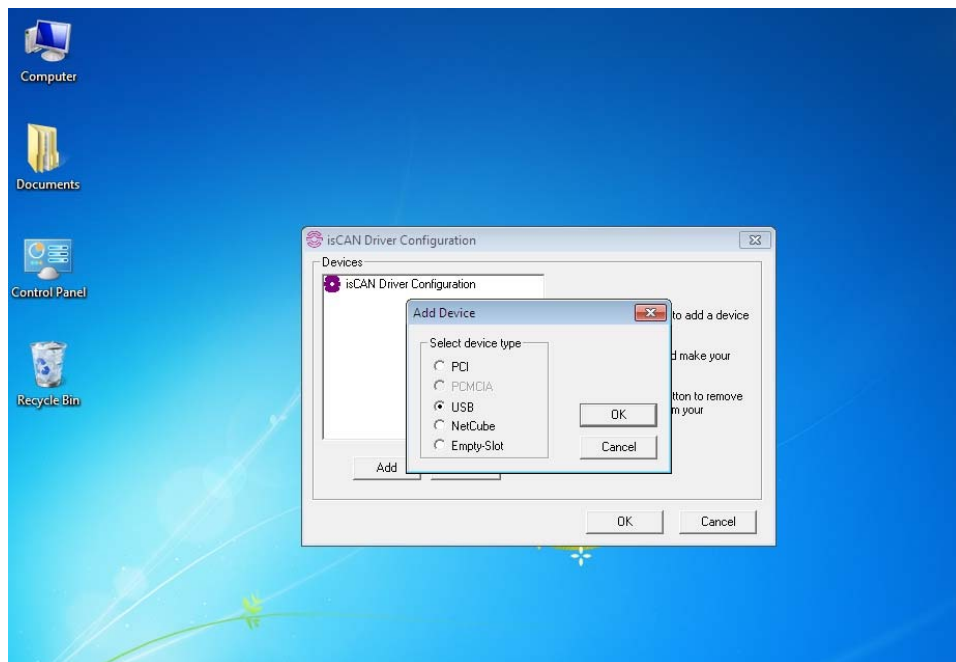
Connect the Ifak adapter to an available USB port. You may see a message confirming you wish to make changes to the computer from an unknown publisher. If so, you must select the **Yes** box to continue the installation. Windows will now install the Ifak driver to your computer. You should see a message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



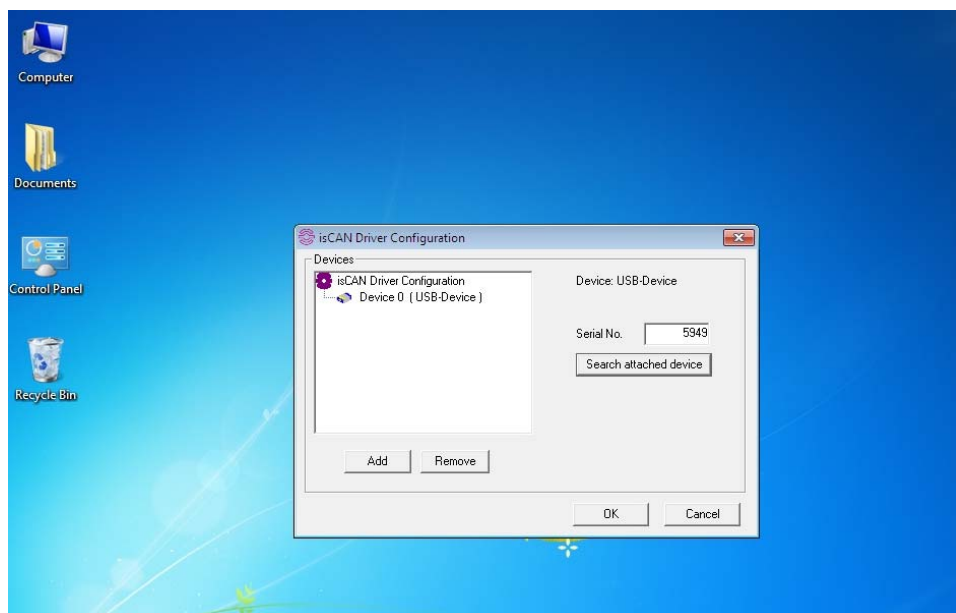
Open the **Start** menu. You should see the is CAN Configuration utility confirming the utility installation. Select the **is CAN Configurator**.



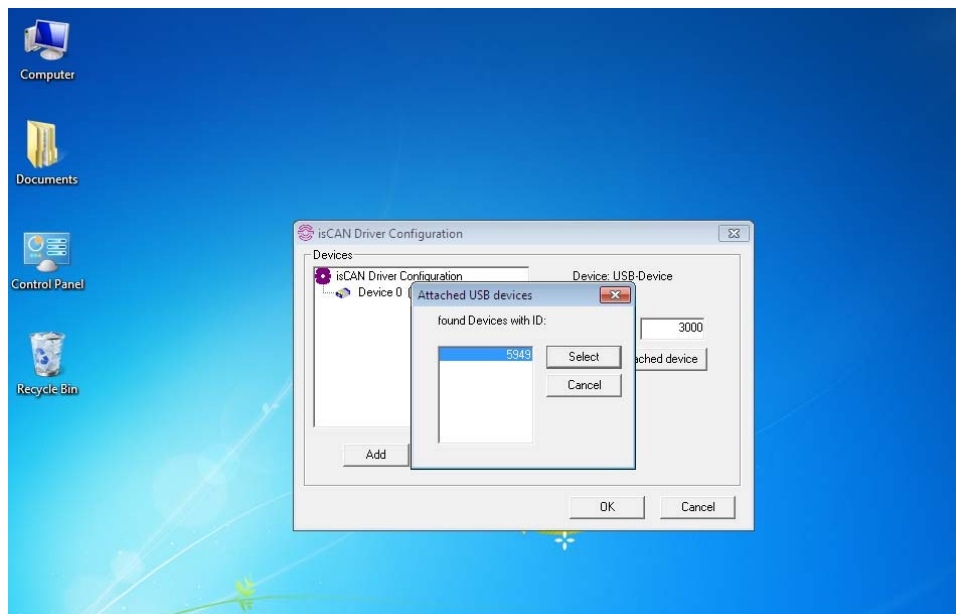
Click the **Add** box.



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



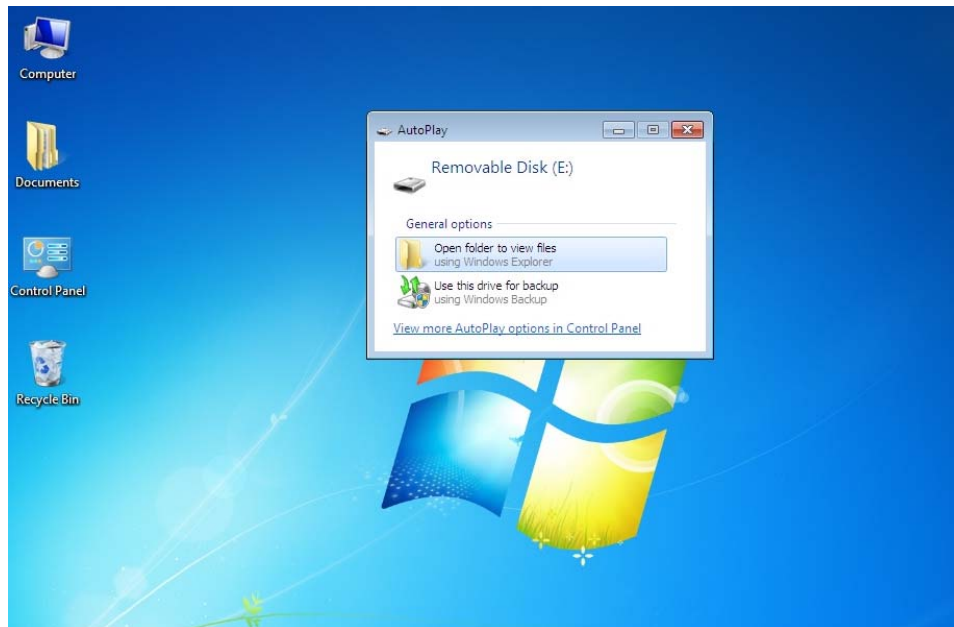
Click on the **Search attached device** box.



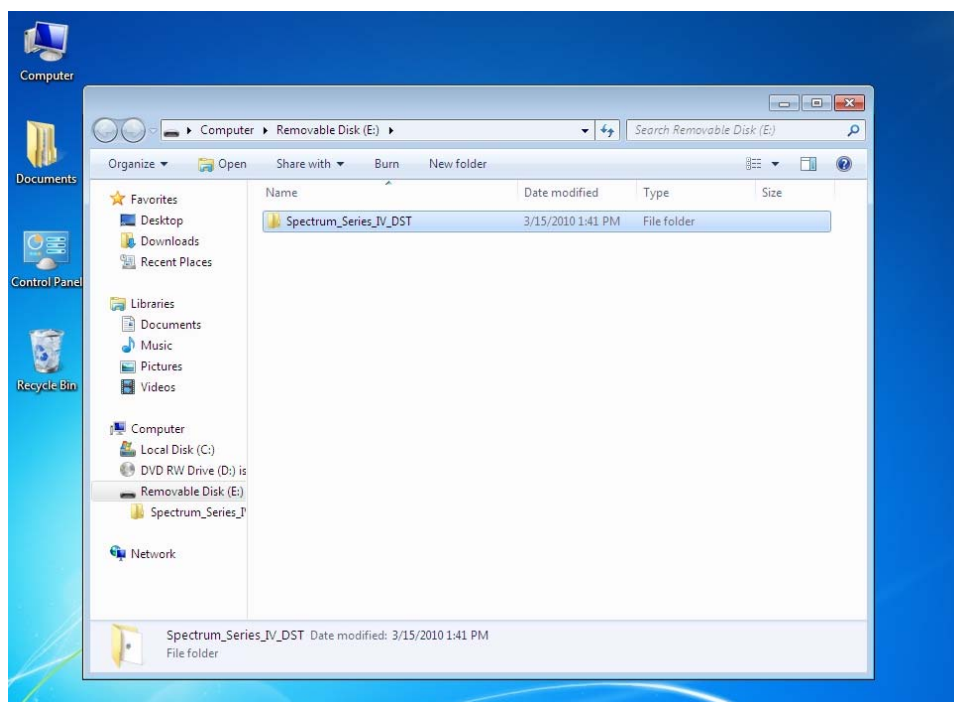
When the Ifak device serial number is shown, click the **Select** box, then click the **OK** box. The Ifak driver and utility installation is now complete. If you had problems during this installation please see the additional information and test instructions for your Ifak adapter included with your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

Spectrum Series IV DST Software Installation:

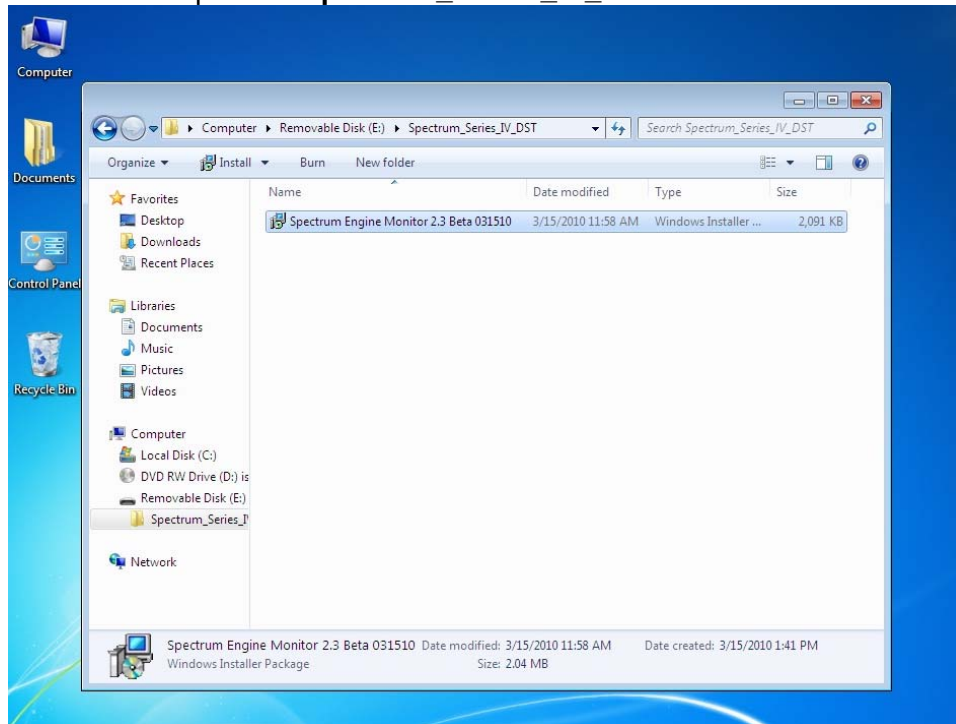
In most instances the OEM manufacturer will have supplied you the DST software installation files. The installation files may have been provided to you by internet download, CD or other media storage. Regardless of the delivery system, please follow the instructions to install the DST software below. 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.



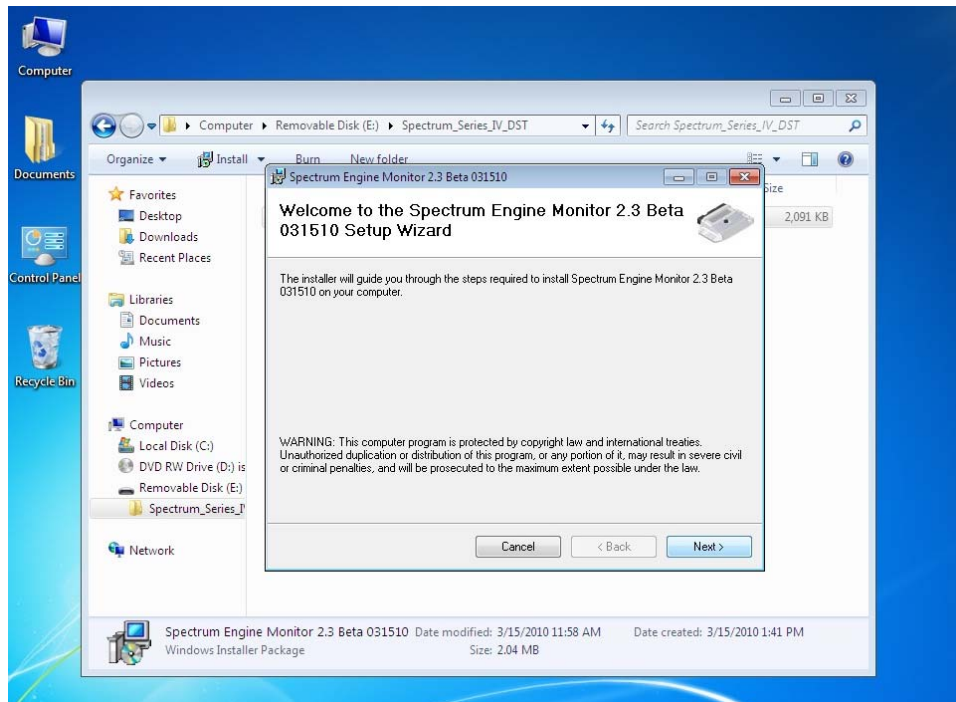
Insert the CD, USB flash drive, other storage media or find the location where the DST software has been saved on your computer.



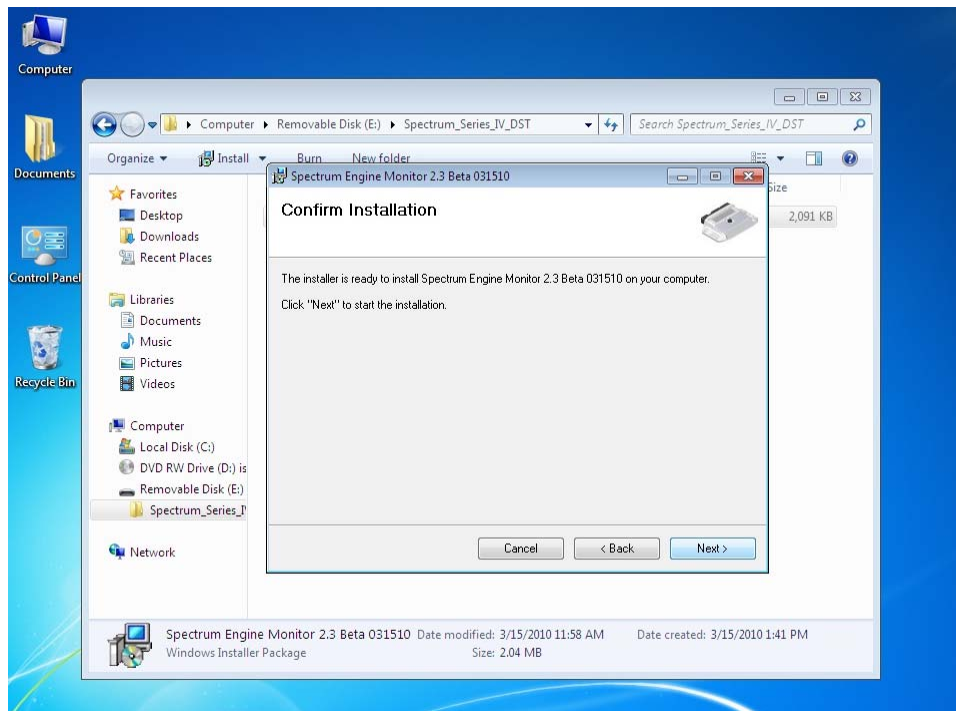
Open the **Spectrum_Series_IV_DST** file folder.



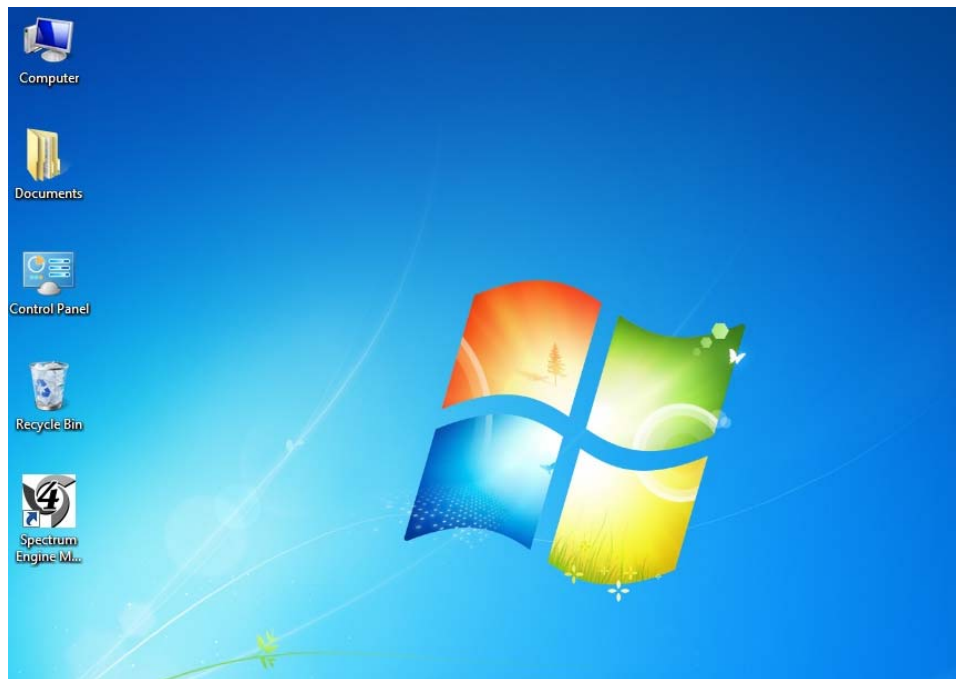
For users with restricted rights using Windows 7 or Windows Vista, it may be necessary to select the **Run as administrator** box similar to the Ifak USB driver installation. For all others, click the **Spectrum Engine Monitor.msi** file. You may receive a Windows message asking you to confirm the installation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



Click the **Next** box.

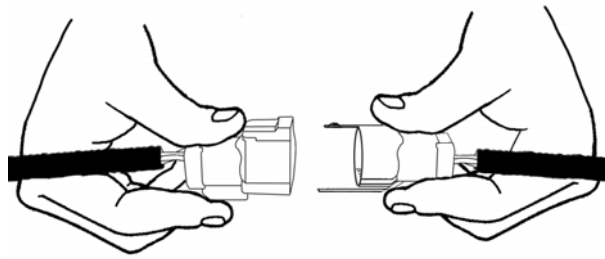


Follow the on screen prompts that will guide you through the installation.

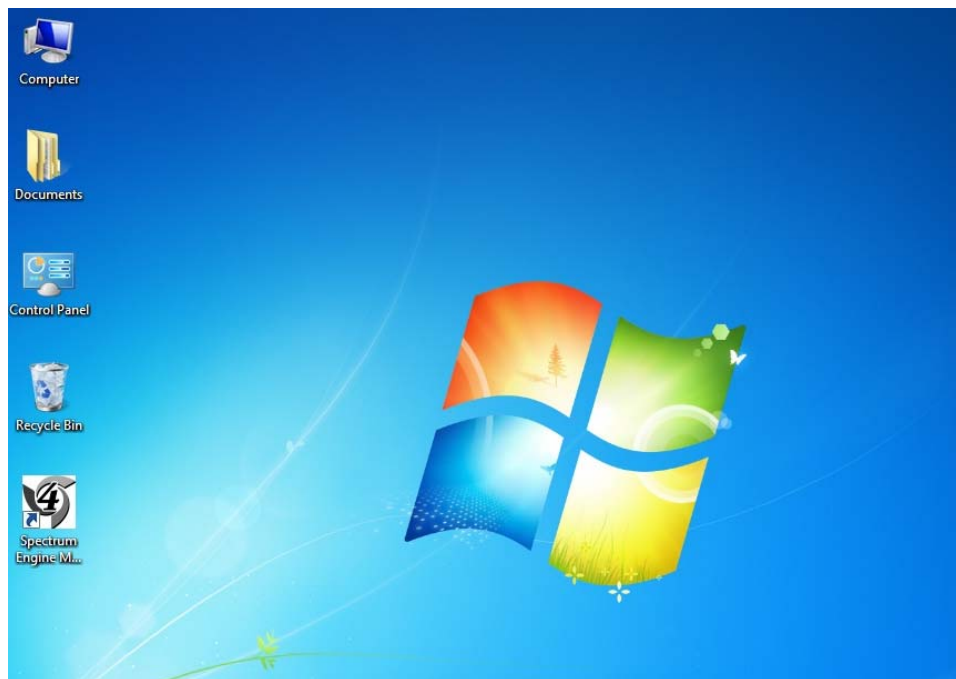


The Spectrum 4 logo shortcut is placed on the desktop confirming the installation is complete. It is now recommended that you re-boot your computer.

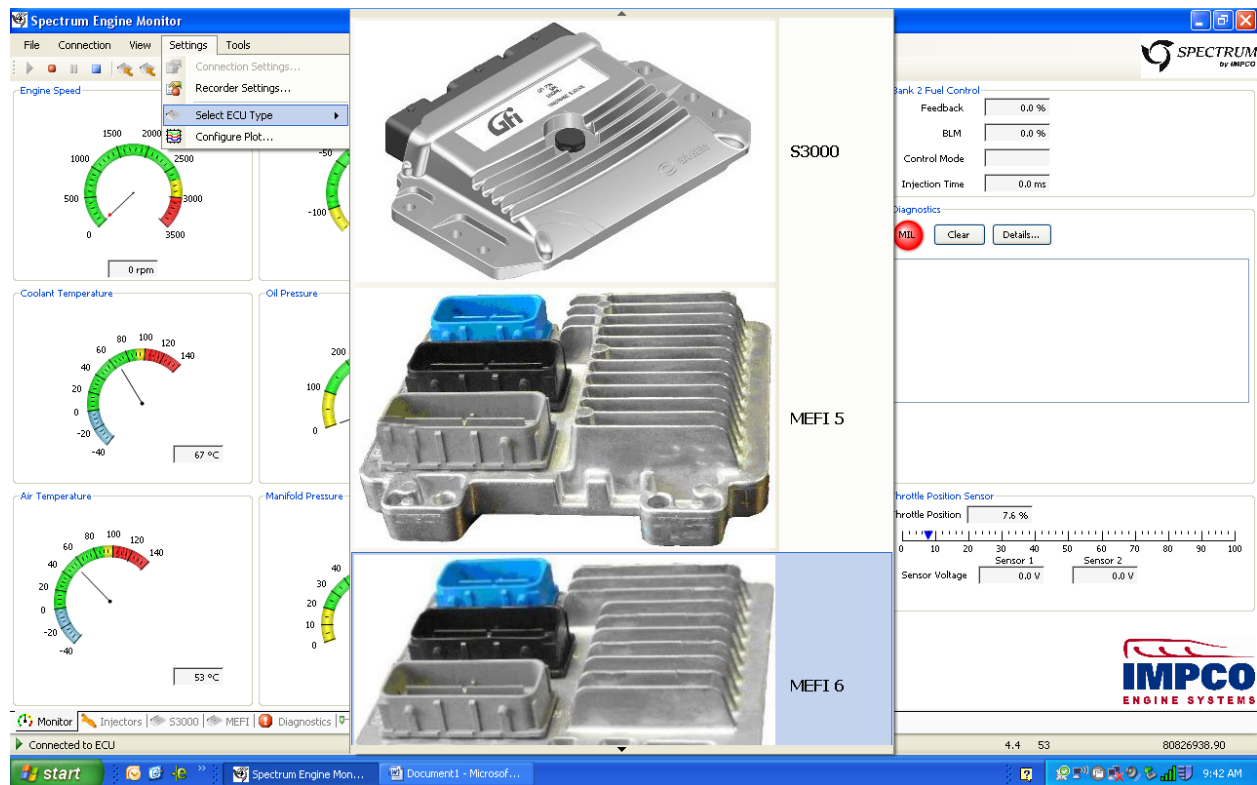
Connecting the DST:



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.

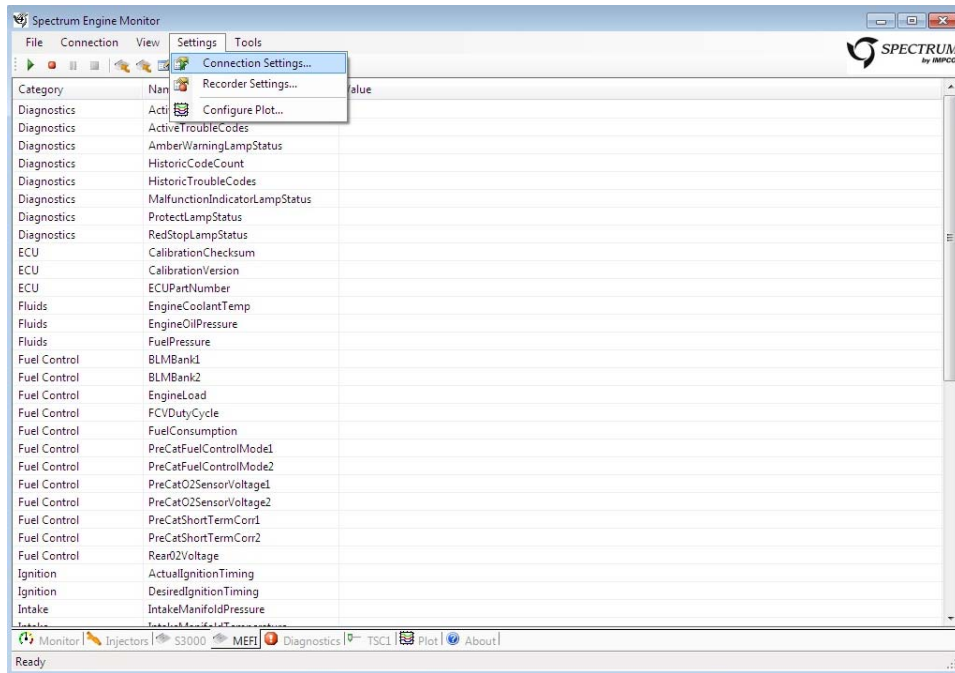


Select the Settings pulldown menu from the top, and mouse over the Select ECU Type, then mouse over to the MEFI 6 controller.

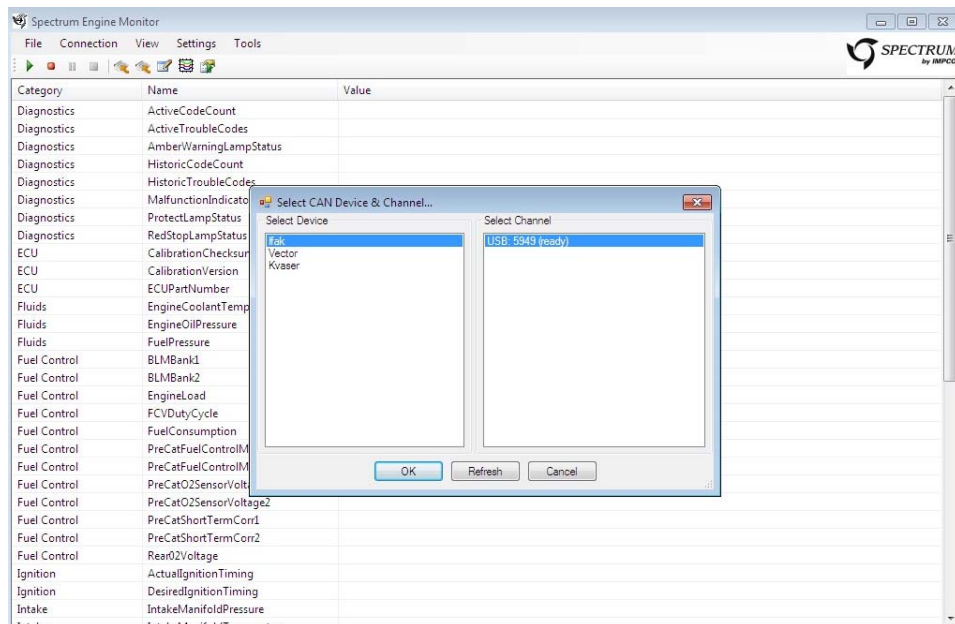
Turn the engine ignition power ON.



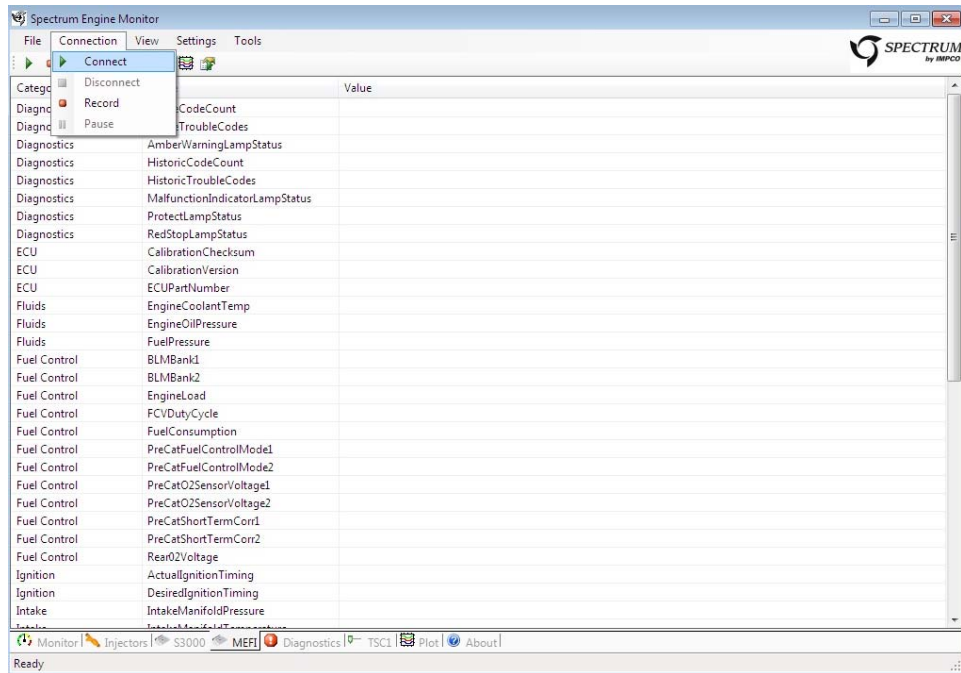
Click on the **MEFI** tab at the lower left of the Spectrum Engine Monitor page.



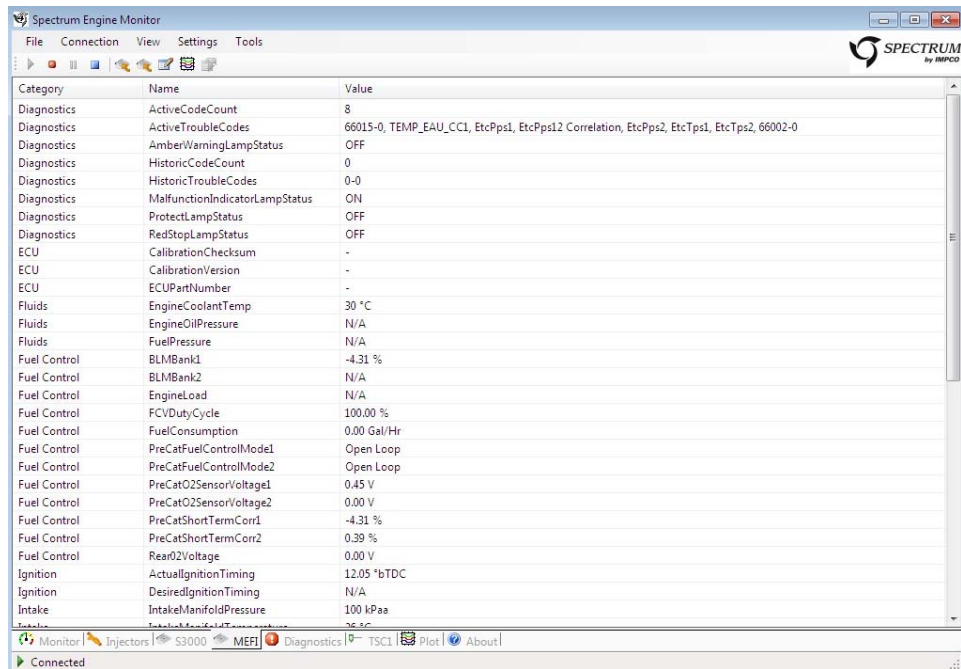
Pull down the **Settings** menu and click on **Connection Settings**.



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.



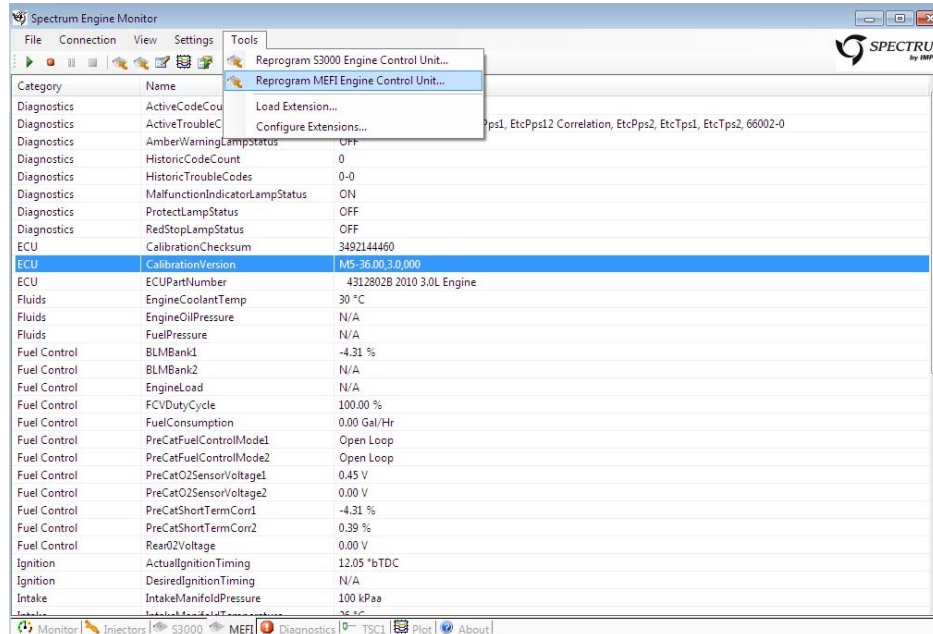
Using the Spectrum DST

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:

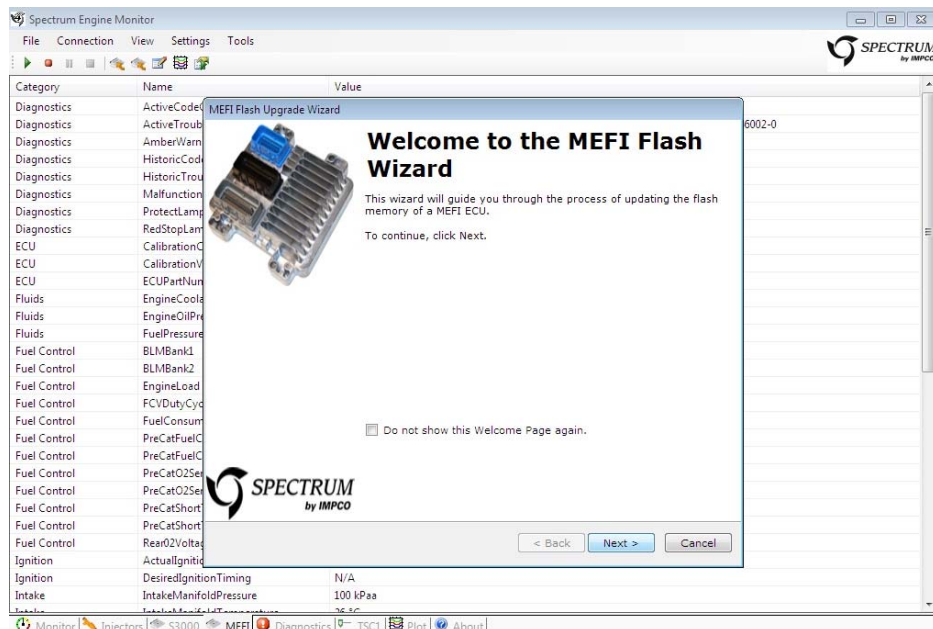
- Updating the ECM calibration using the .s37 calibration file.
- Provide graphical display interface for engine and sensors parameters
- Display and save DTC (Diagnostic Trouble Codes)
- Clear both active and historic DTCs.
- Provide data stream information from engine sensors and actuators
- Plot data.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

Updating the ECM Calibration

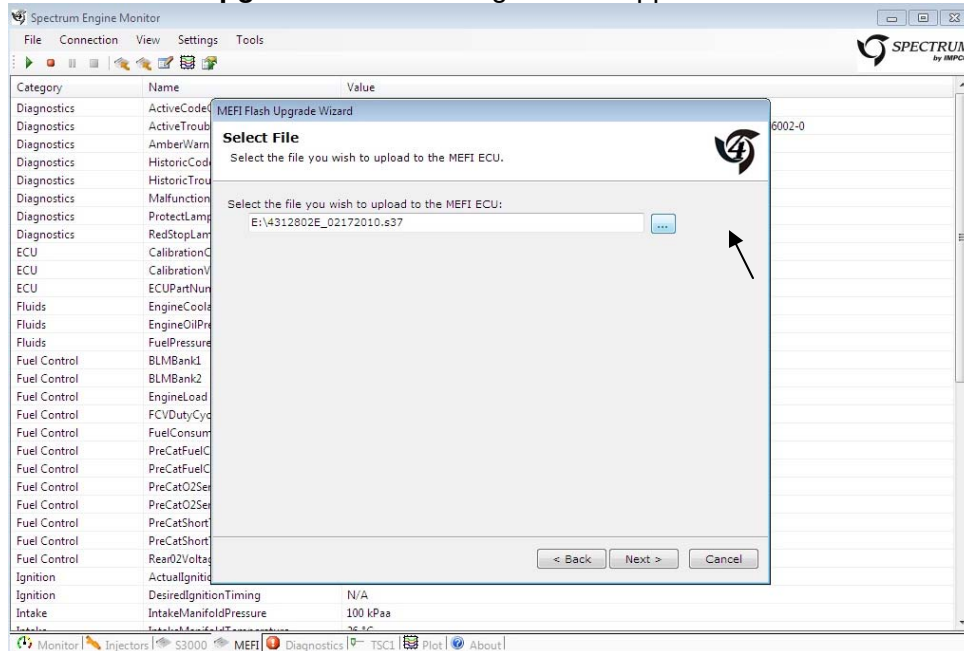
In field updates (or reflashing) are possible with the MEFI ECM using the DST. Always check first to be sure the ECM has been programmed with the latest calibration before attempting any diagnostic or service repair procedure. Calibration files are supplied in the .s37 file format. These files may be 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.



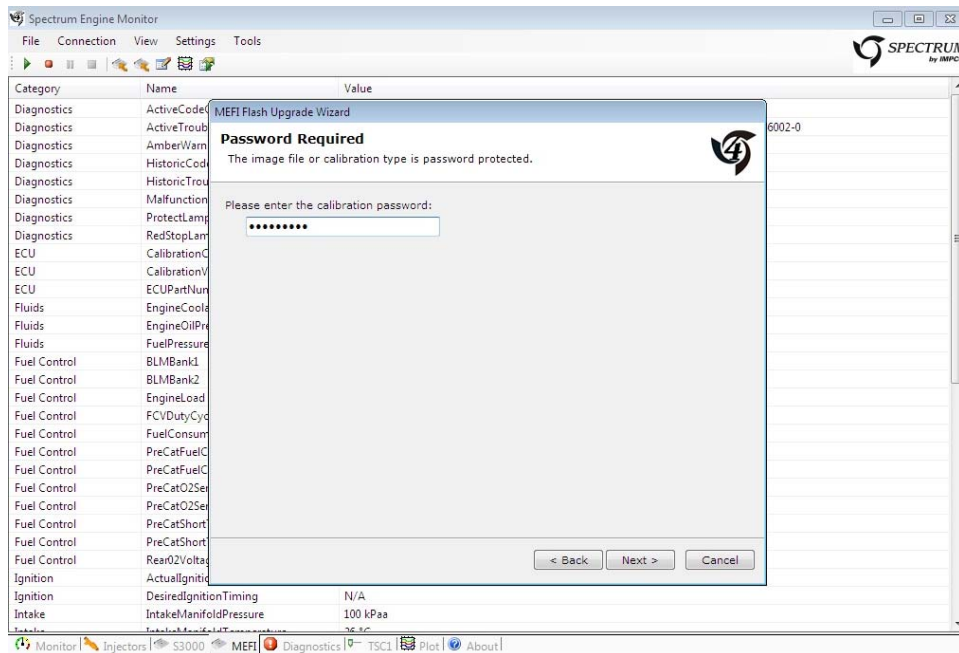
Under the **Tools** drop down menu, select **Reprogram MEFI Engine Control Unit**. Turn ignition power ON.



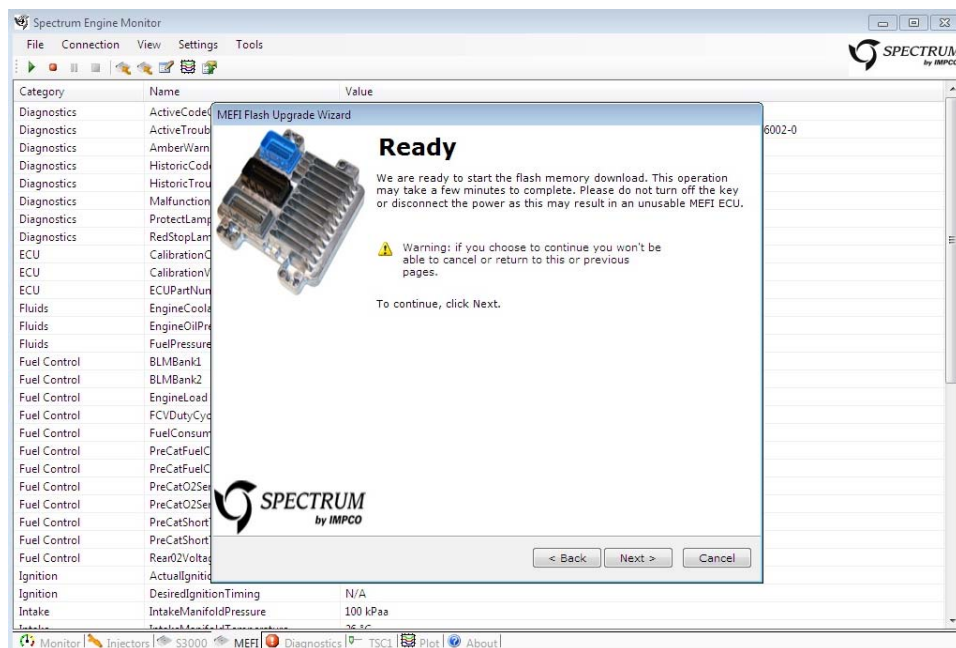
The **MEFI Flash Upgrade Wizard** dialog box will appear. Select the **Next** box.



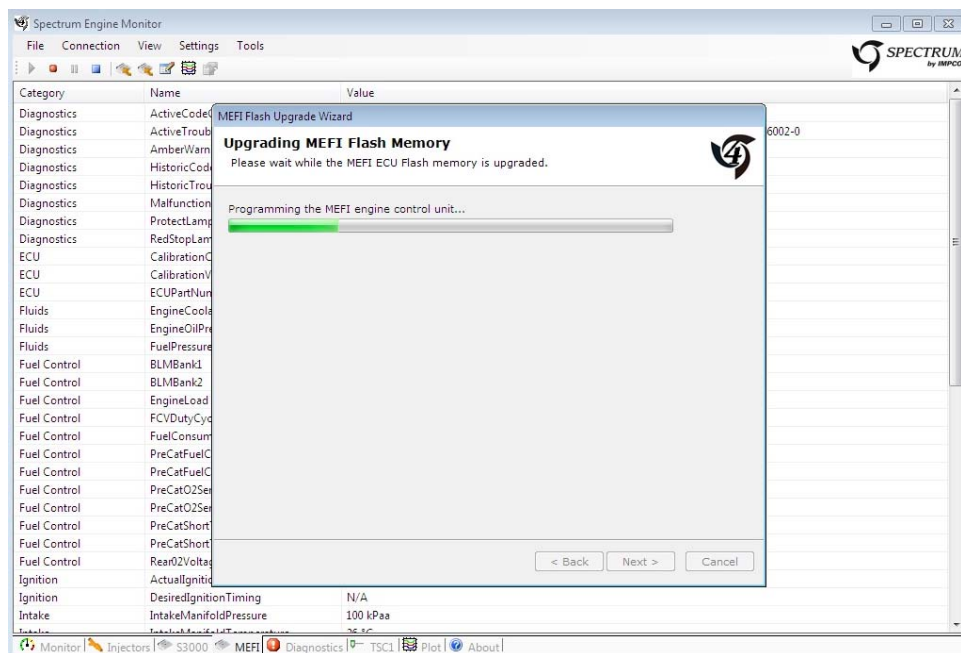
Use the **Browse** box to navigate to the location of the .s37 calibration file.



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



Select the **Next** box.

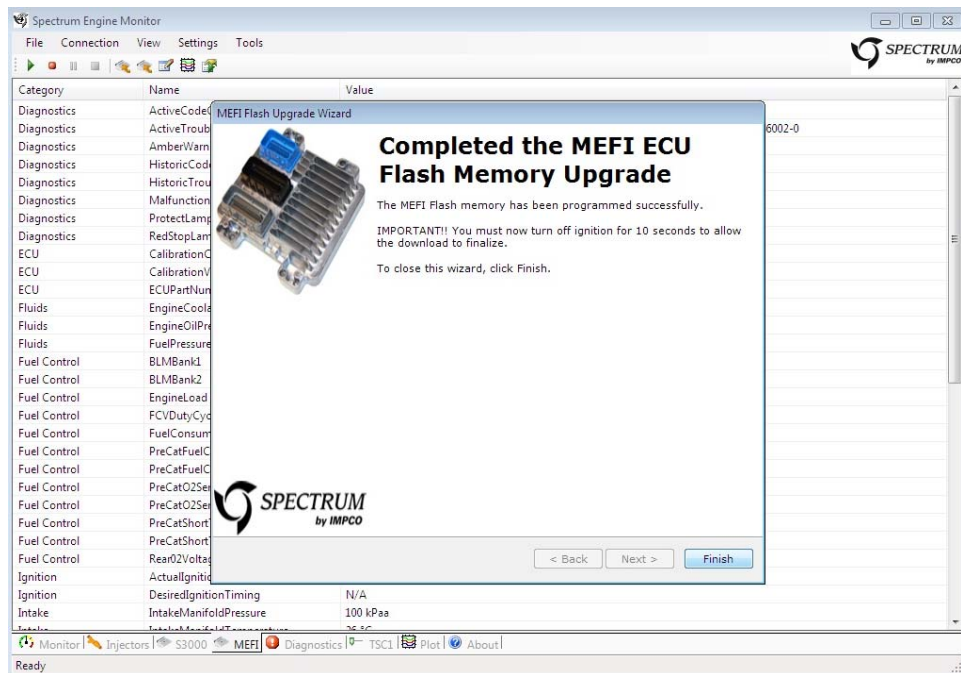


The progress bar shows the status updating. Please wait until you receive a message confirming the update is complete.

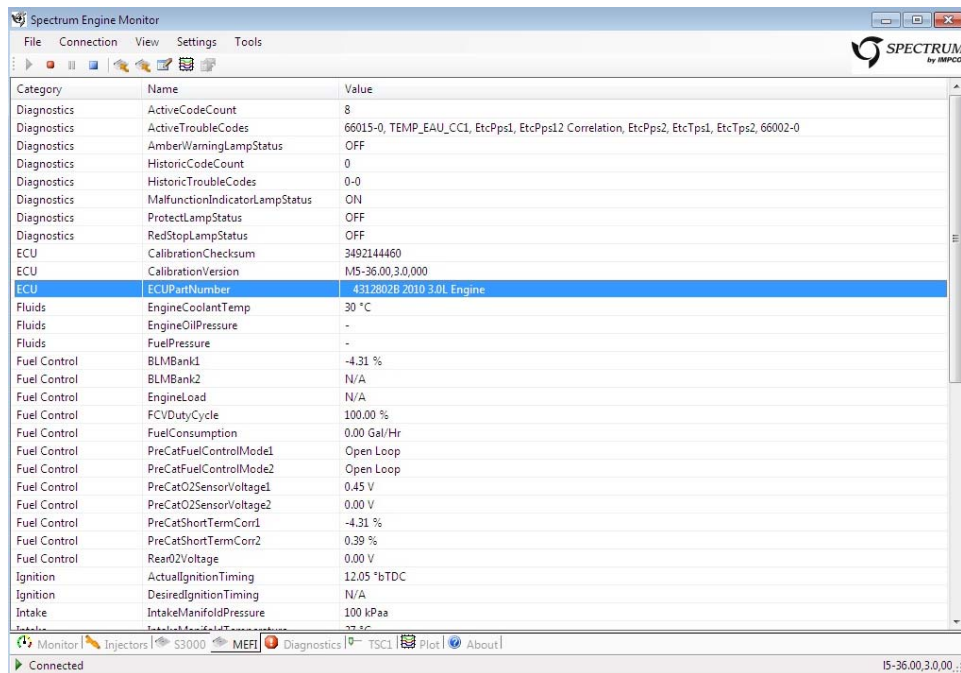


CAUTION

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**.



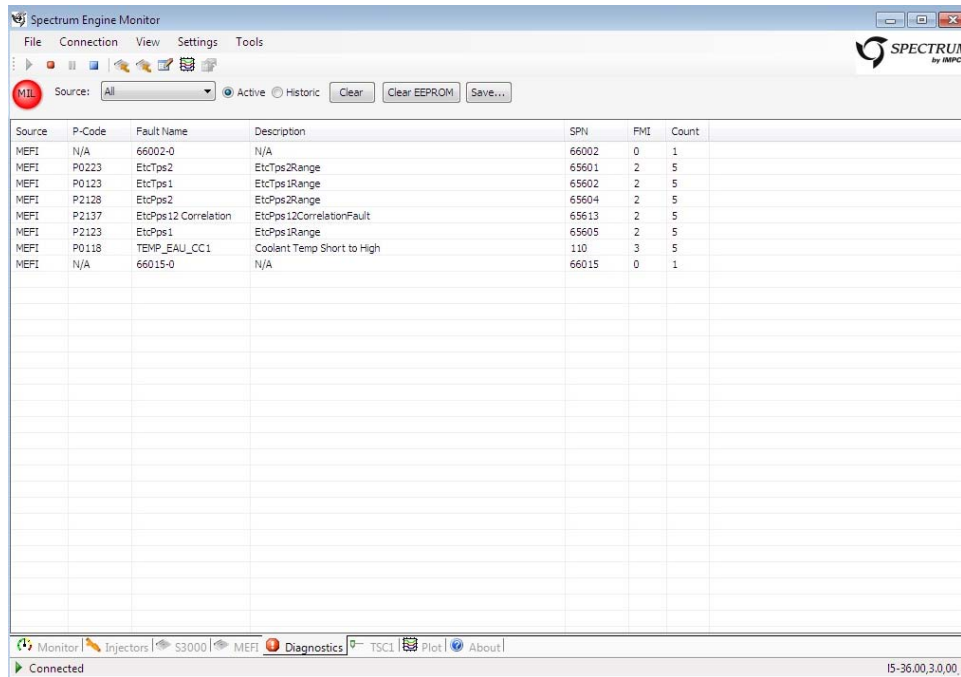
Turn the ignition ON. Verify the calibration updated with the new .s37 file number in the **ECU Part Number** data stream shown above. The reprogramming process is now complete.

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.

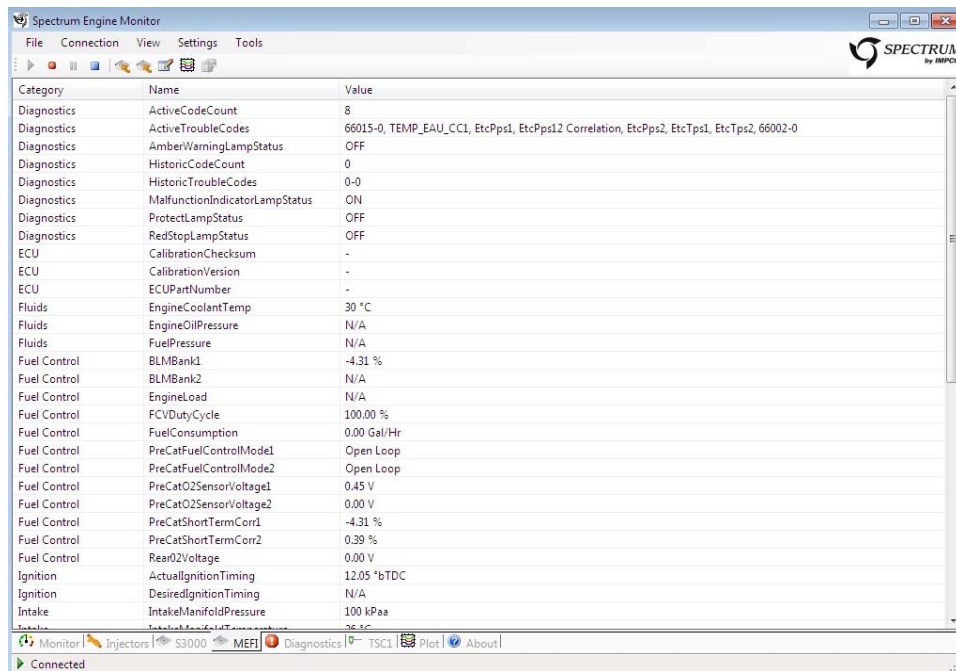
Display DTC (Diagnostic Trouble Codes)



Source	P-Code	Fault Name	Description	SPN	FMI	Count
MEFI	N/A	66002-0	N/A	66002	0	1
MEFI	P0223	EtcTps2	EtcTps2Range	65601	2	5
MEFI	P0123	EtcTps1	EtcTps1Range	65602	2	5
MEFI	P2128	EtcPps2	EtcPps2Range	65604	2	5
MEFI	P2137	EtcPps12 Correlation	EtcPps12CorrelationFault	65613	2	5
MEFI	P2123	EtcPps1	EtcPps1Range	65605	2	5
MEFI	P0118	TEMP_EAU_CC1	Coolant Temp Short to High	110	3	5
MEFI	N/A	66015-0	N/A	66015	0	1

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.

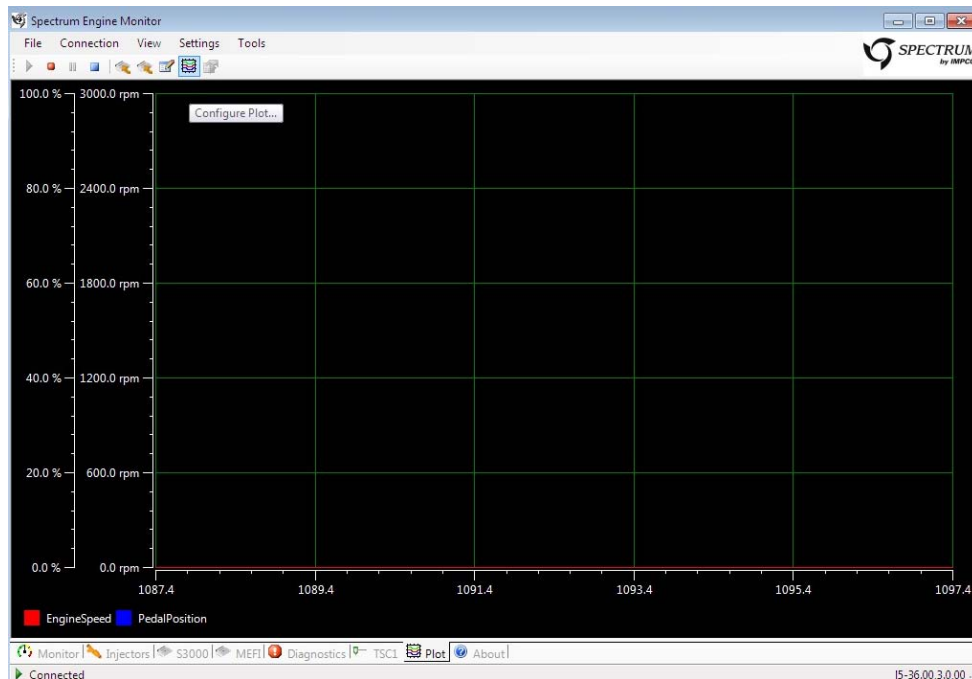
Data Stream:



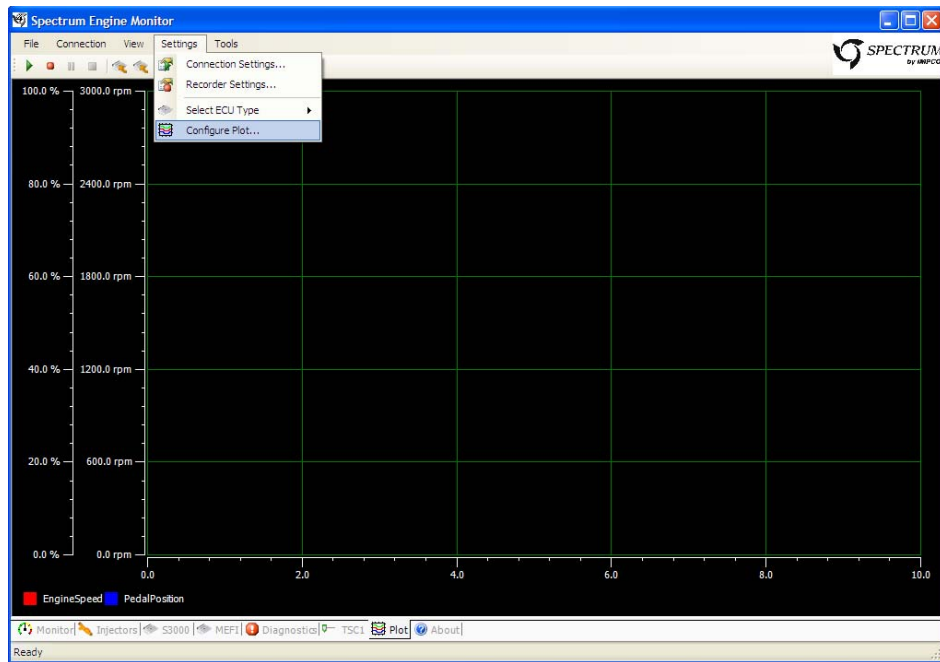
Category	Name	Value
Diagnostics	ActiveCodeCount	8
Diagnostics	ActiveTroubleCodes	66015-0, TEMP_EAU_CCI, EtcPps1, EtcPps12 Correlation, EtcPps2, EtcTps1, EtcTps2, 66002-0
Diagnostics	AmberWarningLampStatus	OFF
Diagnostics	HistoricCodeCount	0
Diagnostics	HistoricTroubleCodes	0-0
Diagnostics	MalfunctionIndicatorLampStatus	ON
Diagnostics	ProtectLampStatus	OFF
Diagnostics	RedStopLampStatus	OFF
ECU	CalibrationChecksum	-
ECU	CalibrationVersion	-
ECU	ECUPartNumber	-
Fluids	EngineCoolantTemp	30 °C
Fluids	EngineOilPressure	N/A
Fluids	FuelPressure	N/A
Fuel Control	BLMBank1	-4.31 %
Fuel Control	BLMBank2	N/A
Fuel Control	EngineLoad	N/A
Fuel Control	FCVDutyCycle	100.00 %
Fuel Control	FuelConsumption	0.00 Gal/Hr
Fuel Control	PreCatFuelControlMode1	Open Loop
Fuel Control	PreCatFuelControlMode2	Open Loop
Fuel Control	PreCatO2SensorVoltage1	0.45 V
Fuel Control	PreCatO2SensorVoltage2	0.00 V
Fuel Control	PreCatShortTermCorr1	-4.31 %
Fuel Control	PreCatShortTermCorr2	0.39 %
Fuel Control	RearO2Voltage	0.00 V
Ignition	ActualIgnitionTiming	12.05 °bTDC
Ignition	DesiredIgnitionTiming	N/A
Intake	IntakeManifoldPressure	100 kPaa
Intake	IntakeManifoldTemperature	35 °C

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.

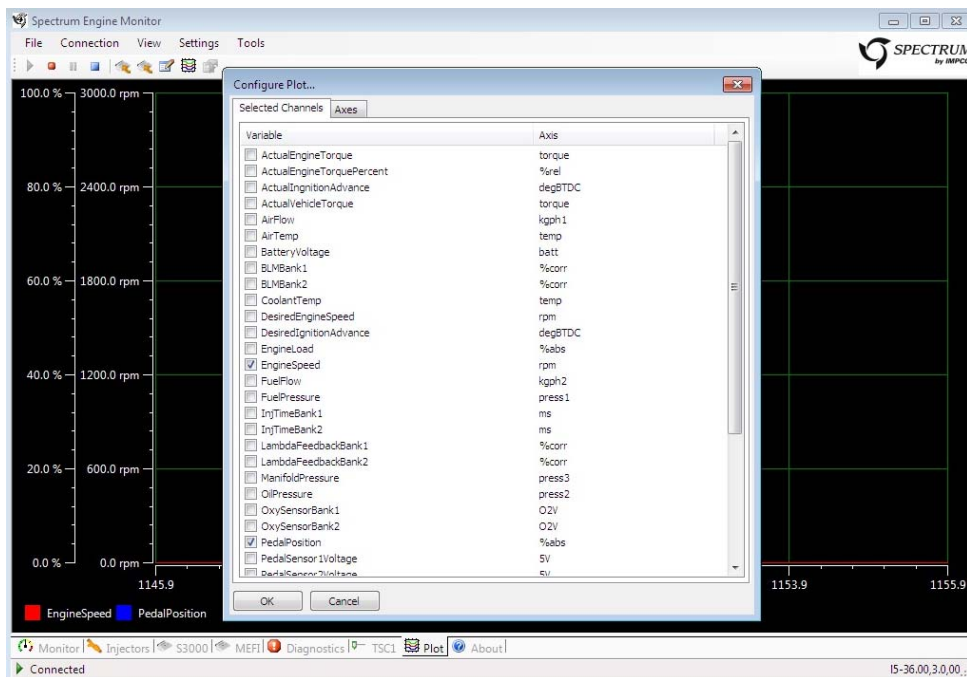
Plot Data:



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.

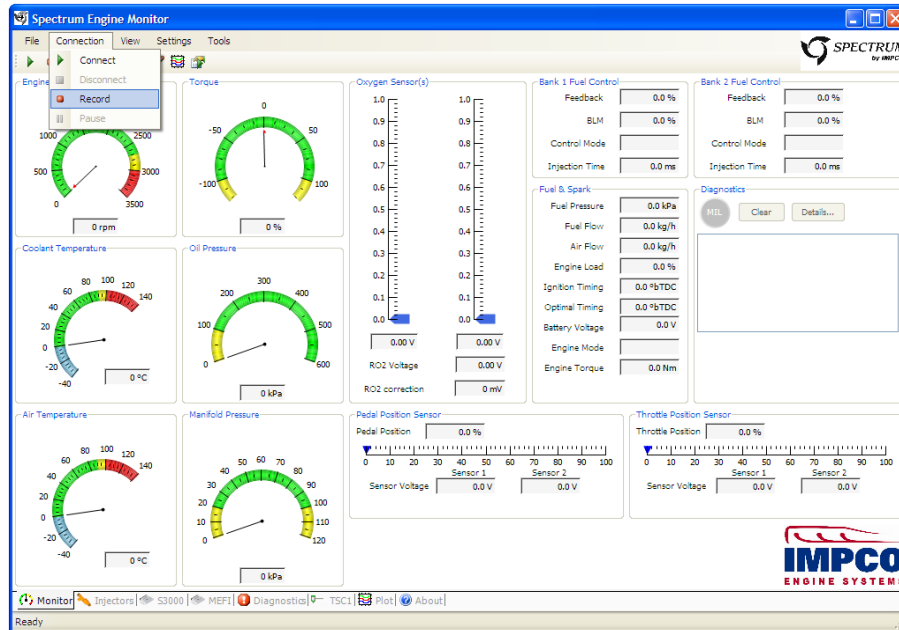


The custom parameters of the plot can be selected by clicking on the plot icon just below the **Settings** menu item at the top left of the page shown above.



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

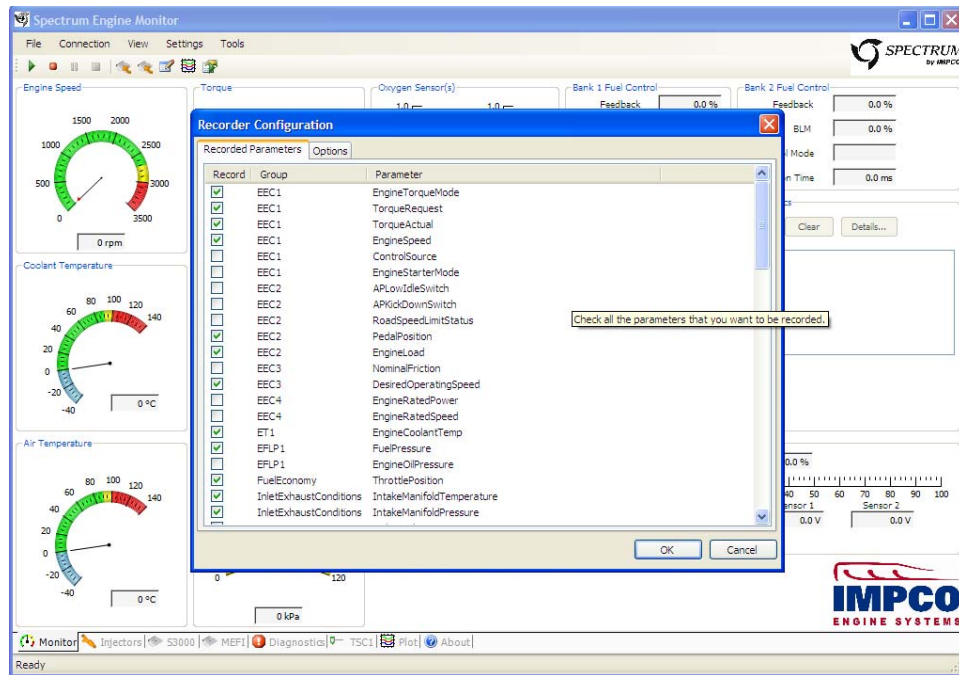
Record Data:



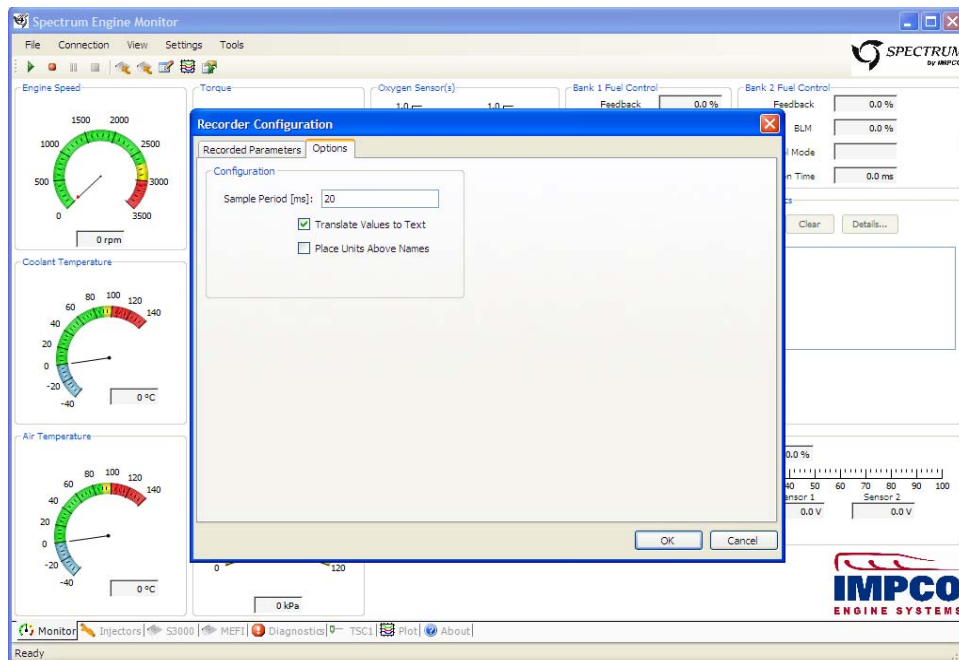
Data stream information may also be recorded and saved to file for future analysis. This function is accessed from the **Connection** menu and is activated by clicking **Record**, click again to stop the recording and the save file. The data is saved as a .csv file at a location specified by the service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

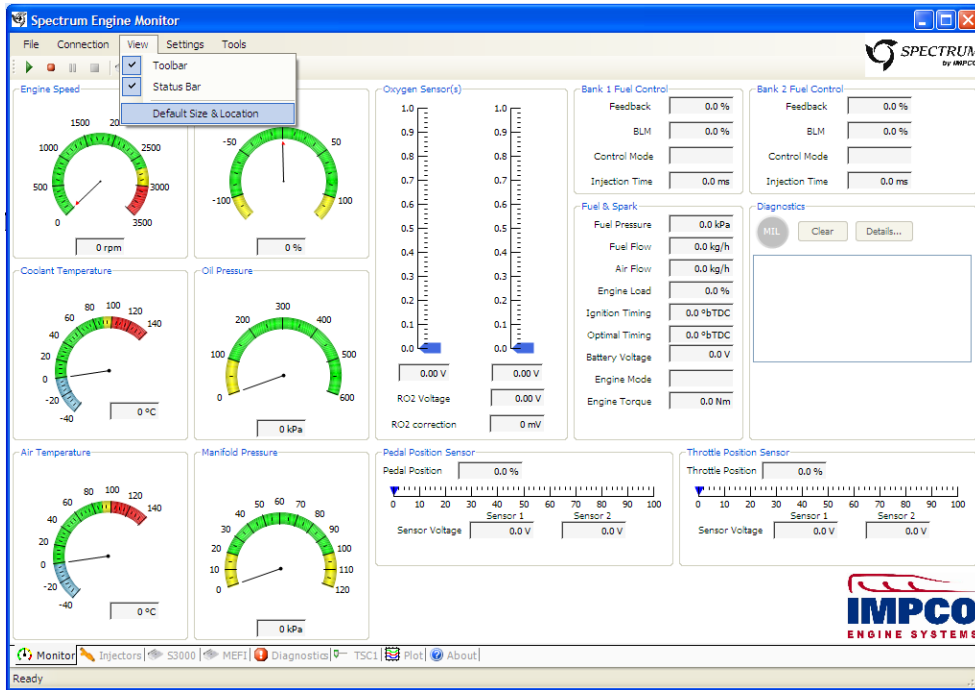


The **Recorder Configuration** windows opens, check/uncheck channels as required.

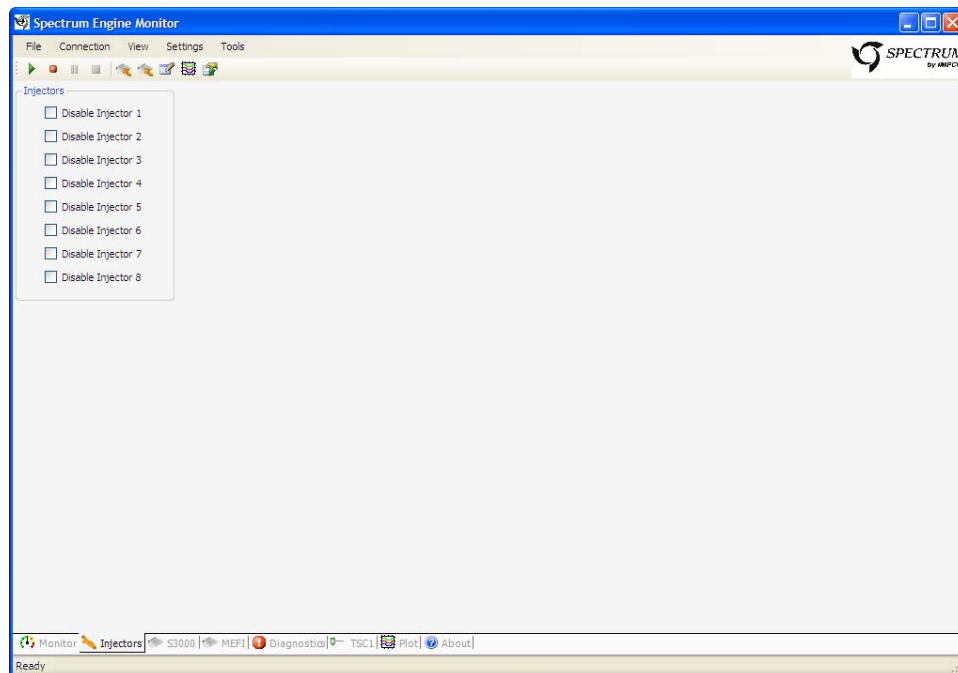


You can change the sample speed from the **Options** tab. To save select **OK**.

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 utmost 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: 480 SCFH @ 6.0" W.C.

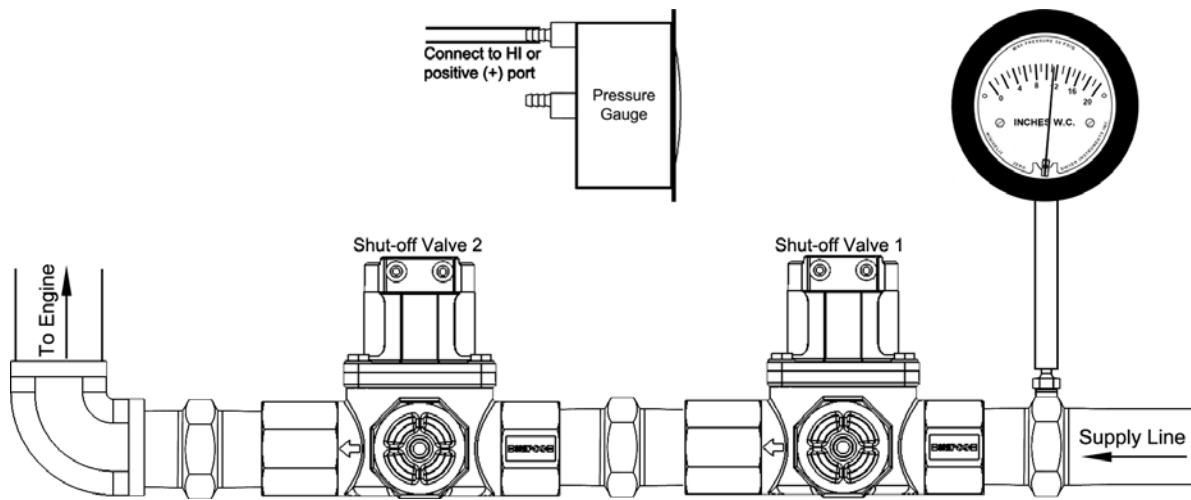
Minimum flow for Propane Vapor: 246 SCFH @ 6.0" W.C.

Maximum Fuel System Regulator Outlet Pressure

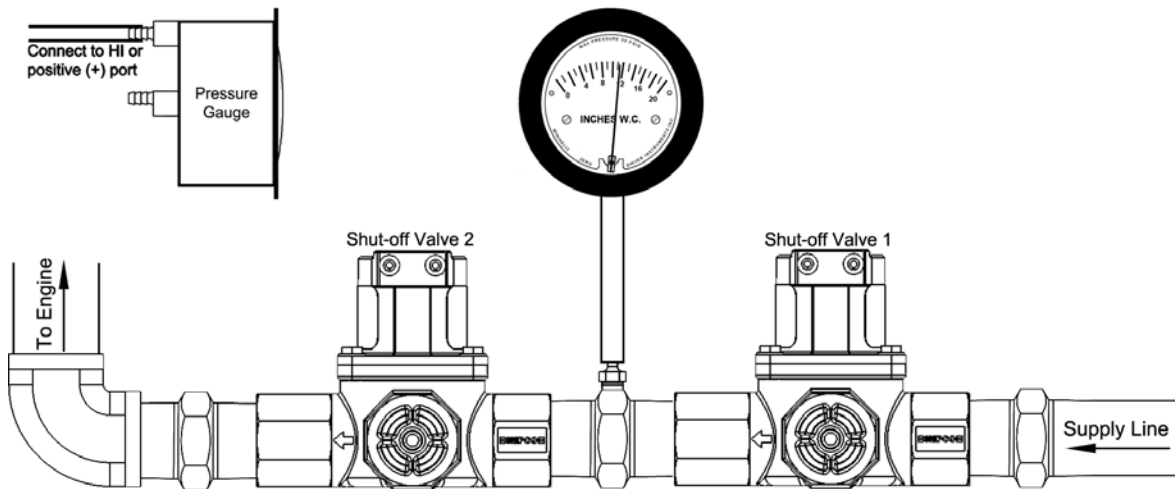
This system uses on a near zero fuel pressure regulator to supply fuel to the intake venturi and throttle assembly.

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 venturi 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.

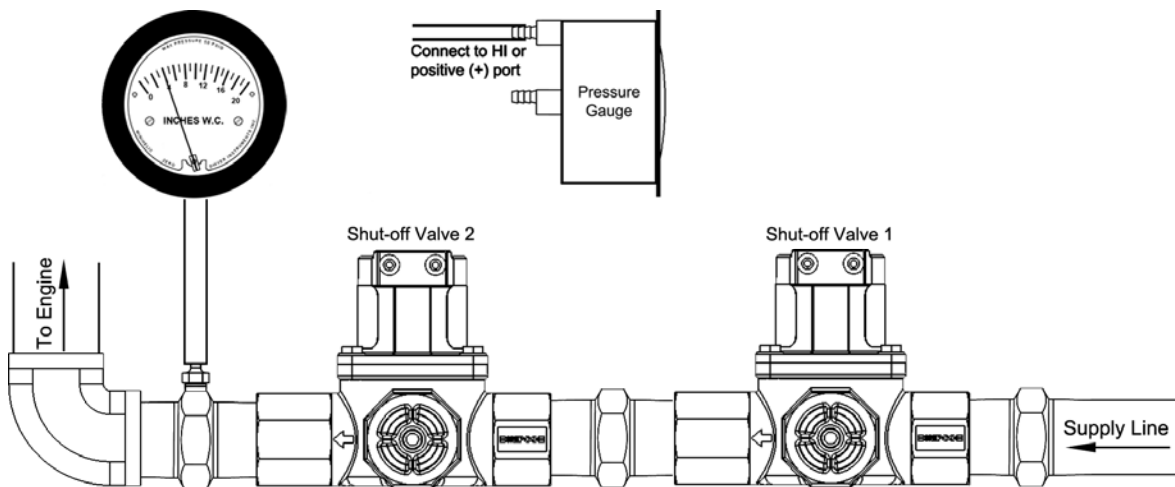
NOTE: Be sure to zero the gauge and/or calibrate it prior to testing, especially after carrying on a plane or using at altitude.



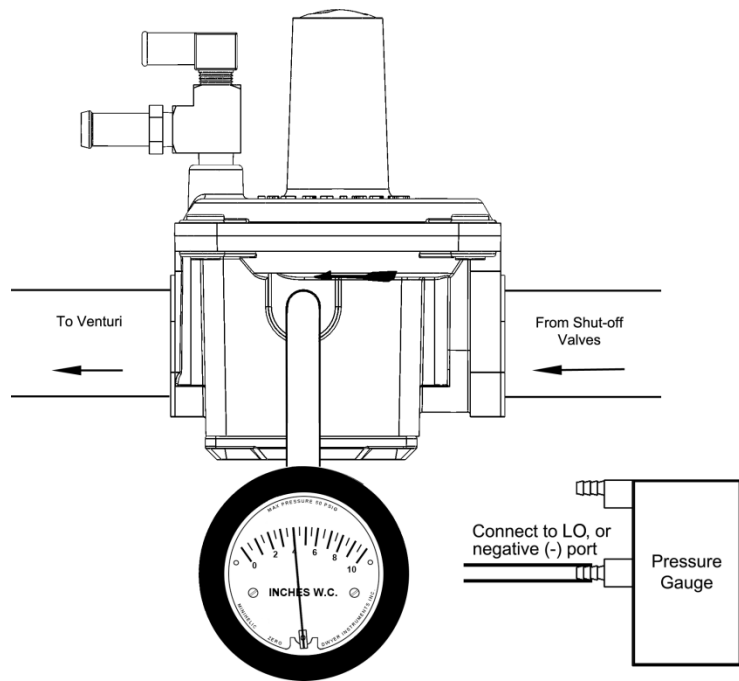
The above illustration shows the 0-20" W.C. gauge installed to measure the supply line fuel pressure.



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.



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 recommended 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, Venturi 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

Checks	Action
DEFINITION: The problem may or may not turn ON the (MIL) or store a Diagnostic Trouble Code (DTC).	
Preliminary Checks	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.
Faulty Electrical Connections or Wiring	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 <i>Wiring Schematics</i>. • Checking for poor terminal to wire connections requires removing the terminal from the connector body.
Operational Test	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.
Intermittent MIL Illumination	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.
Loss of DTC Memory	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.

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 <i>Engine Controls Schematics</i>. • Check battery power, ignition power and ground circuits to the ECM. Refer to <i>Engine Control Schematics</i>. 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, Venturi and throttle body. • Check the fuel system pressures. • Refer to the <i>Fuel System Diagnosis</i>.
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. • Venturi 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

Checks	Action
DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.	
Preliminary Checks	Make sure the engine's operator is using the correct starting procedure.
Sensor Checks	- 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.
Fuel System Checks	Important: A partially closed fuel supply valve will create an extended crank OR no start condition. Check Venturi 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 Venturi, Throttle Body and Air Filter Assembly. Check the fuel system pressures. Refer to the <i>Fuel System Diagnosis</i>.
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 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.

Checks	Action
Engine Mechanical Checks	Check for the following: • Engine vacuum leaks • Manifold vacuum leaks. • Venturi 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 <i>Fuel System Diagnosis</i>. • 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 <i>Fuel System Diagnosis</i>. • 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, Venturi 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

Checks	Action
DEFINITION: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.	
Preliminary Check	None.
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 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.
Engine Mechanical Check	Check the engine for the following: • Improper valve timing. • Engine compression. • Manifold vacuum leaks. • Intake manifold gaskets. • Sticking or leaking valves. • Exhaust system leakage.
Fuel System Checks	Perform a fuel system diagnosis. Refer to <i>Fuel System Diagnosis</i> .

LACK OF POWER, SLUGGISHNESS, OR SPONGINESS

Checks	Action
DEFINITION: The engine delivers less than expected power. There is little or no increase in speed when throttling the engine.	
Preliminary Checks	• Refer to the <i>Fuel system OBD System Check</i>. • Compare the customer's engine with a similar unit to verify customer has an actual problem. <i>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.</i> • Remove the air filter and check for dirt or restriction.
Fuel System Checks	• Check for contaminated fuel, or improper fuel pressure. Refer to <i>Fuel System Diagnosis</i>. • Check for the proper ignition output voltage with the spark tester J 26792 or the equivalent. • Check the Regulator, Venturi 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.
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the TMAP sensor.
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.
Engine Mechanical Check	Check the engine for the following: • Engine compression. • Valve timing. • Improper or worn camshaft. • Refer to <i>Engine Mechanical</i> in the Service Manual.
Additional Check	• 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.

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 <i>Fuel System Diagnosis</i>. • 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

Checks	Action
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.	
Preliminary Check	None.
Sensor Checks	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.
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. • Verify proper operation of the Regulator. • Perform a cylinder compression test. Refer to <i>Engine Mechanical</i> in the Service Manual. • Check the Regulator fuel pressure. Refer to the <i>Fuel System Diagnosis</i>. • Check the Regulator, Venturi and Throttle body for proper installation and leakage.
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. • 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.
Additional Checks	• 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.

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 <i>Fuel System Diagnosis</i>. • 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.

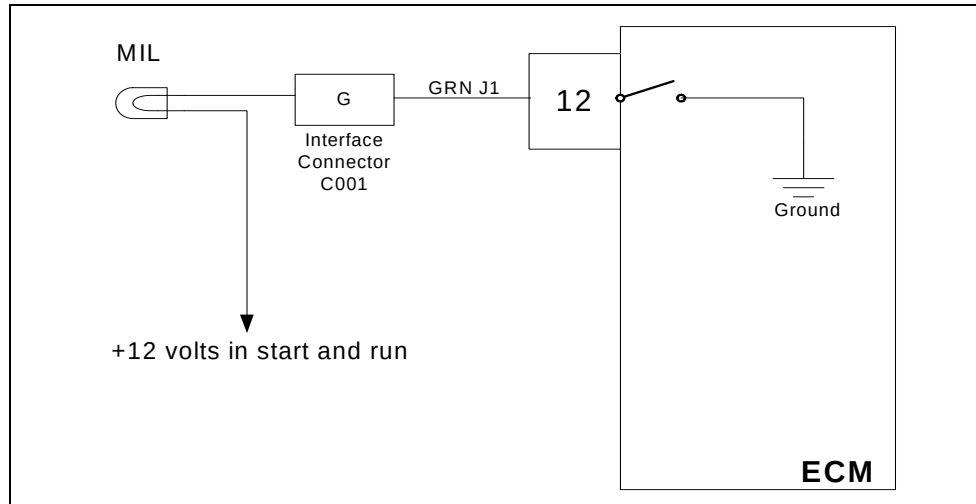
Proper operation of the crankcase ventilation system depends on a sealed engine. If irregular oil flow or dilution is noted and the crankcase ventilation system is functioning properly, check the engine for another possible cause. Correct any of these problems first.

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)

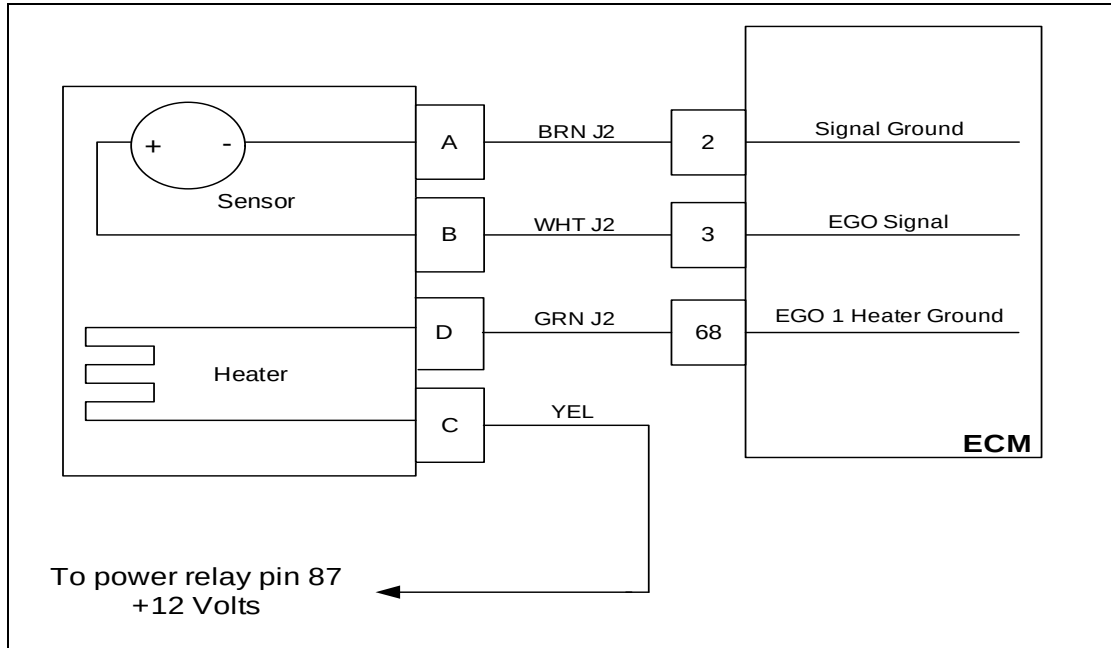
OBD System Check/MIL (Malfunction Indicator Lamp)



Circuit Description

The fuel system is equipped with OBD (On-Board Diagnostics). The system has a MIL (Malfunction Indicator Lamp). The MIL serves as notification of an emissions or system 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 Ignition 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 Ignition 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.

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

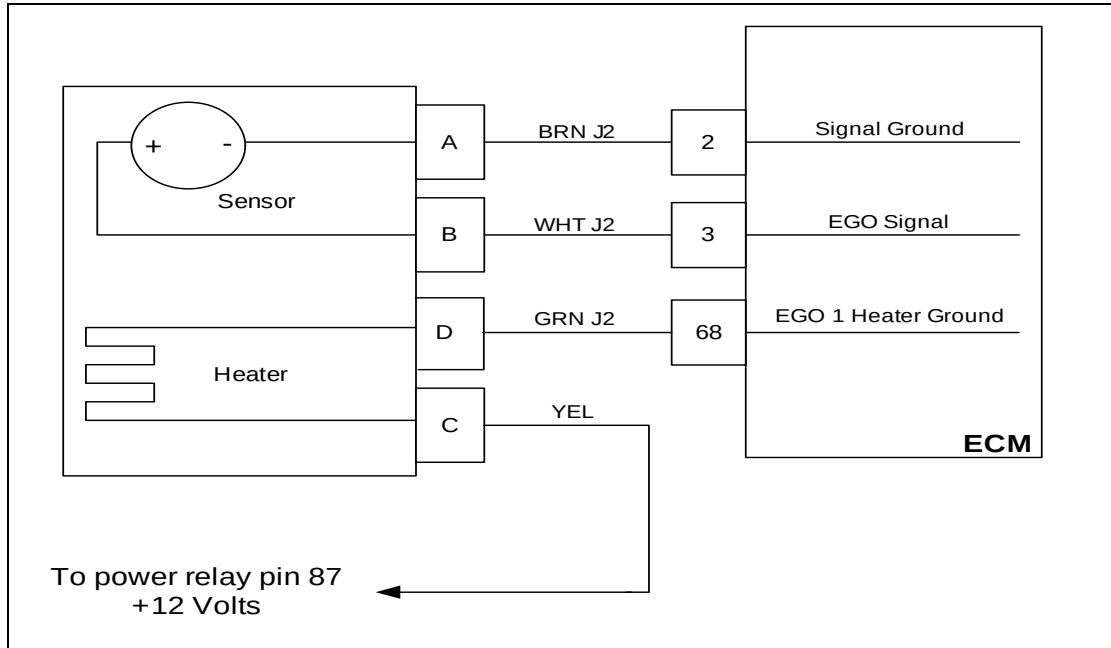
SPN 66019
FMI 5

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 C and D 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 C 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 D 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 68 and HEGO connector pin D 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 D 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 C and D (the two white wires). 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 14.30 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. 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

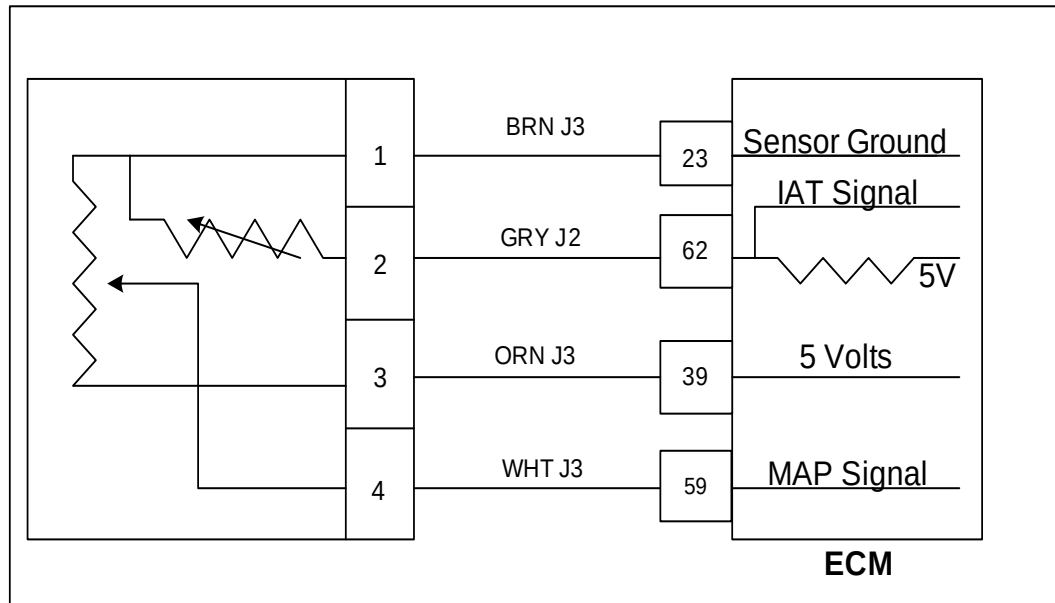
SPN 66019
FMI 3

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 C and D 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 C 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 D 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 68 and HEGO connector pin D 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 D 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 C and D (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 P0106 MAP Sensor Skewed High



Conditions for Setting the DTC

- MAP Sensor
- Check Condition-Engine running
- Fault Condition-MAP above 97 Kpa with rpm greater than 1350 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

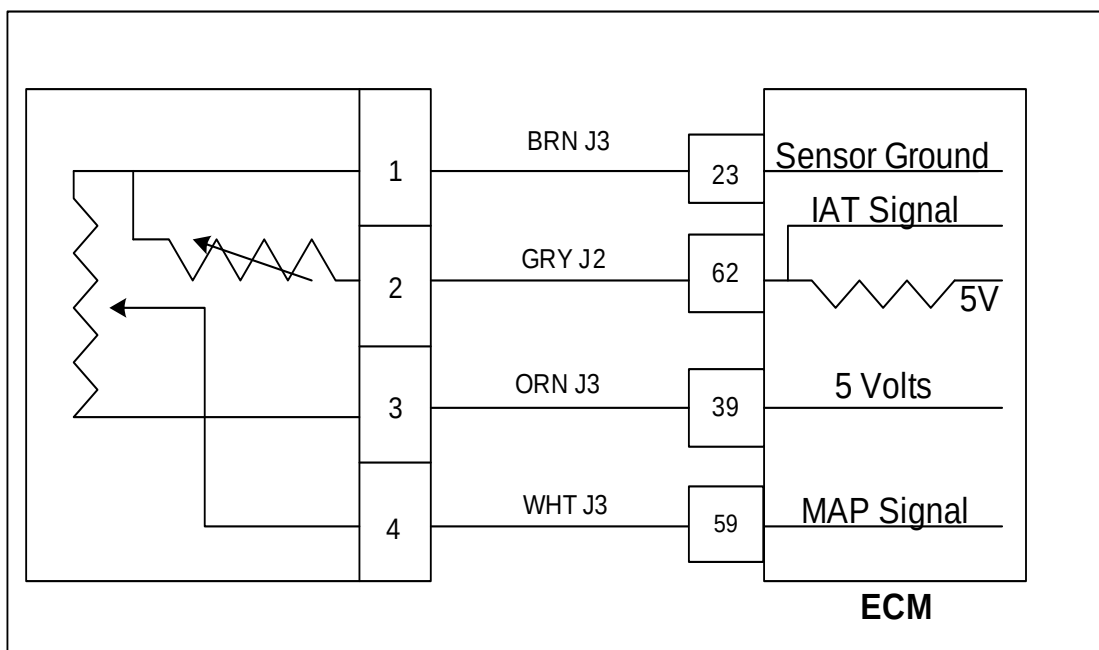
MAP sensors are known to drift or “skew” with age. Small vacuum leaks may also cause this code to set. Check the intake manifold and MAP sensor vacuum seal for leakage before using this diagnostic chart.

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 Intermittent 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 23 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 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 greater than 4.84 volts

Diagnostic Aid

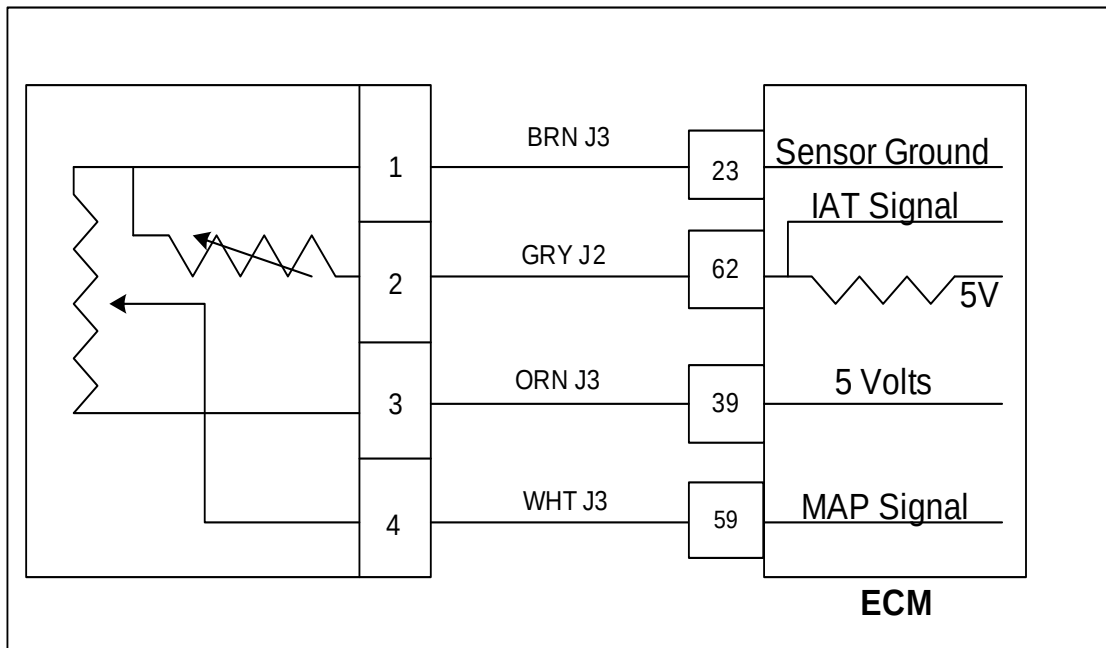
SPN 106
FMI 4

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 23 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 ECM pin 39 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 ECM pin 59 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)

Step	Action	Value(s)	Yes	No
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)
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

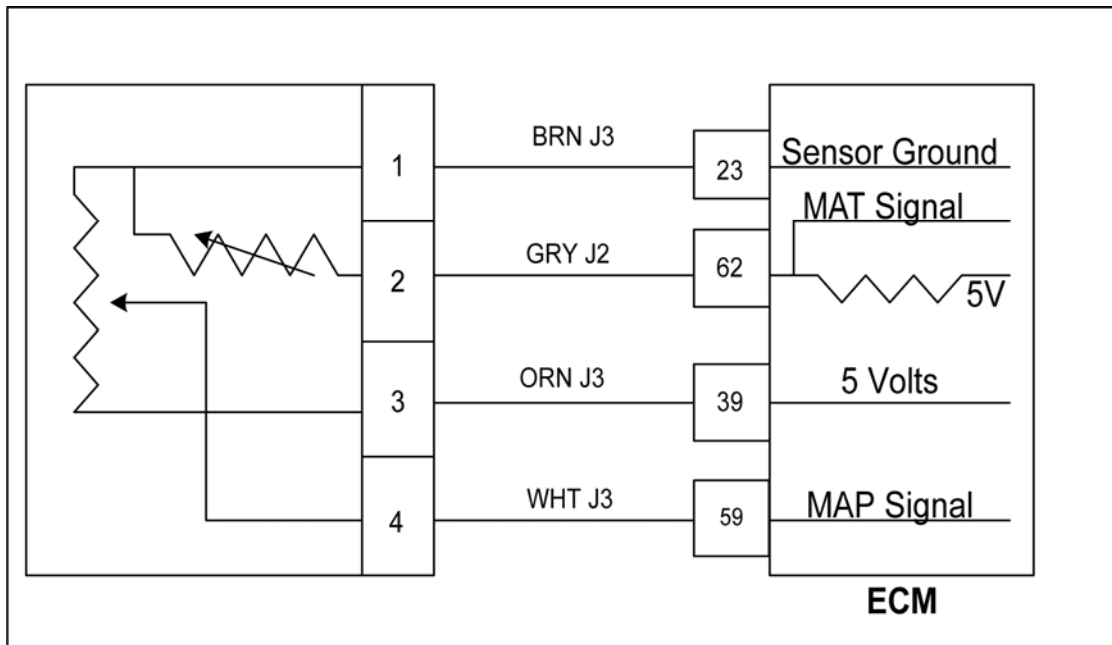
SPN 106
FMI 3

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 ECM connector C0J3 - Disconnect TMAP connector C020 - Using a DVOM check for continuity between TMAP connector pin1 and ECM connector pin 23 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)

Step	Action	Value(s)	Yes	No
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)	-
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 P0112 MAT Sensor Low



Conditions for Setting the DTC

- Manifold Air Temperature
- Check Condition-Ignition ON
- Fault Condition-MAT Sensor Voltage less than 100mv
- 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

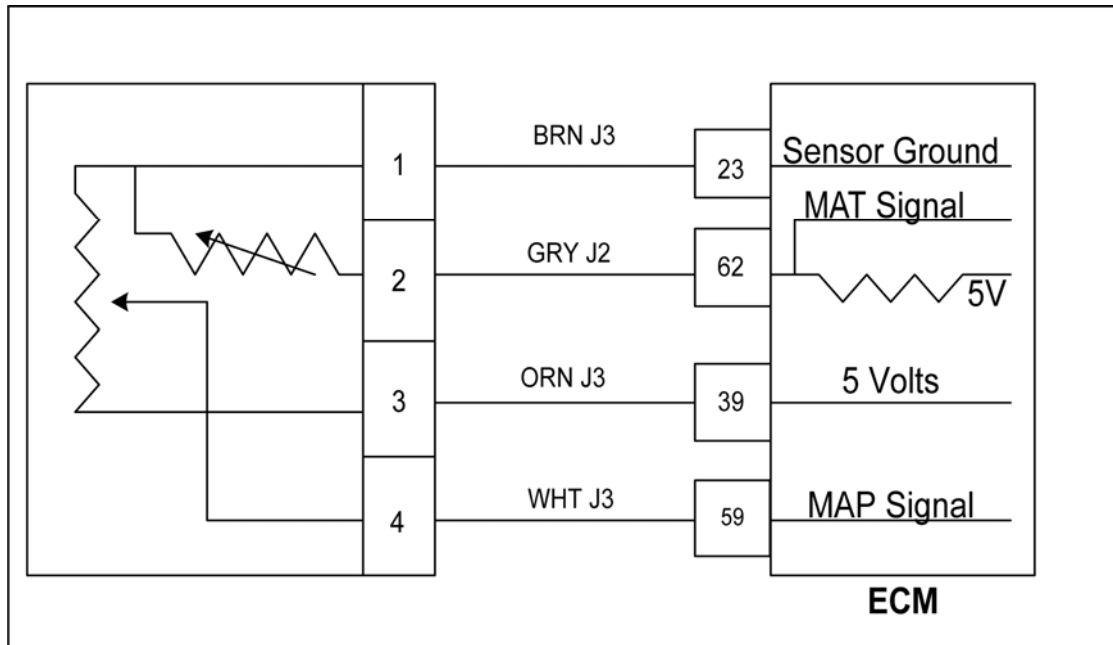
Detects a continuous short low in the circuit or sensor device.

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 ECM connector C0J2 - Using a DVOM check for continuity between TMAP sensor connector pin 1 and ECM connector pin 23 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 ECM pin 62. 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 ECM pins 23 and 62 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 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

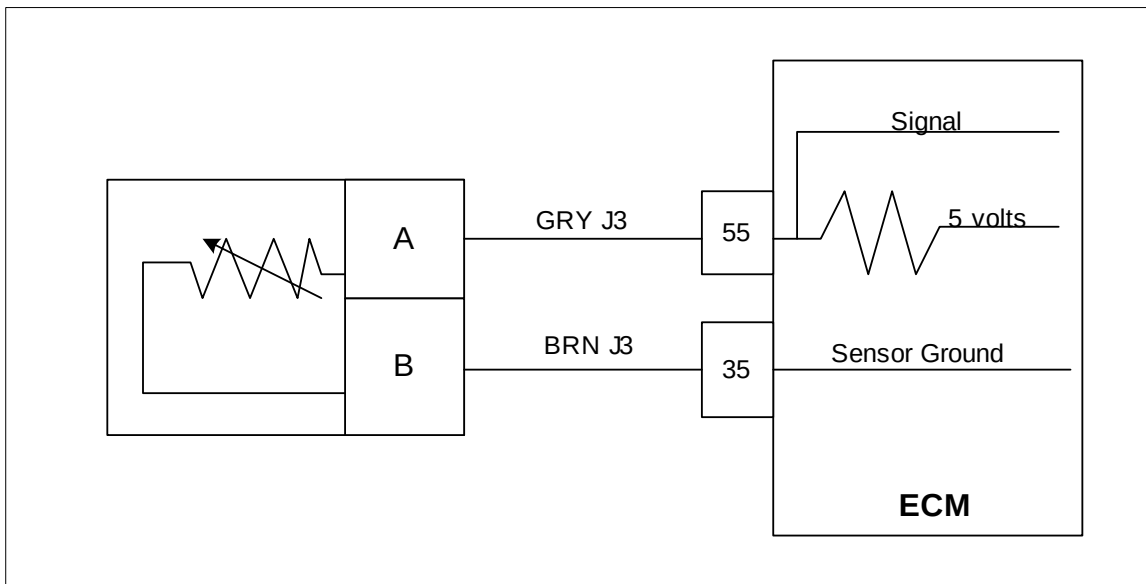
Detects a continuous short high in the circuit or sensor device.

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 ECM connector C0J2 - Using a DVOM check for continuity between TMAP sensor connector pin 1 and ECM connector pin 23 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 ECM pin 62. 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 ECM pins 23 and 62 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 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

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

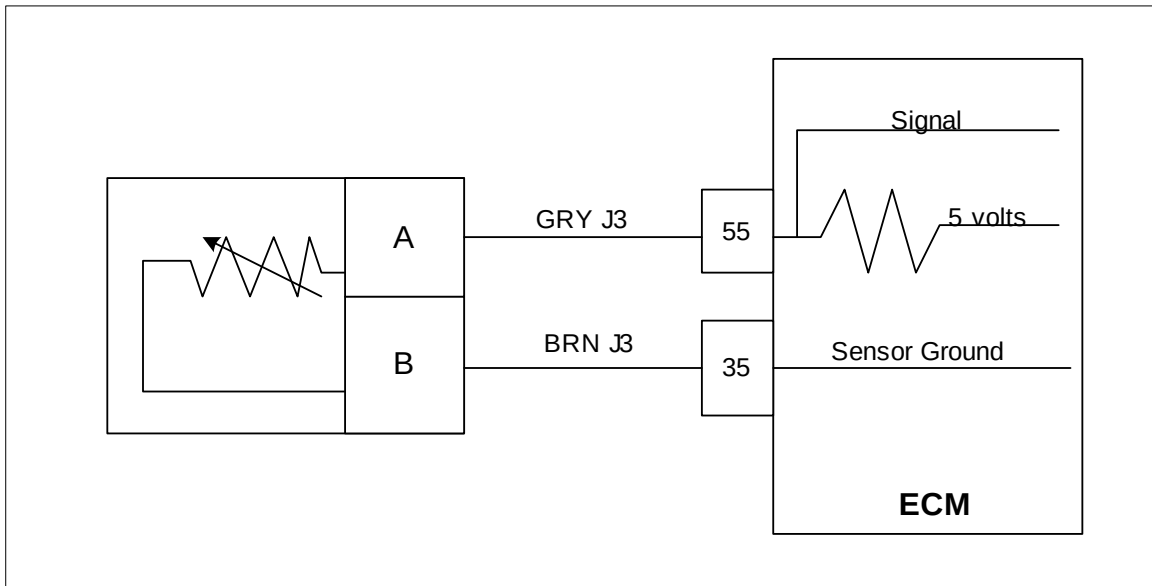
Temp (deg F)	Ohms
242.4	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-5.7	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

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 ECM connector J3 - Using a DVOM check for continuity between ECT connector pin B and ECM connector pin 35 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 ECM connector pin 55. 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

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

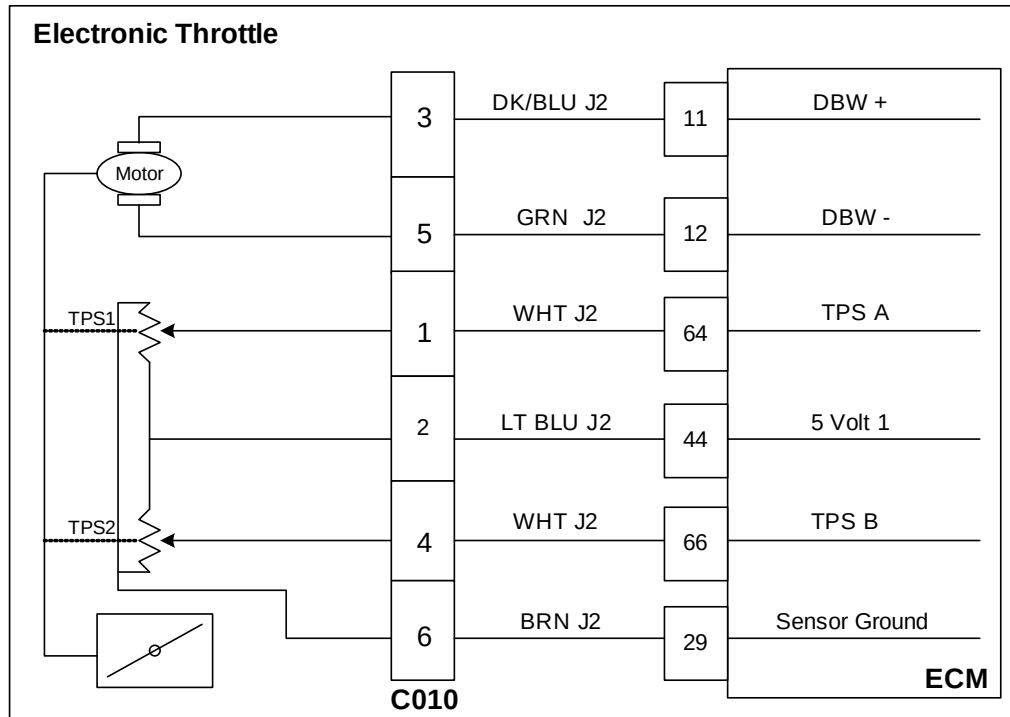
Temp (deg F)	Ohms
242.4	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-5.7	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

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 ECM connector J3 - Using a DVOM check for continuity between ECT connector pin B and ECM connector pin 35 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 ECM connector pin 55. 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 2 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

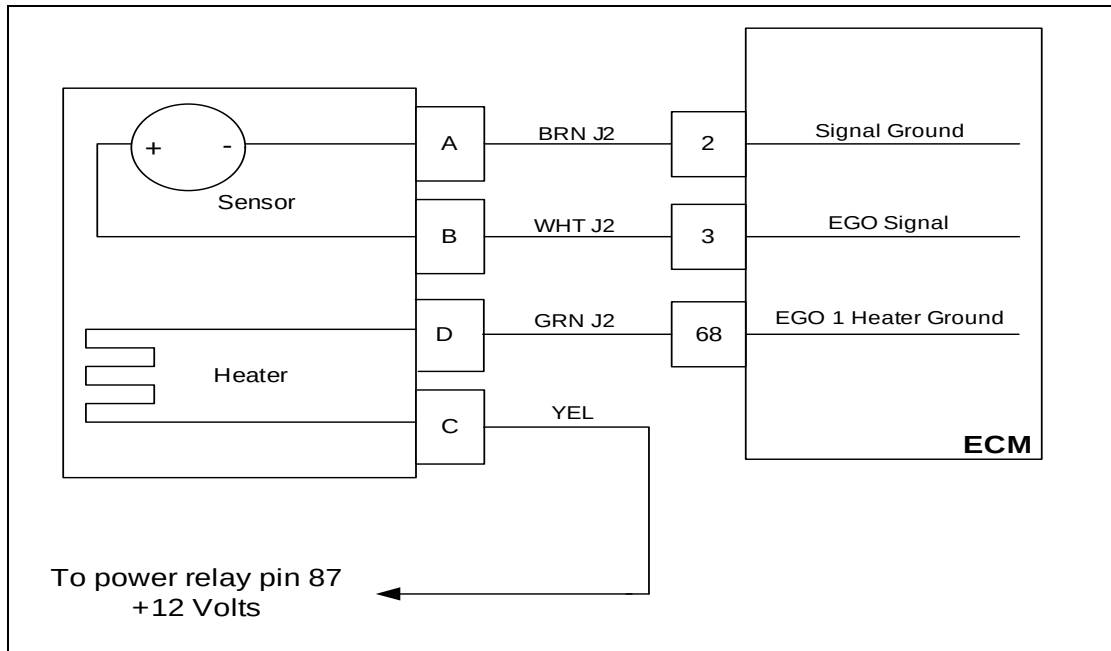
DTC P0122 ETC TPS 1 Range

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 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 ECM connector pin 29 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 4 and ECM connector pin 66 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 4 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 2 and ECM connector pin 44 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 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 ECM connector pin 64 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 5 and ECM connector pin 12 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 3 and ECM connector pin 11 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 3 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)

Step	Action	Value(s)	Yes	No
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)
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 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 signal open. ECT above 50 degrees 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

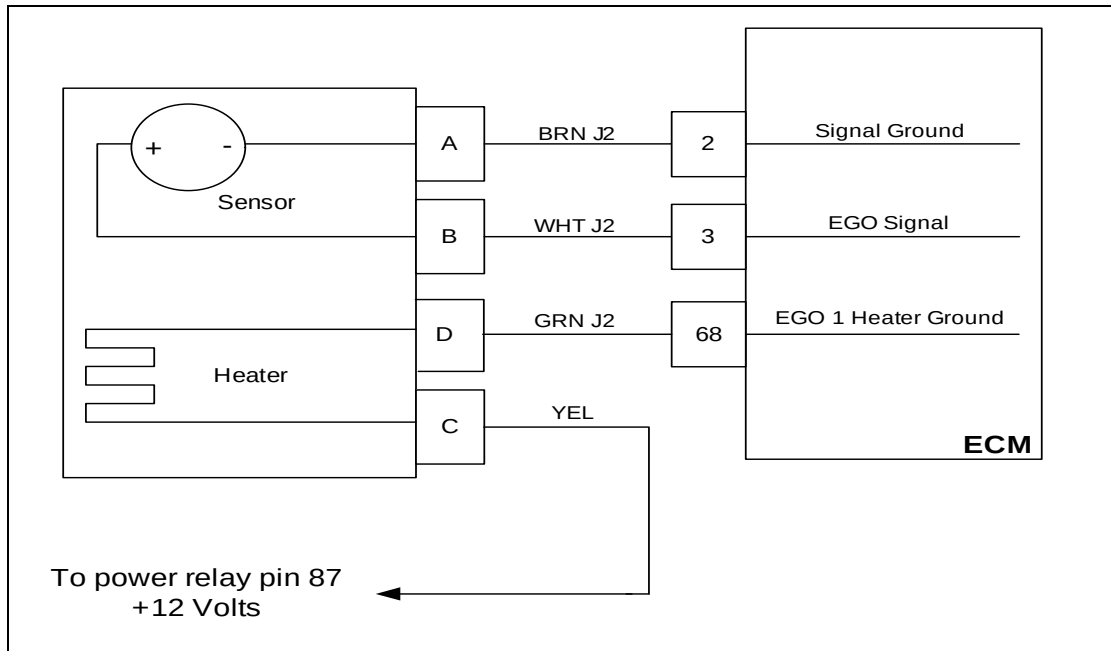
FMI 5

EGO voltage fixed between 0.35 and 0.450 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 A and B 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 B and ECM connector pin 3. 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 200mv with ECT greater than 50 degrees C.
- 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 200mv during closed loop operation.

Diagnostic Aid

SPN 65561

FMI 4

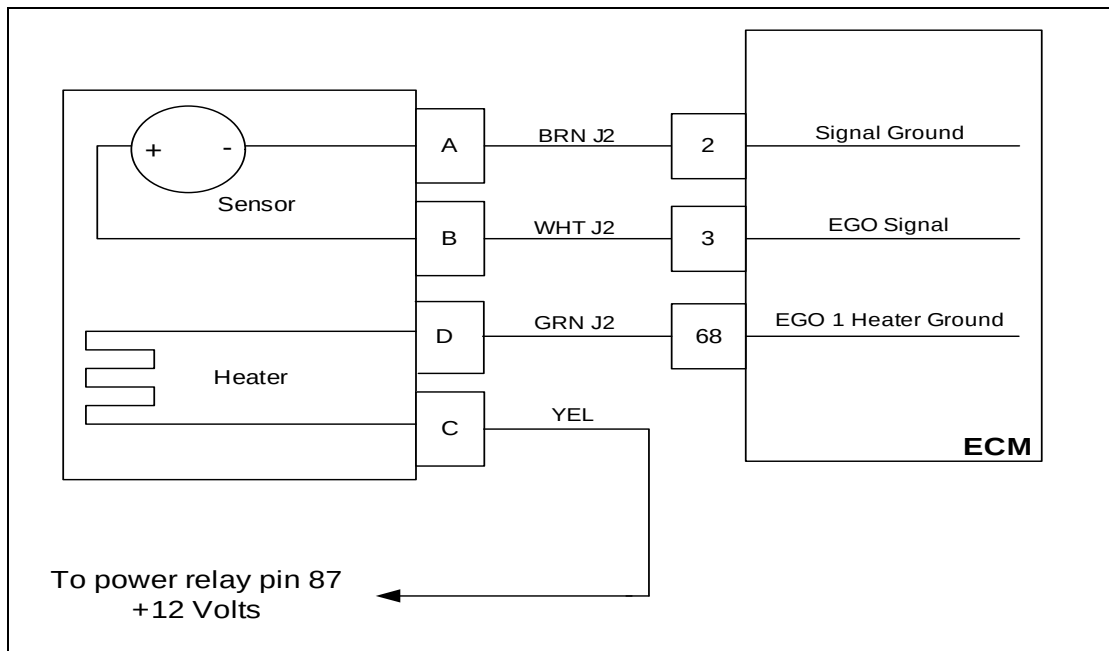
DTC P0131 Oxygen Sensor Voltage Low

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 C and D. 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 C 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 D 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)

Step	Action	Value(s)	Yes	No
7	- Ignition OFF - Disconnect ECM connector C0J2 - Using a DVOM check for continuity between ECM pin 2 and HEGO connector pin A. Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor ground circuit as necessary. Refer to wiring harness repair.
8	Using a DVOM check for continuity between ECM pin 3 and HEGO connector pin B. 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 ECM pin 68 and HEGO connector pin D. 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 B 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 ECM pins 2,3,68 and HEGO pins A, B, C, and D 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)	-

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 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 960mv for 5 seconds or longer with ECT greater than 50 degrees 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

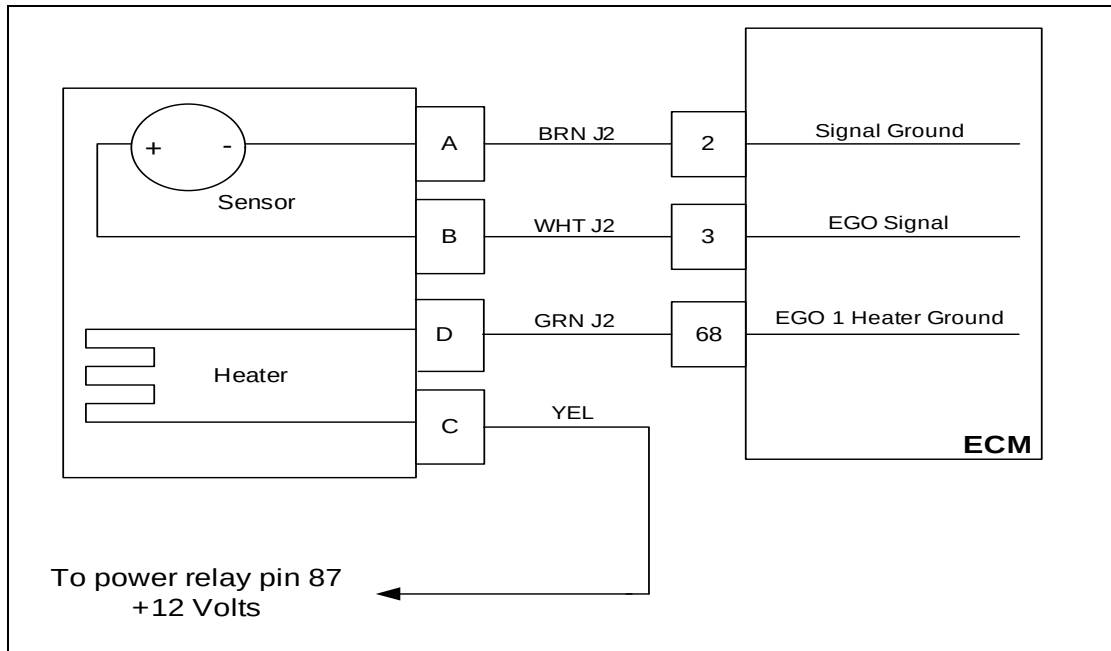
FMI 3

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 B 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 70ms.
- Average rich to lean time 80ms. ECT greater than 50 degrees C. with MAP greater than 30 kPa but less than 80 kPa RPM greater than 700 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.

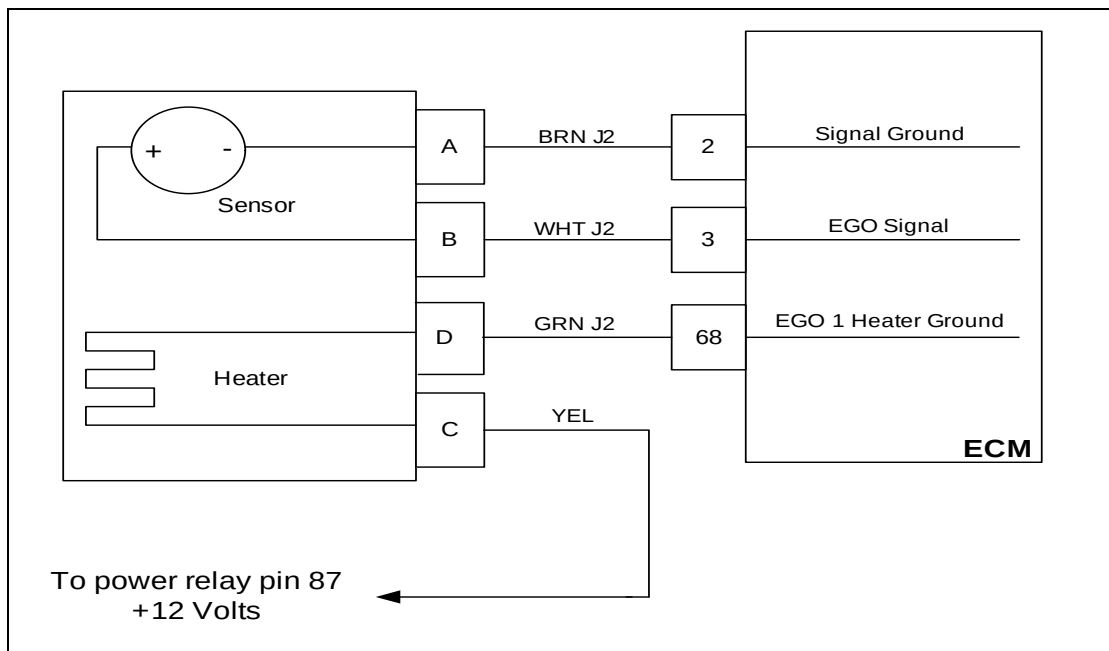
DTC P0133 Oxygen Sensor Response Slow

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 venturi 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 C and D. 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 C 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 D 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)

Step	Action	Value(s)	Yes	No
7	- Ignition OFF - Disconnect ECM connector C0J2 - Using a DVOM check for continuity between ECM pin 2 and HEGO connector pin A. Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor ground circuit as necessary. Refer to wiring harness repair.
8	Using a DVOM check for continuity between ECM pin 3 and HEGO connector pin B. 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 ECM pin 68 and HEGO connector pin D. 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 B 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 ECM pins 2,3,68 and HEGO pins A,B, C, and D 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)	-

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 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 50 degrees C. MAP greater than 30 kPa but less than 80 kPa. RPM greater than 700 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 venturi adapter may also cause the sensor to switch slow.

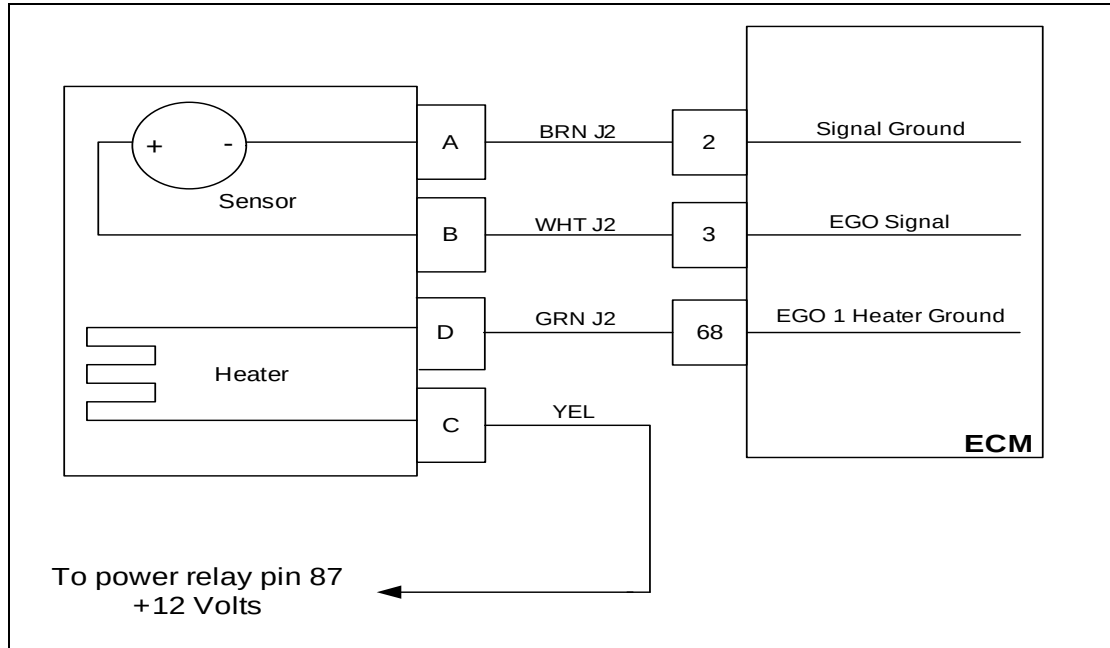
DTC P0134 Oxygen Sensor Insufficient Switching

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 venturi 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 C and D. 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 C 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 D 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)

Step	Action	Value(s)	Yes	No
7	- Ignition OFF - Disconnect ECM connector C0J2 - Using a DVOM check for continuity between ECM pin 2 and HEGO connector pin A. Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor ground circuit as necessary. Refer to wiring harness repair.
8	Using a DVOM check for continuity between ECM pin 3 and HEGO connector pin B. 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 ECM pin 68 and HEGO connector pin D. 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 B 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 ECM pins 2,3,68 and HEGO pins A, B, C, and D 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)	-

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 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 89.5% for more than 120 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

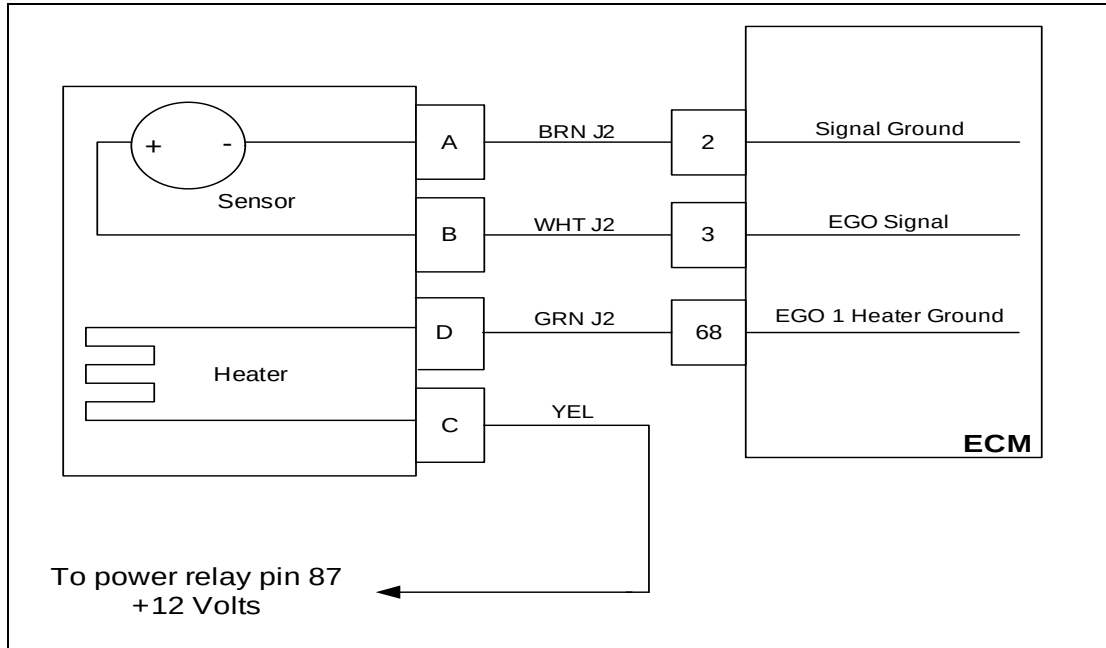
SPN 66019
FMI 8

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 C and D (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 D and ECM pin 68 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 C 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 P1161 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 25%
- 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 -25% fuel correction.

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 misrouted 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 venturi 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.

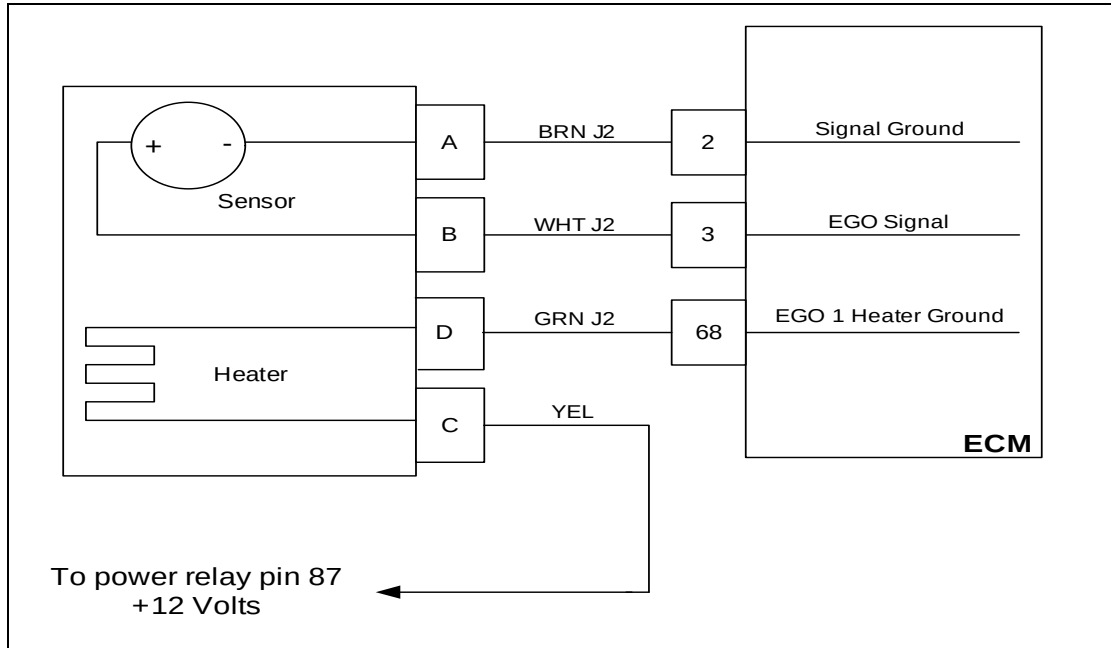
DTC P0171 Fuel Trim High

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 C and D 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 C 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 D 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)

Step	Action	Value(s)	Yes	No
7	- Ignition OFF - Disconnect ECM connector C0J2 - Using a DVOM check for continuity between ECM pin 2 and HEGO connector pin A Does the DVOM show continuity?		Go to Step (8)	Repair the open sensor ground circuit as necessary. Refer to wiring harness repair.
8	Using a DVOM check for continuity between ECM pin 3 and HEGO connector pin B 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 ECM pin 68 and HEGO connector pin D 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 B 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 ECM pins 2,3,68 and HEGO pins A, B, C, D 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)	-

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 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) Greater than -25%
- 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 -25% fuel corrections.

Diagnostic Aid

SPN 65565

FMI 1

Fuel System High secondary fuel pressure will cause the system to run rich. A faulty fuel venturi or pressure regulator may also cause the system to run rich.

FCV A faulty fuel control valve can cause the system to run rich.

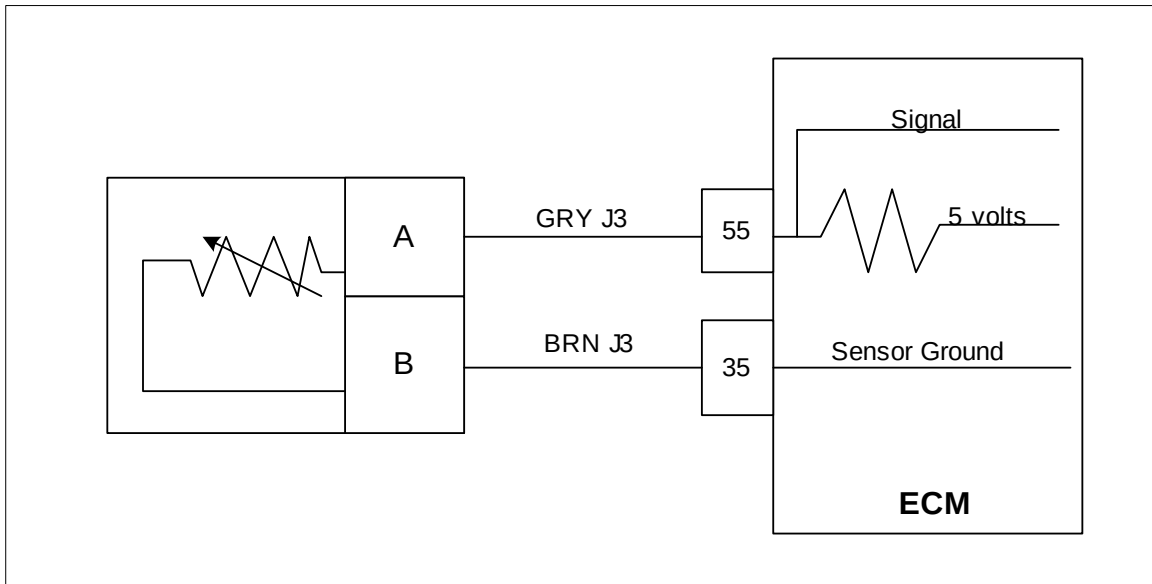
Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the fuel system to run rich.

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 greater than 1.10 volts at 104 degrees C.
- MIL-On during active fault
- Engine shut down

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 104 degrees C.

Diagnostic Aid

SPN 110

FMI 15

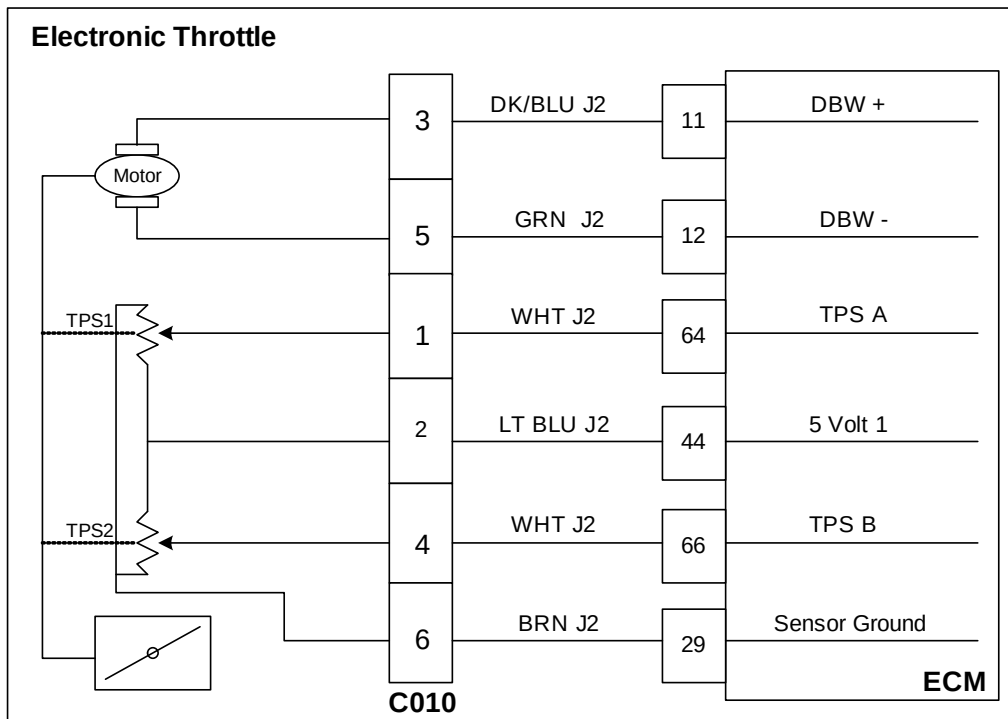
Use the temperature vs. Ohms chart above to determine the sensor accuracy. Resistance readings should be $\pm 5\%$.

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
-5.7	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

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 104 degrees 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 104 degrees C. or greater Does the temperature gauge indicate 104 degrees 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



Conditions for Setting the DTC

- Electronic Throttle Control
- Check Condition-Ignition ON
- Fault Condition-TPS 2 voltage below 0.25 TPS 2 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 65601
FMI 2

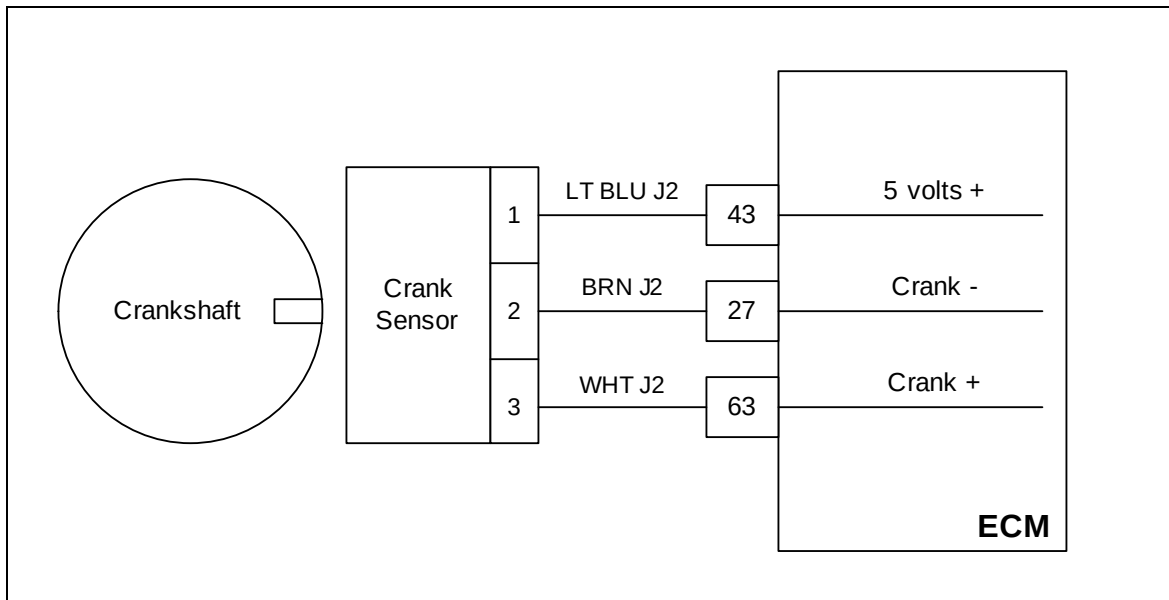
DTC P0222 ETC TPS 2 Range

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 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 ECM connector pin 29 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 4 and ECM connector pin 66. 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 4 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 2 and ECM connector pin 44 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 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 ECM connector pin 64 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 5 and ECM connector pin 12 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 3 and ECM connector pin 11 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 3 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)

Step	Action	Value(s)	Yes	No
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)
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

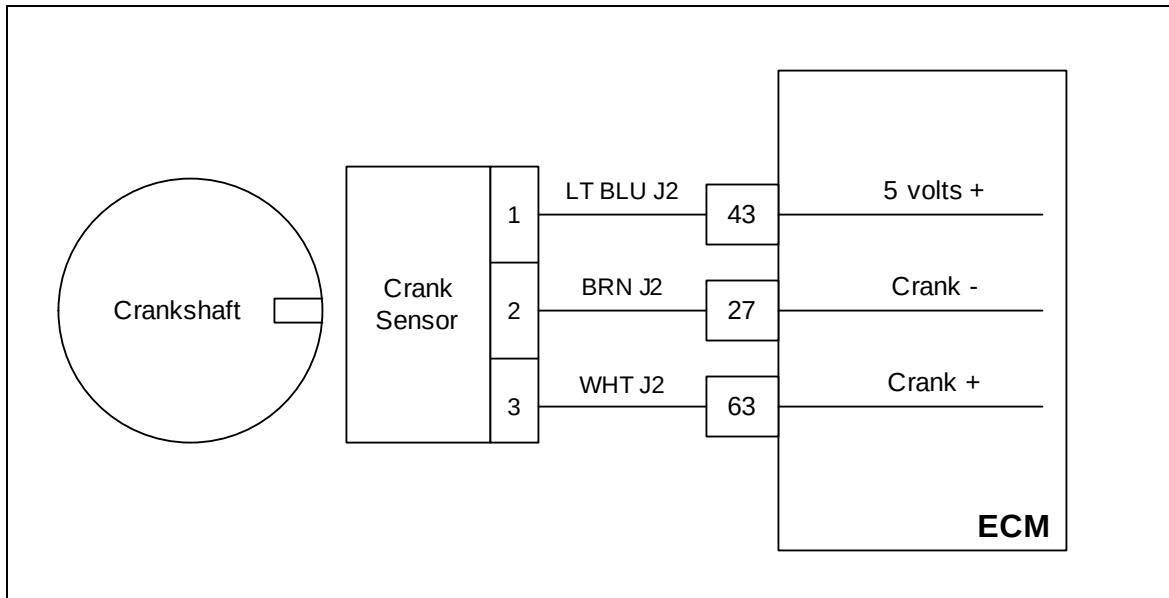
SPN 636
FMI 2

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 1 and ECM pin 43 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 2 and ECM pin 27 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 3 and ECM pin 63 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 2 and 3 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 2 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 3 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 driveability - 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

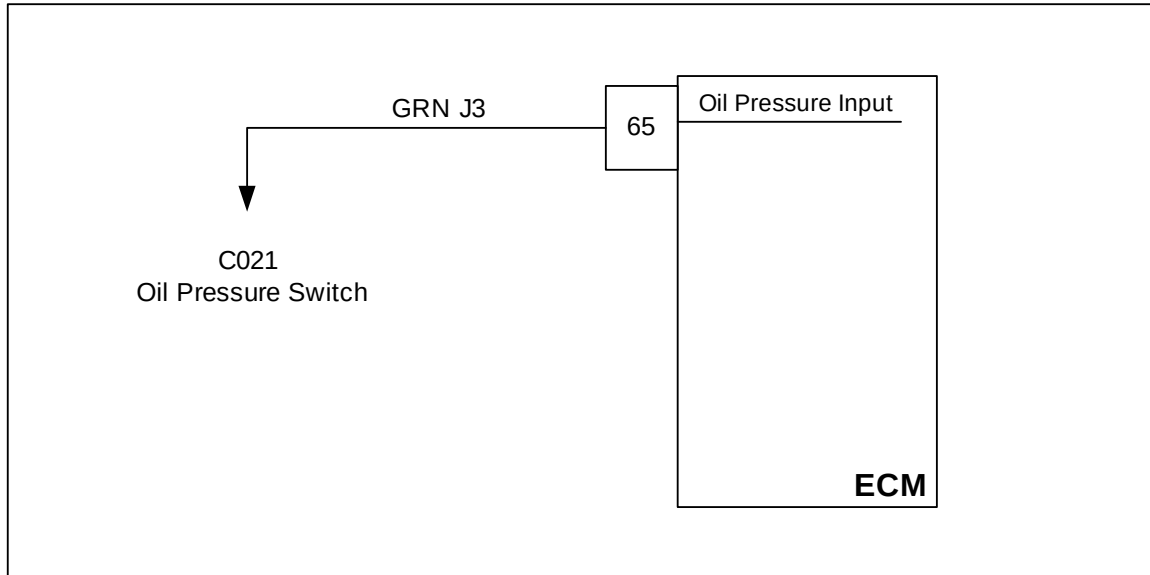
Poor engine grounds, open spark plug wires faulty cap and rotor are known causes of EMI that may set this code. If this code is set with DTC P0642 run the diagnostic chart for this code first as a failure of the 5 volt circuit may cause this code to set.

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 1 and ECM pin 43 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 2 and ECM pin 27 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 3 and ECM pin 63 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 2 and 3 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 2 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 3 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 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 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 5 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

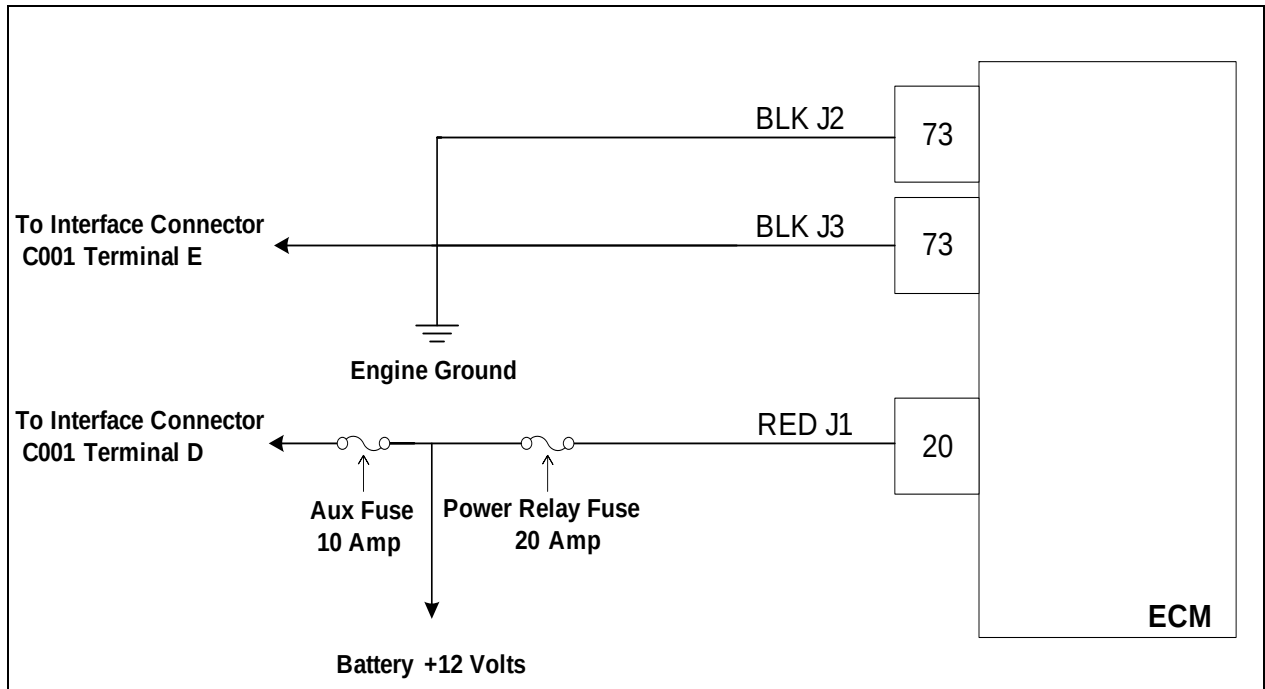
Never assume the fault is due to an electrical malfunction. Low oil pressure can damage the engine. Verify oil pressure before proceeding with this diagnostic.

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 ECM connector pin 65 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
- 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

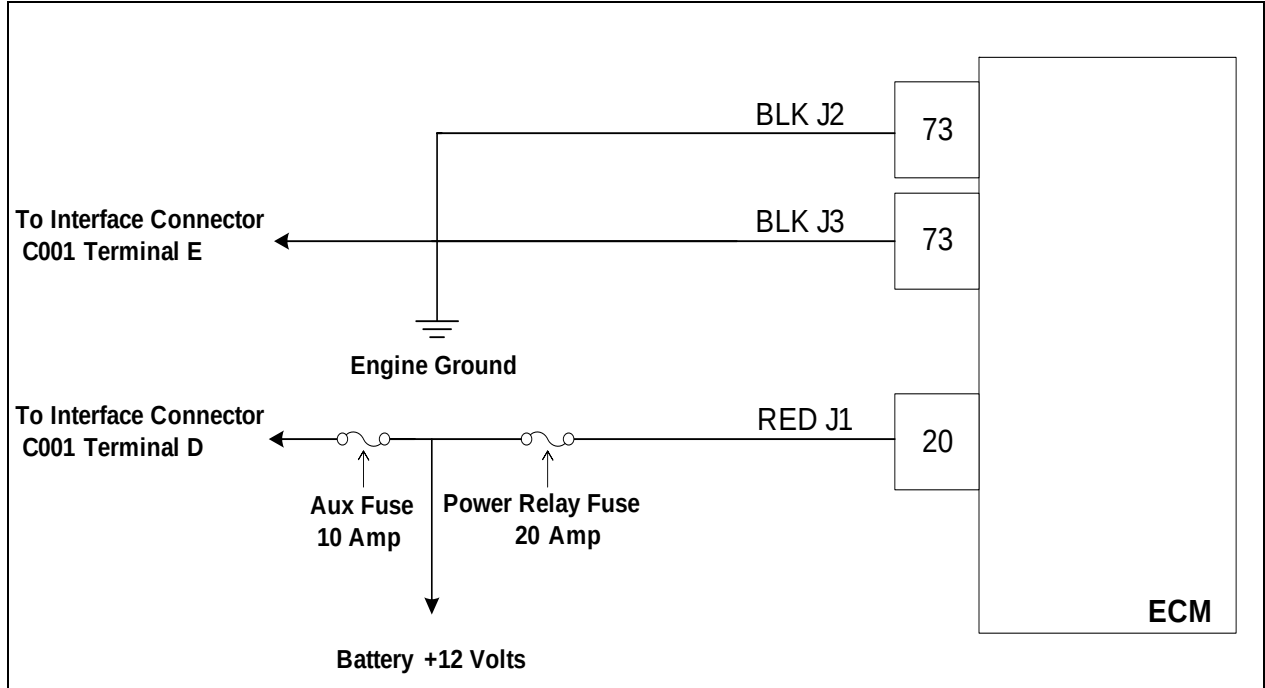
FMI 17

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
- 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

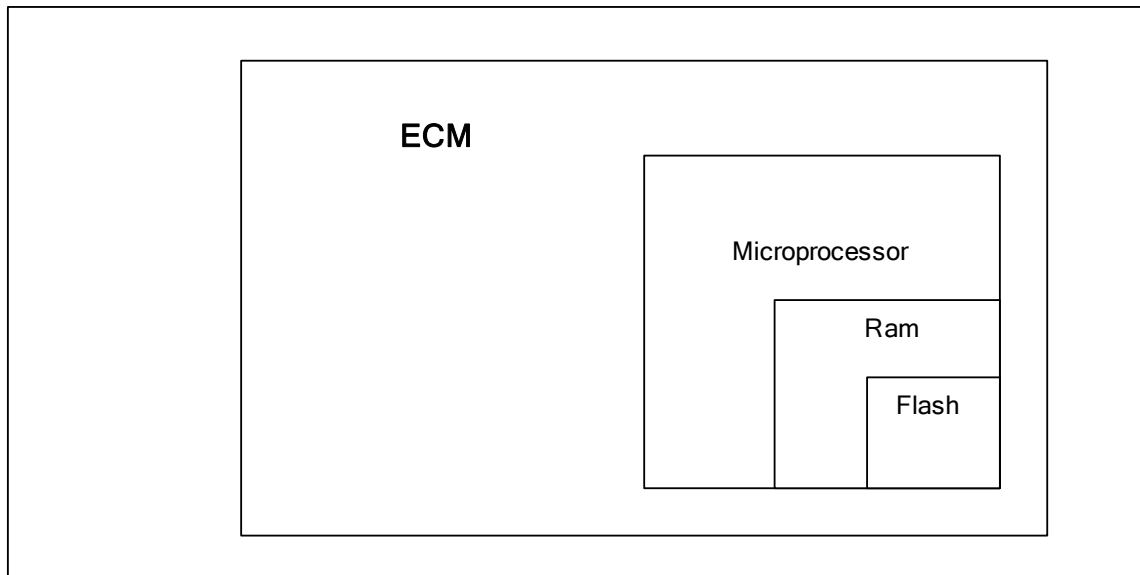
FMI 15

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 C001 pins E and F, 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 65581
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 C001 pins E and F, 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
- 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 chart.

Diagnostic Aid

SPN 65581
FMI 12

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 C001 pins E and F, 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.

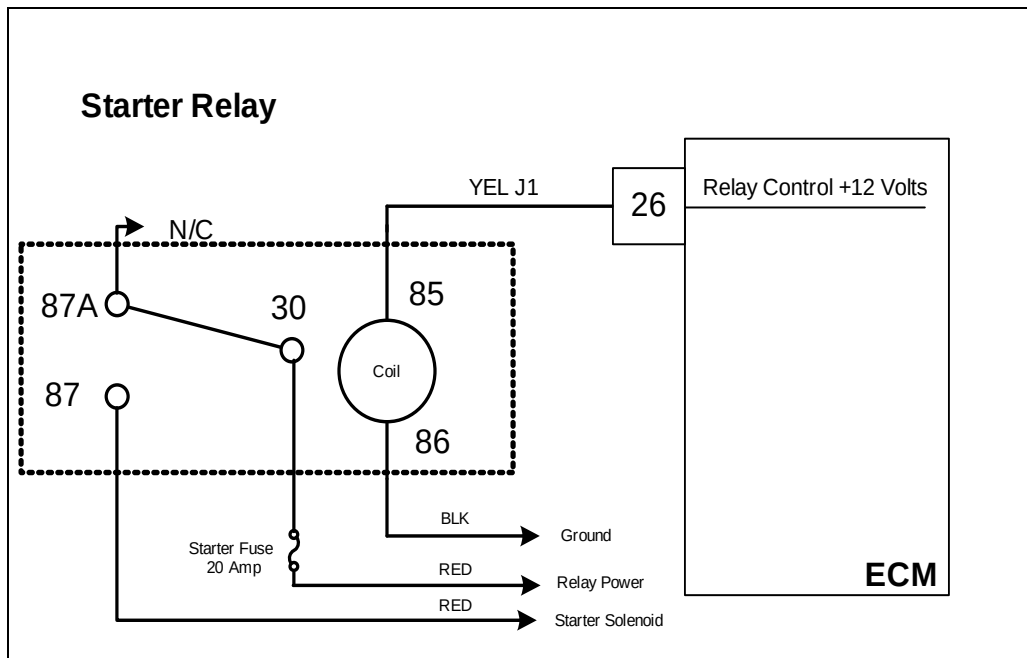
Diagnostic Aid

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 C001 pins E and F, 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 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

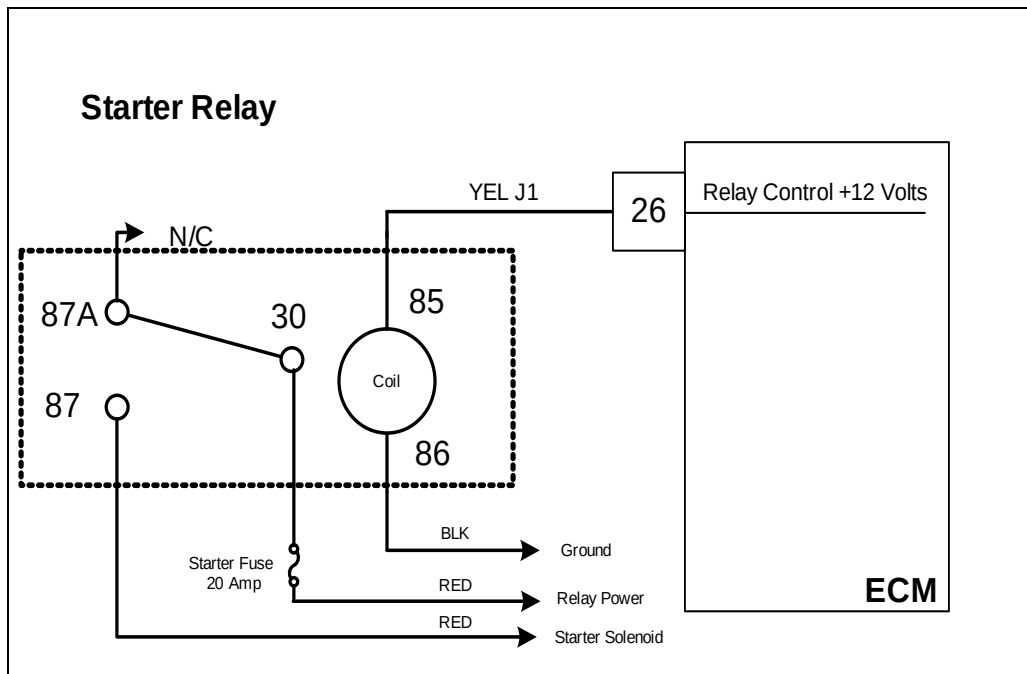
SPN 66002

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	- Disconnect ECM connector C001 - Using a DVOM check the resistance value between ECM pin 26 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 ECM pin 26 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

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 ECM pin 26 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 65620

FMI 4

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

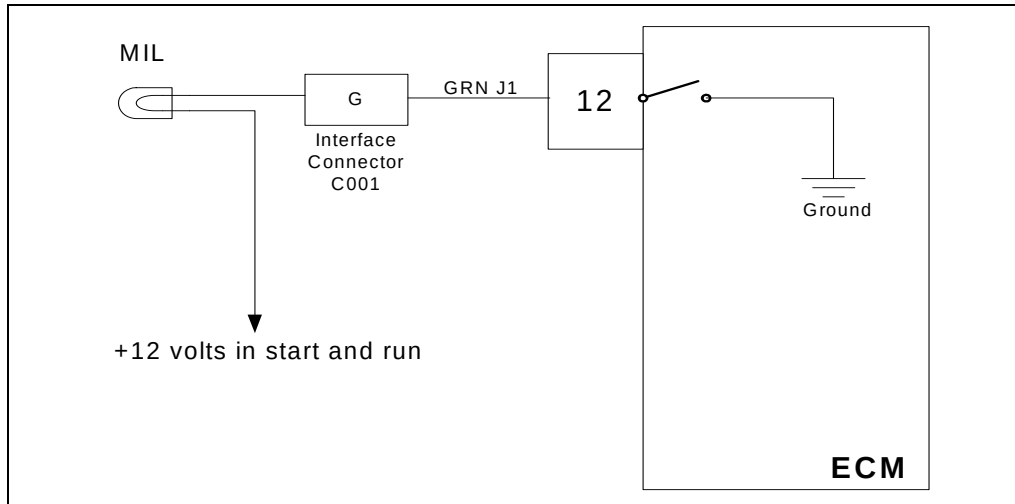
DTC P0642 5 Volt Buffer A Reference Low

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 C0J1 - Using DVOM check for continuity between ECM pin 35 and ECM pin 37 engine ground Does the DVOM show a resistance value of 4.1K Ohms $\pm 10\%$?	4.1K Ohms $\pm 10\%$	Go to Step (4)	Repair the open 5 volt circuit. Refer to wire harness repair section
4	Using a DVOM check between ECM pin 35 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 ECM pin 39 and cam sensor pin C 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 ECM pin 35 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 39 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 ECM pin 35 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 Ignition 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 Ignition 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	- Ignition ON, Engine Running - DST (Diagnostic Scan Tool) connected In System Data Mode - Clear system fault code - Ignition OFF - Ignition 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	- Ignition OFF - Re-install the bulb or driver device - Disconnect the interface connector C001 - Using a DVOM check for continuity between Genset 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 Genset 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 Genset 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 run 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 65621

FMI 4

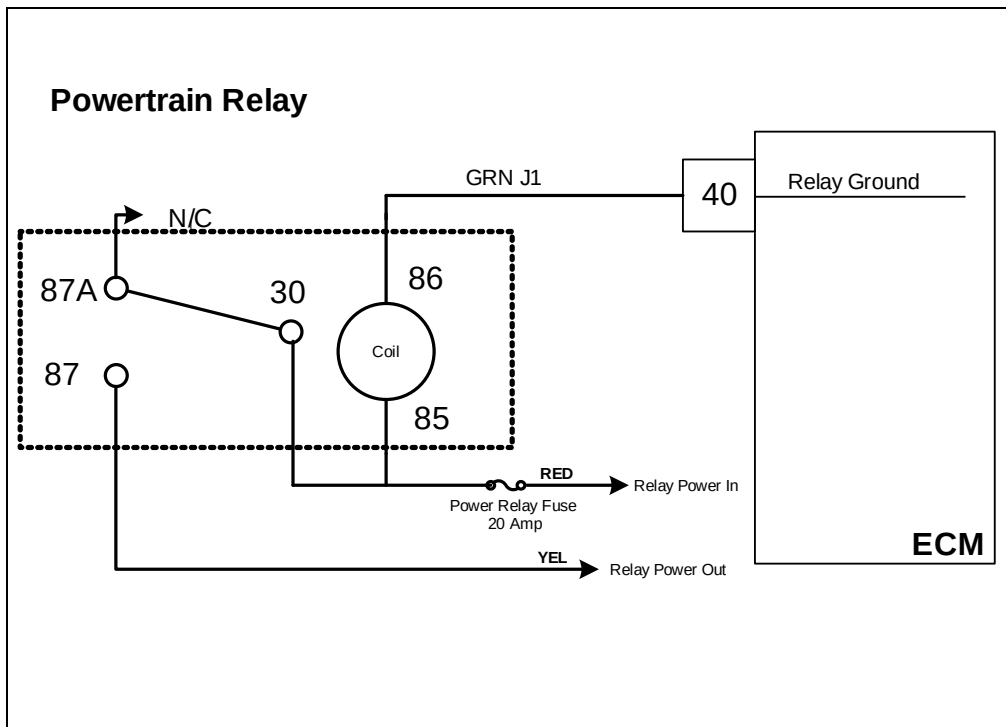
DTC P0652 5 Volt Buff B Reference Low

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 ECM pin 33 and ECM pin 36 engine ground Does the DVOM show a resistance value of 4.1K Ohms $\pm 10\%$?	4.1K Ohms $\pm 10\%$	Go to Step (4)	Repair the open 5 volt circuit. Refer to wire harness repair section
4	Using a DVOM check between ECM pin 33 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 crank sensor connector C013 - Using a DVOM check for continuity between ECM pin 43 and crank sensor pin 1 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 ECM pin 43 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 ECM connector pin 44 and throttle connector pin 2 Does the DVOM show continuity?		Go to Step (8)	Repair the open 5 volt circuit. Refer to wire harness repair section
8	Using a DVOM check between ECM pin 44 and engine ground Does the DVOM show continuity?		Repair the shorted 5 volt circuit. Refer to wire harness repair section	Go to Step (9)

Step	Action	Value(s)	Yes	No
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 than ignition voltage.

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

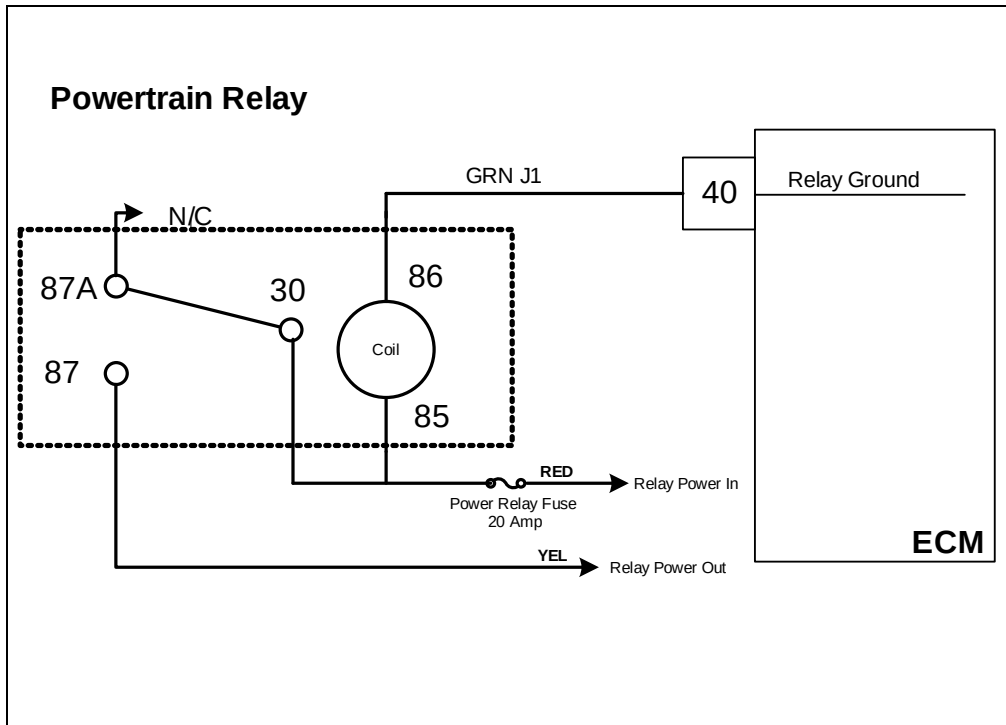
Check battery and starter condition before proceeding with the diagnostic.

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 ECM 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

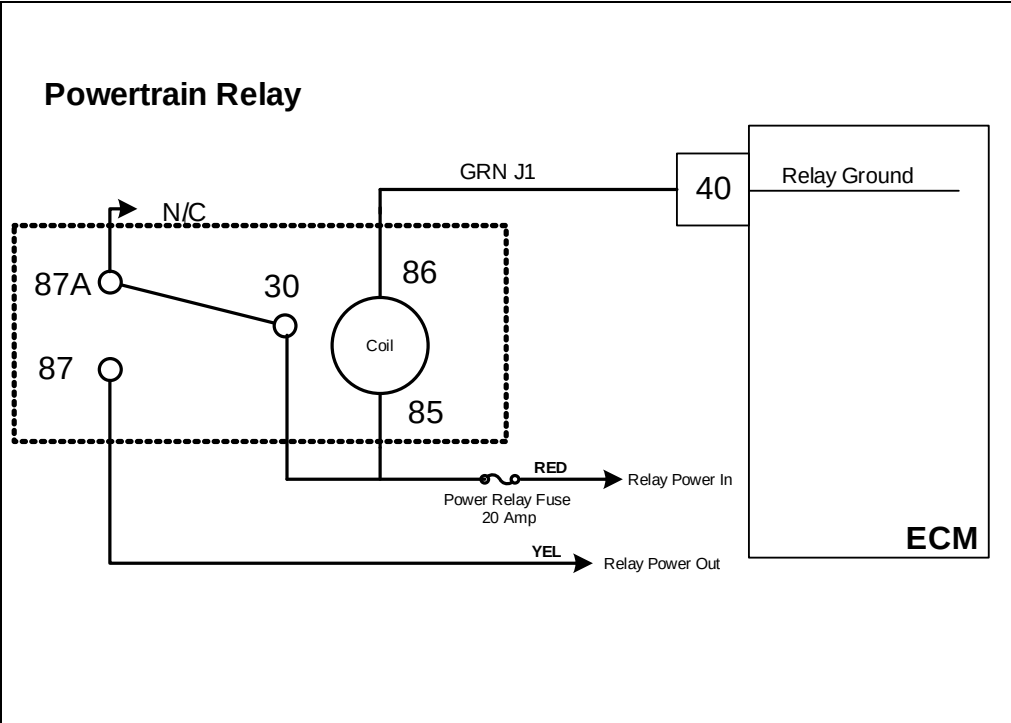
Relay coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

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 125 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 ECM 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 ECM 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

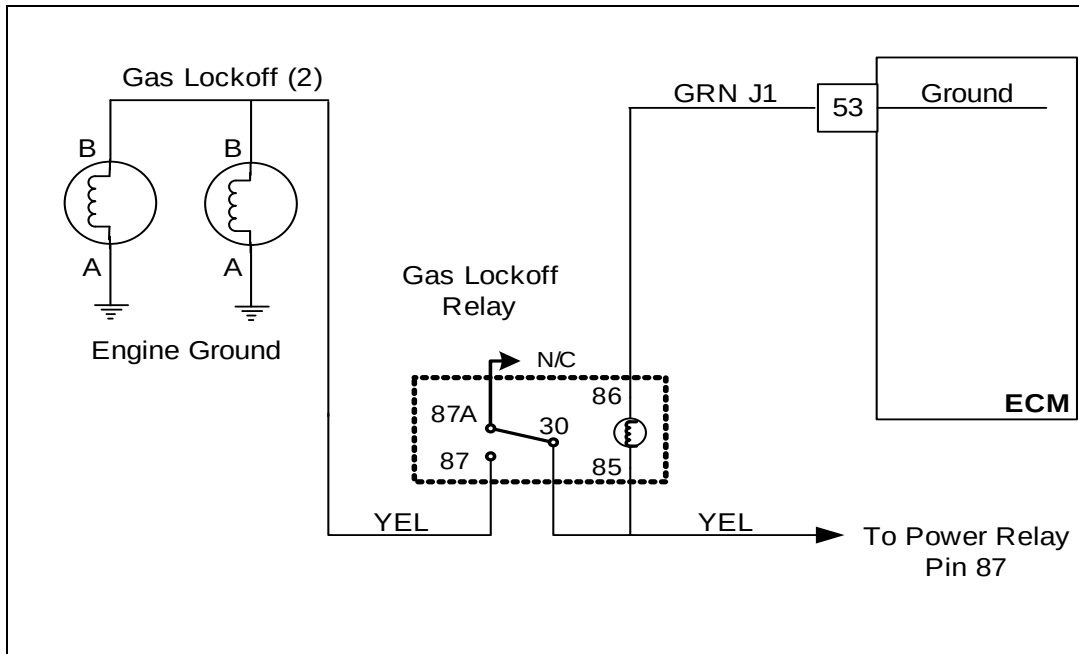
Relay coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

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 ECM pin 71 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

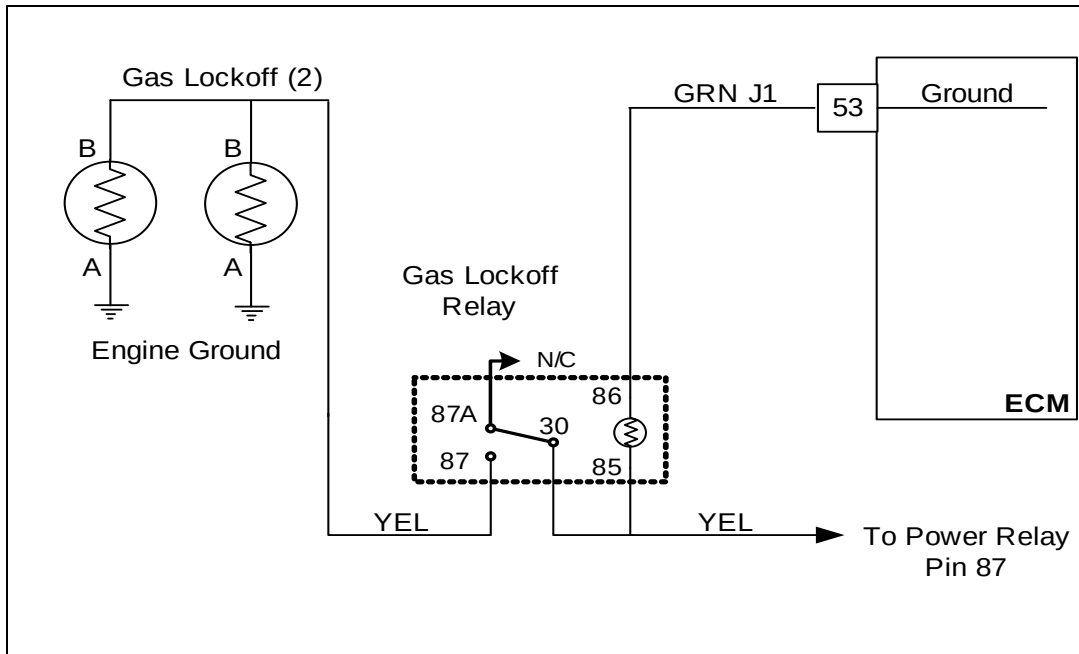
FMI 5

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 115 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 ECM 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

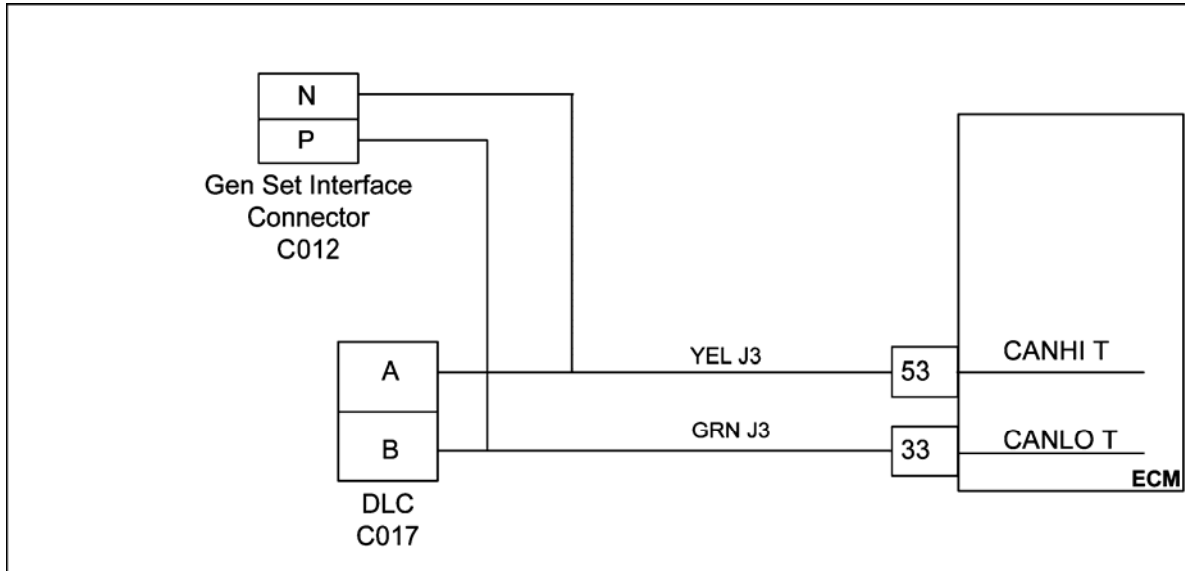
FMI 3

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 ECM 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
- MIL-ON

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.

Diagnostic Aid

SPN 65559

FMI 11

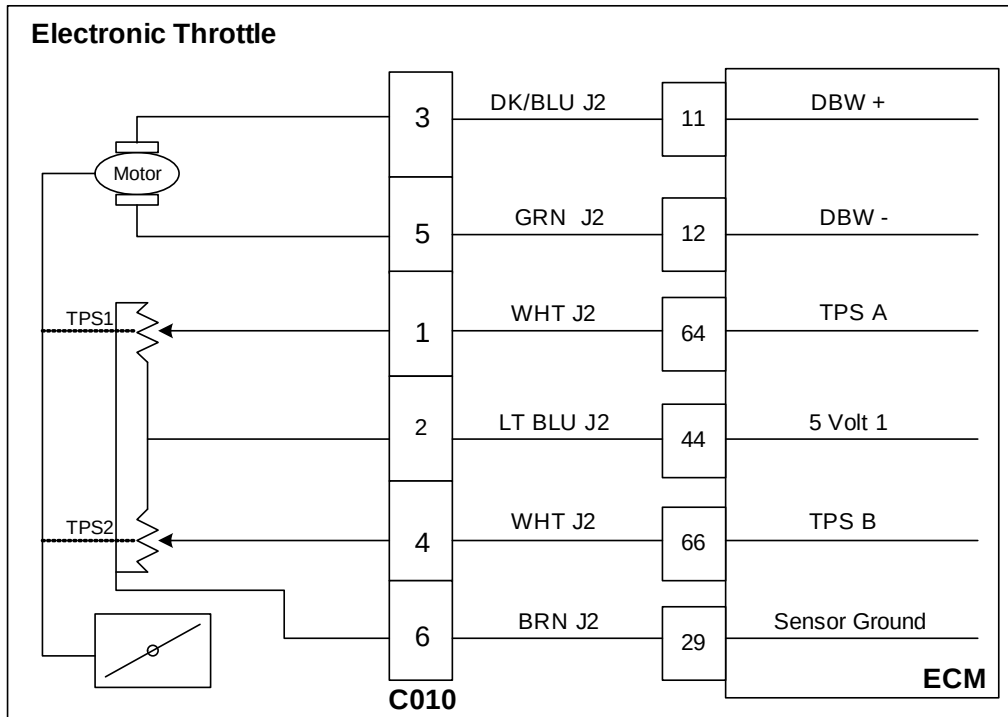
Always run the Genset control panel diagnostics before proceeding with this chart. Disconnect individual CAN devices that may have been installed on the CAN line to see if the problem is resolved before proceeding with this chart.

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 ECM power connection C002 is clean and tight - Check that the ECM 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 C0J3 - Disconnect Genset Interface Connector (GIC) - Using a DVOM check for continuity between ECM connector pin 53 and GIC 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 ECM connector pin 33 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 ECM pins 53 and 33 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)

Step	Action	Value(s)	Yes	No
7	Using a DVOM check for continuity to engine ground on ECM pins 33 and 53. Do you have continuity between them?		Repair the shorted to ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (8)
8	Using a DVOM check for continuity to battery positive on ECM pins 33 and 53. Do have continuity 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 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

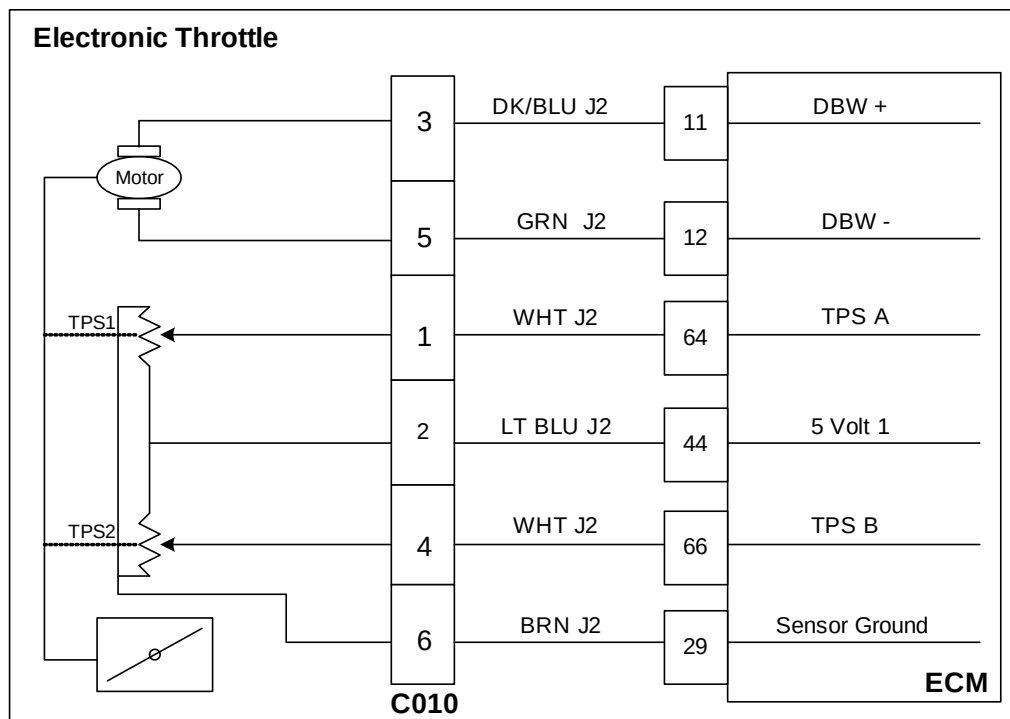
DTC P2111 ETC Return Fault

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 ECM connector pin 29 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 4 and ECM connector pin 66 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 4 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 ECM connector pin 44 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 ECM connector pin 64 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 5 and ECM connector pin 12 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 3 and ECM connector pin 11 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 3 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 7
FMI 65615

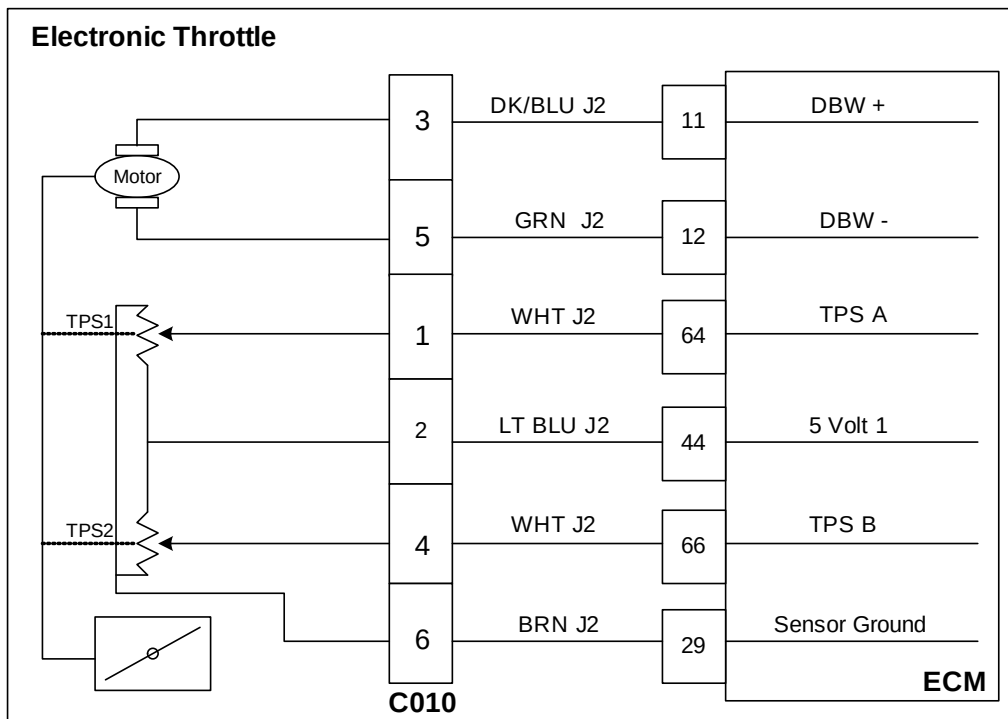
DTC P2119 ETC Actuation Fault

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 ECM connector pin 29 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 4 and ECM connector pin 66 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 4 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 ECM connector pin 44 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 ECM connector pin 64 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 5 and ECM connector pin 12 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 3 and ECM connector pin 11 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 3 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 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

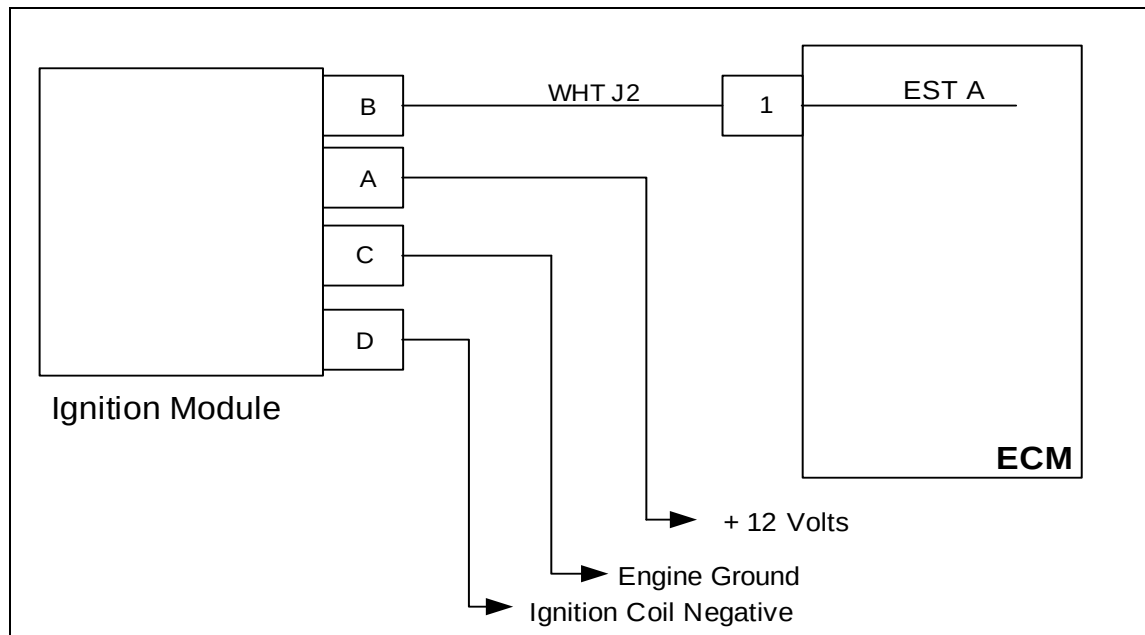
DTC P2135 ETC TPS 1 and TPS 2 Range

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 ECM connector pin 29 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 4 and ECM connector pin 66 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 4 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 2 and ECM connector pin 44 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 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 ECM connector pin 64 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 5 and ECM connector pin 12 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 3 and ECM connector pin 11 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 3 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)

Step	Action	Value(s)	Yes	No
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)
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 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 P2300 EST Short Low



Conditions for Setting the DTC

- Check condition-Engine running or cranking
- Fault condition-100 ms for 720 degrees engine rotation
- MIL-On during active fault

Circuit Description

The ECM triggers the ignition module by providing a signal to the EST A pin 1. The ignition module then completes the ignition coil primary circuit ground from pin D to power the ignition coil. This code will set if the ECM detects the EST circuit to be shorted low.

Diagnostic Aid

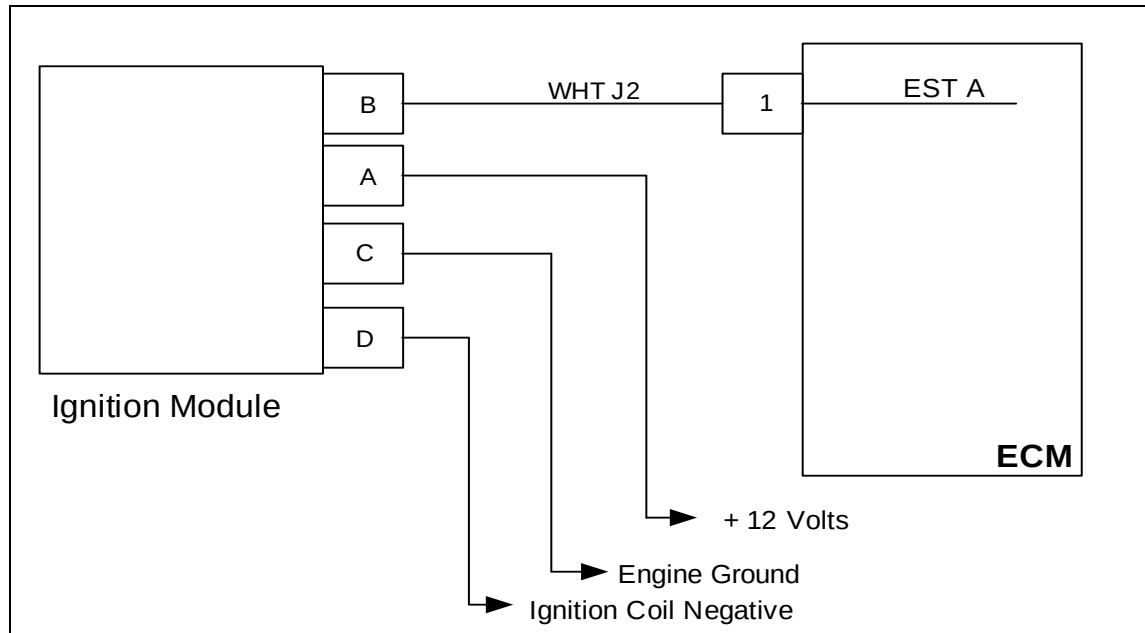
SPN 65541
FMI 4

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 ECM connector pin 1 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-100 ms for 720 degrees engine rotation
- MIL-On during active fault

Circuit Description

The ECM triggers the ignition module by providing a signal to the EST A pin 1. The ignition module then completes the ignition coil primary circuit ground from pin D 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

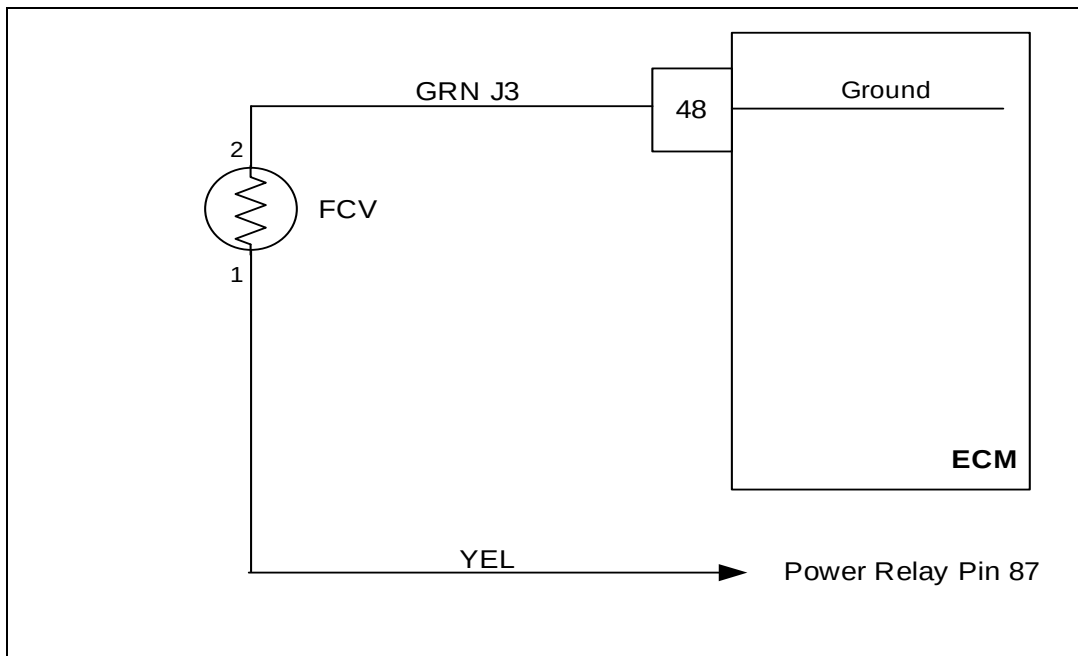
SPN 65541
FMI 5

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 ECM connector pin 1 and ignition module connector pin B. 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 ECM 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 P2300 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 66015

FMI 3

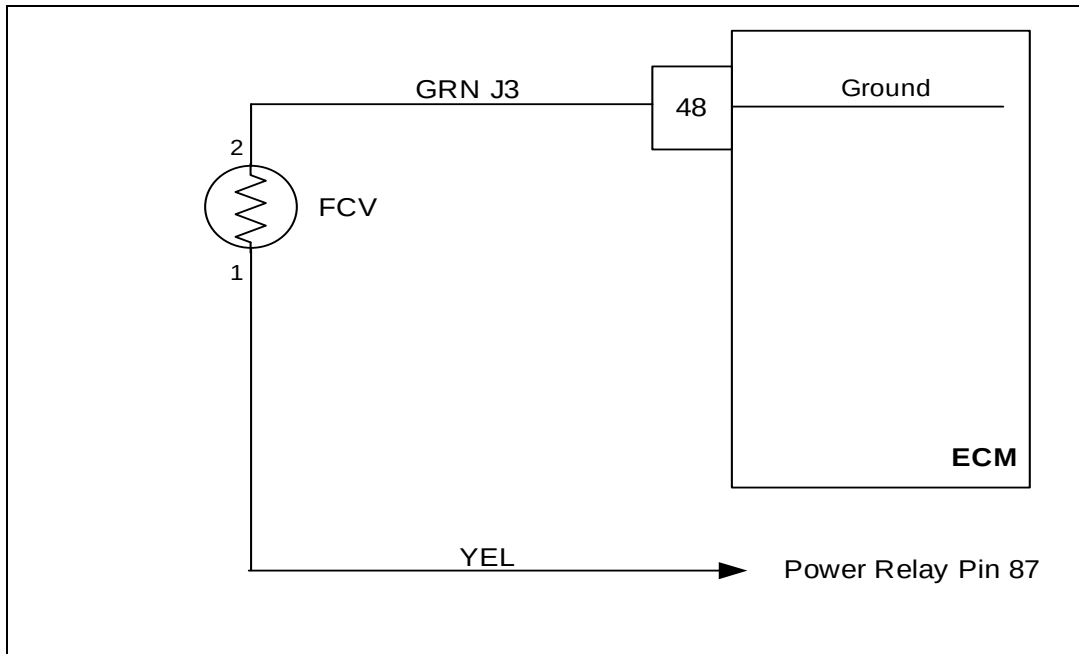
FCV coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

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 ECM pin 48 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 pin 1 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)

Step	Action	Value(s)	Yes	No
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 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 equal to or higher than system voltage

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 system voltage indicating a shorted FCV valve coil or shorted to voltage control circuit.

Diagnostic Aid

SPN 66015

FMI 3

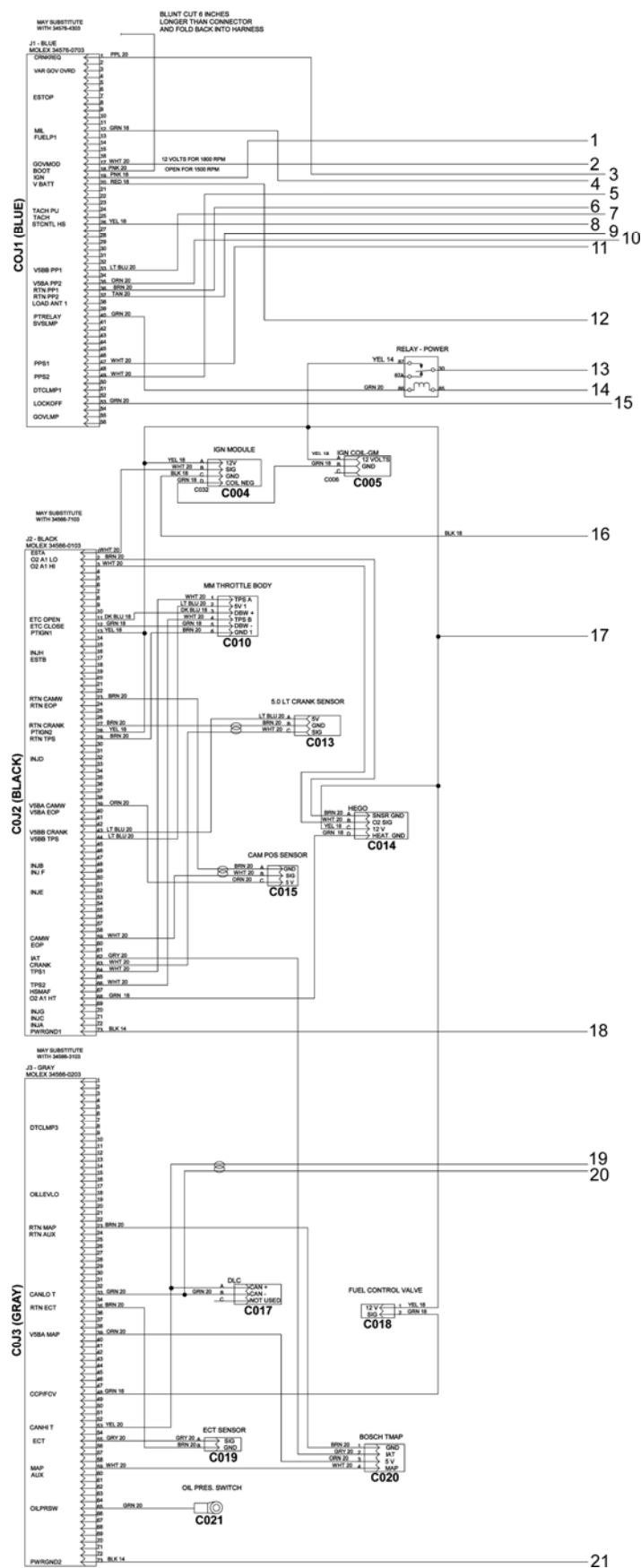
FCV coil resistance changes with temperature. The following diagnostic charts have steps to measure relay coil resistance values. When checking the resistance values is sure the relay is at a reasonable temperature, between +20 and +100 degrees F.

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 (8)	-
4	- Ignition OFF - Disconnect the ECM wire harness connector C0J3 - Ignition ON - Using a DVOM check for voltage between ECM pin 48 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 (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 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

3.0L Stationary Power Generation Engine Wire Harness Schematic



NO CONNECTION TO
TERMINALS - J/K/L/M/R/S
REQUIRED FOR MOST GEN-SET
APPLICATIONS



Connector #	Description	Color	Housing #	Lock #	Terminal #	Seal #	Clip #	Cavity Plug #	Manufacturer
C0J1	ECU Connector J1	Blue							
C0J2	ECU Connector J2	Black	1-284272-5		968221-5 Gold, 968221-1 Tin			284583-1	TYCO
C0J3	ECU Connector J3	Gray	1-284272-6		968221-5 Gold, 968221-1 Tin				TYCO
C001	Vehicle Interface Connector (VIC 1)		15326863	15358785	12191819	12191153			PED
C002	Battery Positive (+)		10mm Ring						
C003	Starter Solenoid		5mm Ring						
C004	Ignition Control Module		12162188/12162189		12103881/12124075	Included			PED
C005	Ignition Coil	Tan	12146121	12052845	12048074	15324976			PED
C006	Shut-Off Valve		12052641	12052634	12048074	12049086	12052634		PED
C007	Shut-Off Valve		12052641	12052634	12048074	12049086	12052634		PED
C008	Alternator +		6mm Ring						
C009	Starter +		8mm Ring						
C010	Throttle -Mag. Mel. (DBW)		42121700		964274-2	963530-1			FEP
C011	Alternator Field		12162193		12103881/12124075				PED
C012	Engine Ground (Left Side)		10mm Ring						
C013	Crank Sensor		314033700	Included	334670005	Included			MOLEX
C014	Oxygen Sensor		12160825	12160826-LONG	12177150 Gold	12089678	12176368		PED
C015	Camshaft Position Sensor		12110293	12052845	12048074	15324976			PED
C016	Battery Negative (-)		10mm Ring						
C017	Diagnostic Link Connector (DLC)		DT06-3S-CE06	W3S-1939	0462-201-16141				DEUTSCH
C018	Fuel Control Valve for Genset		1420-2000	4661974 -Green	331060014	Included			SEBRO
C019	Engine Coolant Temperature (ECT)		12162194		12103881				PED
C020	TMAP		1-928-403-736		1-928-498-056	1-928-300-599			BOSCH
C021	Oil Pressure Switch		4mm Ring						

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.

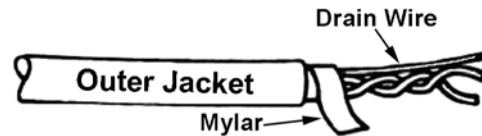
CONNECTORS AND TERMINALS

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.

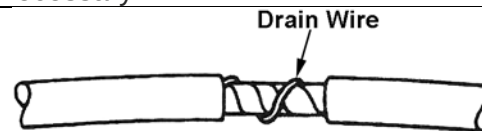
REPAIRING TWISTED/SHIELDED CABLE



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.

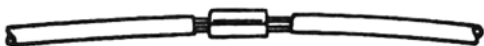


6. Tape over entire juncture and secure.

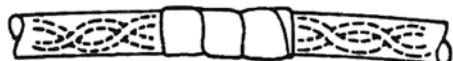
REPAIRING TWISTED LEADS



1. Locate Damaged Wire.
2. Remove insulation as required.



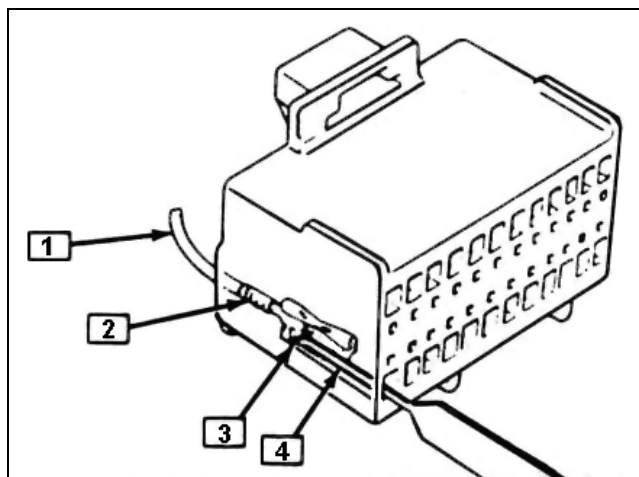
3. Splice two wires together using splice clips and rosin core solder.



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.

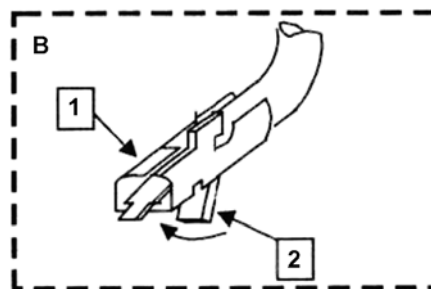
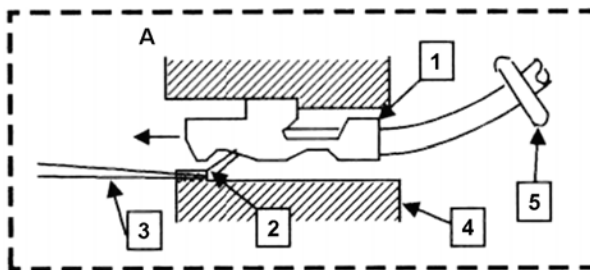


Micropack Connector

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.



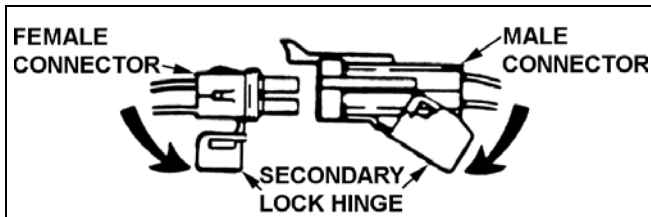
Metri-Pack Series 150 Terminal Removal

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).

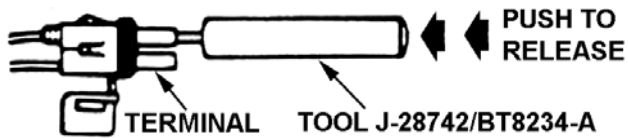
WEATHER-PACK

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.

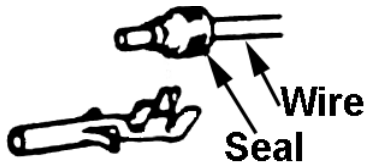
WEATHER-PACK TERMINAL REPAIR



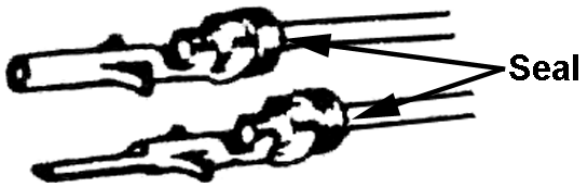
1. Open secondary lock hinge on connector.



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.

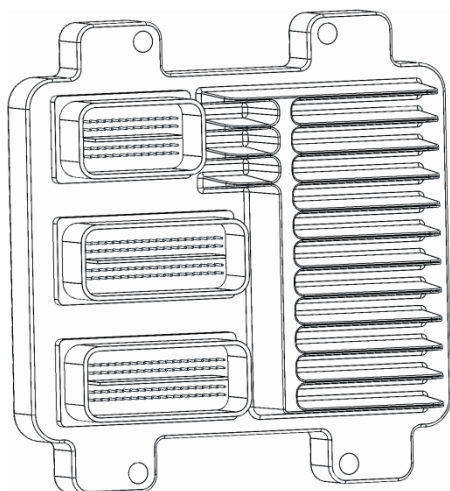
Servicing the Fuel System

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, Washers and Spacers mounting the ECM to the Bracket.



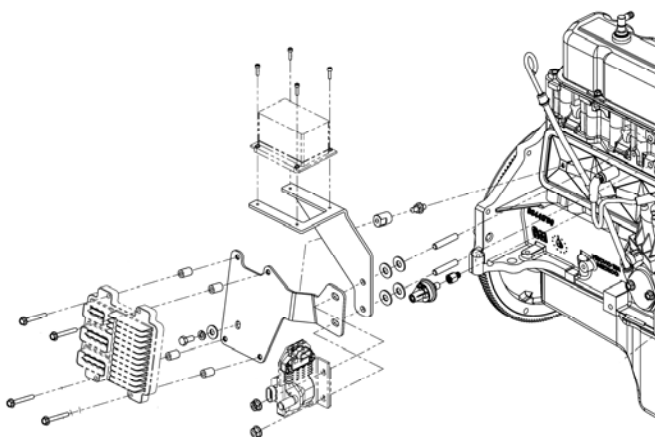
ECM

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 wire harness 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.



ECM Mounting Bracket, Fuse Bracket and Ignition Coil Installation

II. ECM BRACKET

REMOVAL PROCEDURE

1. Remove ECM. Refer to *I. ENGINE CONTROL MODULE*.
2. Remove Ignition Coil. Refer to *III. IGNITION COIL/MODULE*.
3. Remove Bolt securing ECM bracket to the engine and remove the Bracket.

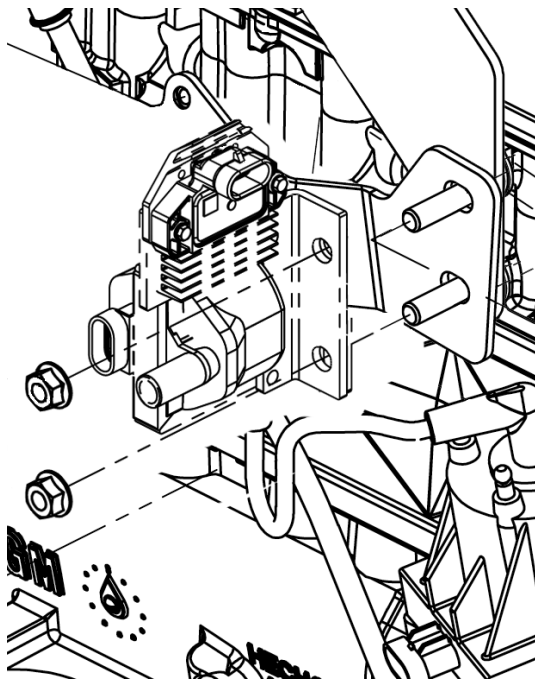
INSTALLATION PROCEDURE

1. Place the ECM Bracket on the studs.
2. Secure the Bracket with Bolt, Lock Washer and Washer and **torque to 7-9 ft.lbs. (9.5-12.2 Nm).**
3. Install the Ignition Coil. Refer to *III. IGNITION COIL/MODULE*.
4. Install the ECM. Refer to *I. ENGINE CONTROL MODULE (ECM)*.

III. IGNITION COIL/MODULE

REMOVAL PROCEDURE

1. Disconnect negative battery cable.
2. Remove all electrical connections to the Ignition Coil/Module Assembly.
3. Remove two Nuts securing the Ignition Coil/Module Assembly to the Studs on the side of the engine.
4. Remove Ignition Coil from studs.



Ignition Coil Installation

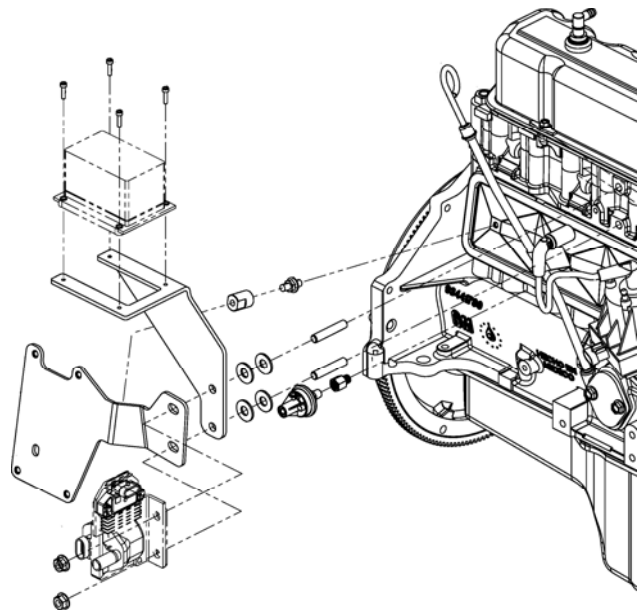
INSTALLATION

1. Place Ignition Coil/Module on studs.
2. Thread Nuts on studs and **torque to 27.3-33.2 ft.lbs. (37-45Nm)**.
3. Connect electrical connectors to the Ignition Coil/Module Assembly.
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. FUSE BOX BRACKET

REMOVAL PROCEDURE

1. Disconnect negative battery cable.
2. Remove four Screws securing the fuse box to the bracket and remove the fuse box.
3. Remove Ignition Coil, ECM and ECM Bracket. Refer to *I. ENGINE CONTROL MODULE (ECM)*, *II. ECM BRACKET* and *III. IGNITION COIL/MODULE*.
4. Remove Bracket from studs.



The Fuse Box Bracket shares mounting studs with the ECM Bracket and Ignition Coil.

INSTALLATION PROCEDURE

1. Place the Fuse Box Bracket, ECM bracket and Ignition Coil on studs. Refer to *I. ENGINE CONTROL MODULE (ECM)*, *II. ECM BRACKET* and *III. IGNITION COIL/MODULE*.
2. Thread Nuts on studs and **torque to 27.3-33.2 ft.lbs. (37-45Nm)**. Refer to *III. IGNITION COIL/MODULE*.
3. Place Fuse Box on top of Bracket and thread Screws with washers into the Bracket. **Torque to 2-3 ft.lbs (2.7-4.0Nm)**.
4. Connect electrical connectors to the Ignition Coil. Refer to *III. IGNITION COIL/MODULE*.
5. Reattach negative battery cable.
6. Start engine.
7. If a DTC code is found, refer to the Electrical Section for further diagnosis.

V. 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.

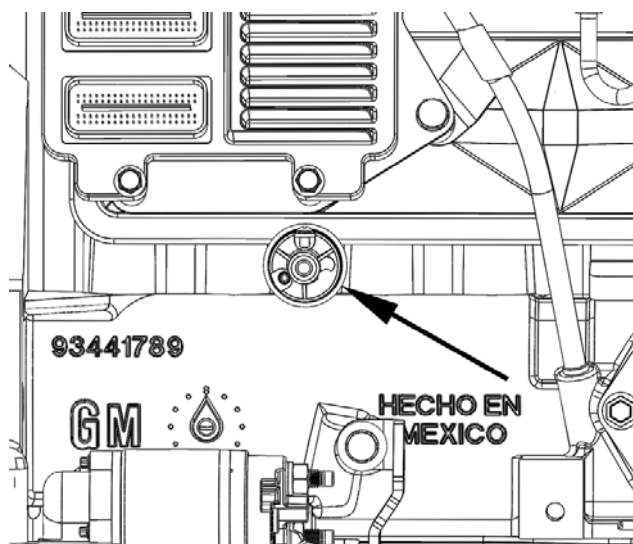


CAUTION

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.

VI. OIL PRESSURE SENDER



The Oil Pressure Sender, shown installed on the side of the engine below the ECM and above the starter.

REMOVAL PROCEDURE

1. Disconnect the negative battery cable.
2. Locate the Oil Pressure Sender on the side

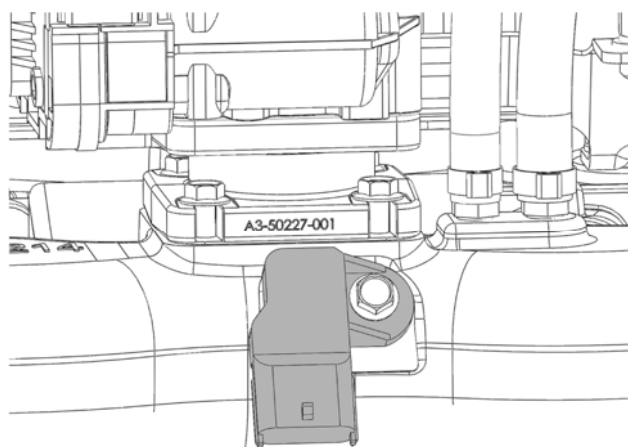
of the engine.

3. Remove electrical connection from Oil Pressure Sender.
4. Using a wrench, hold the brass adapter (to prevent from turning) and turn the Switch 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. If the Brass Adapter was removed or is to be added to a new Sender, add thread locker/sealer and thread on to the engine block. **Torque to 2-3 turns past tight.**
2. Install Oil Pressure Sender. **Torque to 2-3 turns past tight, ensuring the electric connector (screw) is accessible.**
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 Sensor, shown mounted on the Intake Manifold.

REMOVAL PROCEDURE

1. Disconnect the negative battery cable.
2. Locate the TMAP Sensor on the Intake Manifold plenum.

3. Disconnect electrical connector.
4. Remove the retaining screw.
5. Remove TMAP Sensor by pulling straight up with a slight rocking motion.

INSTALLATION PROCEDURE

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

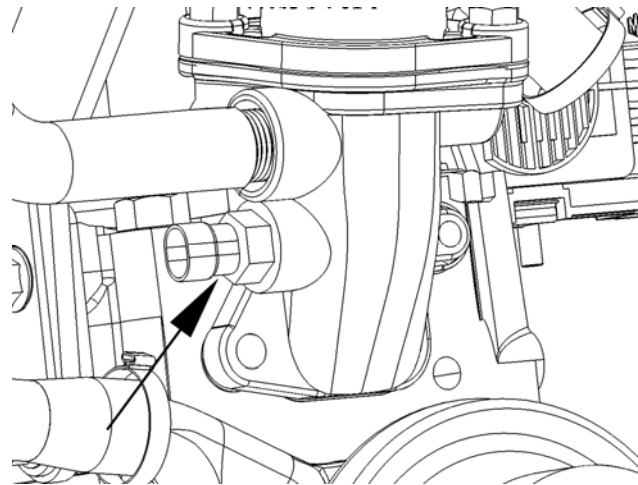


CAUTION

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.

1. Install the TMAP and secure with Retaining Screw. **Torque to 7-9 ft.lbs. (9.5-12.2 Nm).**
2. Reconnect electrical connector.
3. Reconnect the negative battery cable.
4. Start engine and run until it reaches normal operating temperature.
5. 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 is mounted to the lower Thermostat housing located on the front of the engine.

REMOVAL PROCEDURE

1. Disconnect the negative battery cable.
2. Drain the coolant.



WARNING

Do not remove the cooling system pressure cap (radiator cap) or another coolant system component 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.

3. Locate the ECT on the side of the engine.
4. Remove electrical connector from the ECT.
5. Unscrew the sensor from the engine.

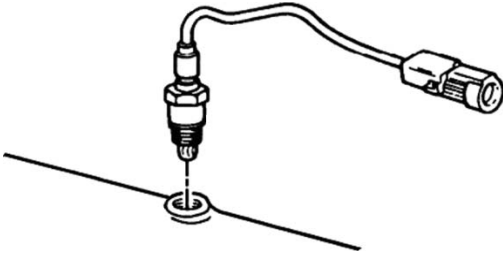
INSTALLATION PROCEDURE

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 cooling system.
5. Reconnect the negative battery cable.
6. Start the engine and let run until it reaches normal operating temperature. 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.

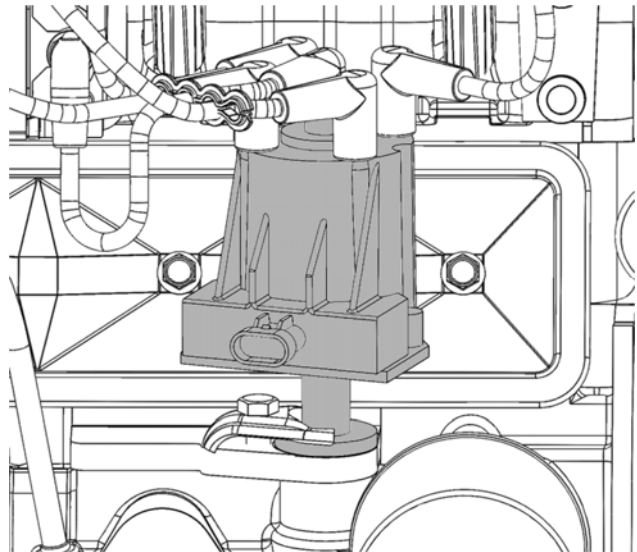
IMPORTANT

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 the 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.

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

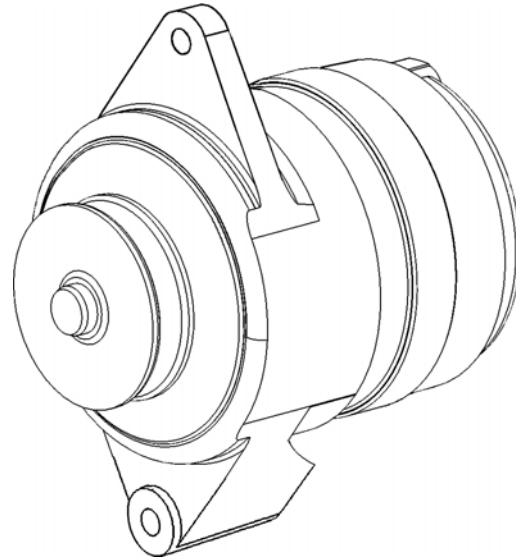
1. Align the Rotor with the mark made on the Distributor housing (the location of the rotor when it was removed) and place into the engine ensuring the rotor, distributor housing and the mark on the engine are all in alignment when the Distributor is fully seated.
2. Install the Distributor mounting clam Bolt and **tighten to 18 ft. lbs (25 Nm)**. Verify that the rotor and Distributor housing remain in line with the 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, ensuring the wires are connected to the correct cylinder. Note that the firing order is 1-3-4-2. Refer to the *IGNITION SYSTEM SPECIFICATIONS* in the Appendix for additional information.
6. Connect Ignition Coil wire to Distributor Cap.
7. Reconnect negative battery cable.
8. Start engine. Run engine 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



Alternator

REMOVAL PROCEDURE

1. Disconnect the negative battery cable.
2. Remove the electrical connectors from the alternator.
3. Remove nut on the lower bolt.
4. Remove the bolt securing the alternator to the bracket.
5. Remove the V-belt.
6. Slide the lower bolt out and remove Alternator. Note that a washer, located between the bracket and alternator mounting flange, may fall out.

INSTALLATION PROCEDURE

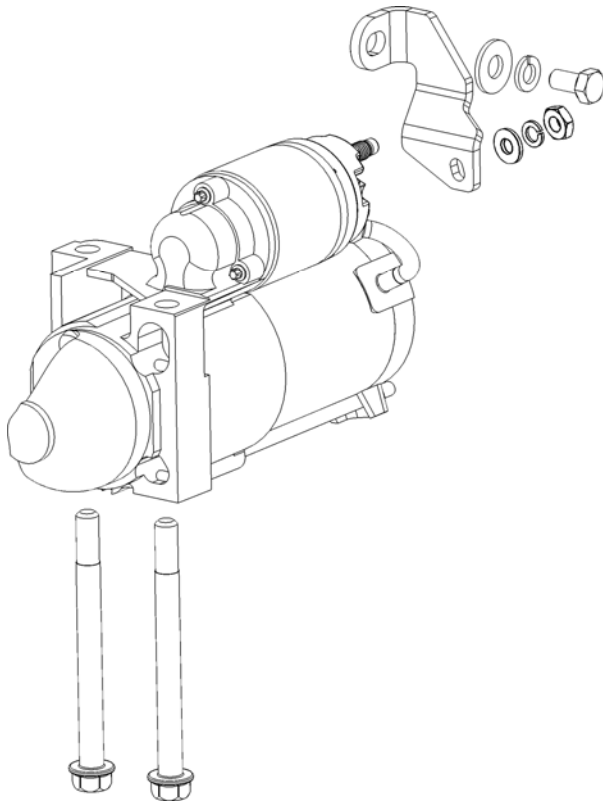
1. Insert bolt through the first hole (the one closest to the front of the engine), then place a washer on the bolt just behind the first hole. Put alternator in place and slide in lower bolt, through the flange on the alternator and second hole.
2. Add the spacer, washer, lockwasher and nut to the lower bolt. Finger tighten nut.
3. Place V-belt on pulleys.
4. While applying outward pressure to the alternator to tighten the V-belt, insert and tighten the screw to secure the alternator to the bracket and tighten. Check for play in V-belt. If too loose, loosen bolt and retighten. If tension on V-belt is correct, **torque the top bolt to 12.5 ft.lbs (17 Nm)**.
5. **Torque the nut on the lower bolt to 33.2 ft.lbs (45 Nm)** and ensure the alternator is

securely mounted with no play.

6. Connect electrical connections to the Alternator. Tighten the output terminal nut and **torque to 7-9 ft.lbs. (9.5-12.2 Nm)**.
7. Reconnect the negative battery cable.
8. Start engine and check for MIL. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XII. STARTER

REMOVAL PROCEDURE



Starter and mounting hardware

1. Disconnect the negative battery cable.
2. Remove the two electrical connections (battery and start switch) connection from the starter solenoid on top of the starter. Do not remove the cable between the solenoid and starter.
3. Remove the bolt securing the starter bracket to the side of the engine.
4. Remove the two Bolts securing the Starter and remove Starter.

INSTALLATION PROCEDURE

1. Place starter in position, making sure the starter teeth are properly meshed with the

flywheel.

2. Insert the two bolts under the starter and hand tighten.
3. Insert the bolt securing the starter bracket to the side of the engine and **torque to 22.1 ft.lbs. (30Nm)**.
4. **Torque the two long starter bolts to 25.8-33.2 ft.lb (35-45Nm)**.
5. Connect the positive battery terminal wire and nut to the solenoid stud and **torque to 5.9-8.1 ft.lbs (8-11Nm)**.
6. Connect the starter solenoid wire and nut to the smaller stud on the solenoid and **torque to 14.1-26.6 in.lbs. (1.6-3Nm)**.
7. Connect negative battery cable.
8. Start engine to ensure proper operation of the starter.

XIII. CAMSHAFT POSITION SENSOR

REMOVAL PROCEDURE

1. Disconnect negative battery cable.
2. Label Spark Plug Wires with matching Distributor Cap numbers and remove by pulling and twisting each spark plug wire boot $\frac{1}{2}$ 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 CMP Sensor
9. Remove the Camshaft Sensor from the Distributor.

INSTALLATION PROCEDURE

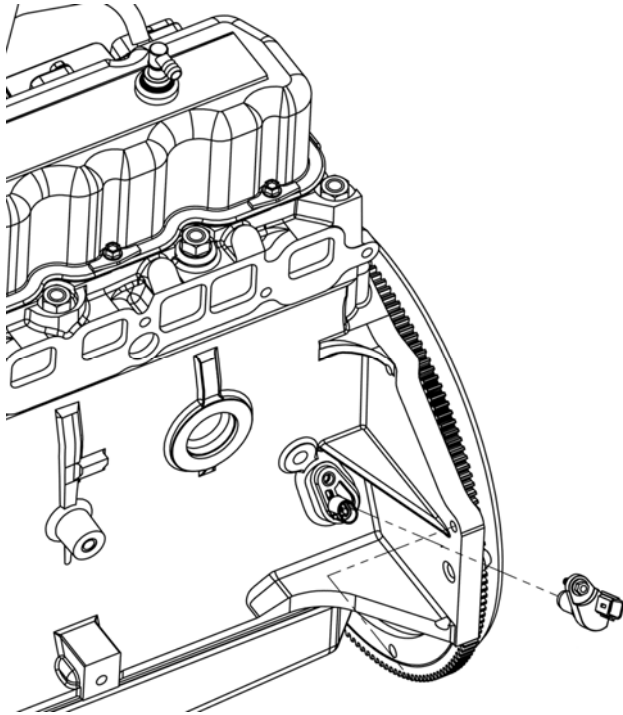
IMPORTANT

Do 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 sensor harness connector.

5. Connect Spark Plug wires to the Distributor Cap, ensuring the wires are connected to the correct cylinder. Note that the firing order is 1-3-4-2. Refer to the *IGNITION SYSTEM SPECIFICATIONS* in the Appendix for additional information.
6. Start engine. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XIV. CRANKSHAFT POSITION SENSOR



Crank Sensor as shown on the side of the engine.

REMOVAL PROCEDURE

1. Disconnect negative battery cable.
2. Remove electrical connector from Crank Sensor.
3. Remove bolt securing the Crank Sensor and remove from the side of the engine.

INSTALLATION PROCEDURE

1. Place the Crank Sensor into the hole in the side of the engine and secure with bolt.
Torque to 7-9 ft.lbs. (9.5-12.2 Nm).
2. Attach electrical connector.
3. Attach negative battery cable.

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

XV. CRANKSHAFT SENSOR RELUCTOR RING

REMOVAL PROCEDURE

1. Remove front engine cover assembly.
2. Slide the CKP Sensor Reluctor Ring off the crankshaft.

IMPORTANT

The CKP Sensor Reluctor Ring is dish shaped. Note its orientation prior to removal to ensure proper installation.

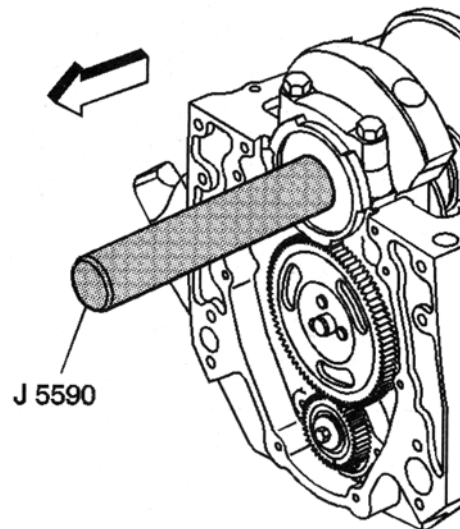
INSTALLATION PROCEDURE

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.

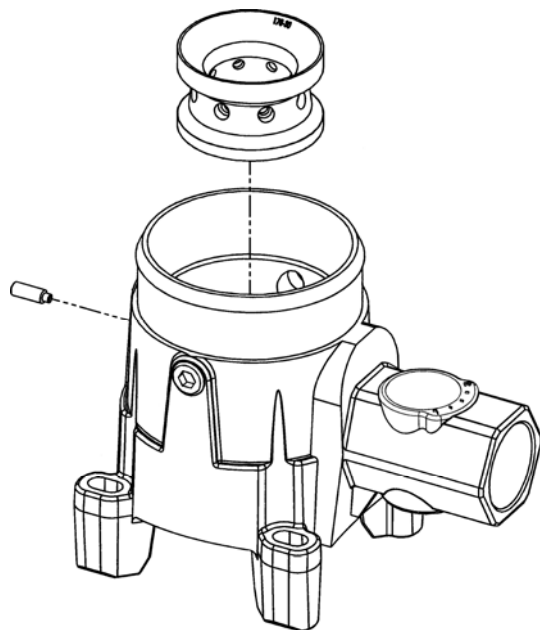
2. Use tool J 5590 to push the CKP Sensor Reluctor Ring until it is firmly seated against the crankshaft sprocket.



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

3. Install the front engine cover assembly.

XVI. VENTURI & ADAPTER



The Venturi shown above the Venturi Adapter and Set Screw

REMOVAL PROCEDURE

1. Remove the air intake assembly connected to the Venturi Adapter.
2. Using a 2mm hex tool, loosen the Set Screw securing the Venturi.
3. Gently pull the Venturi from the Adapter and remove.



CAUTION

The Venturi is a precision component and damage to it or the Adapter may affect the performance of the fuel system. Do not use sharp tools to remove or insert the Venturi as they may scratch or cause damage. When placing the Venturi in the Adapter, ensure it is placed straight into the Adapter and bottomed out against the seat inside the Adapter.

INSTALLATION PROCEDURE

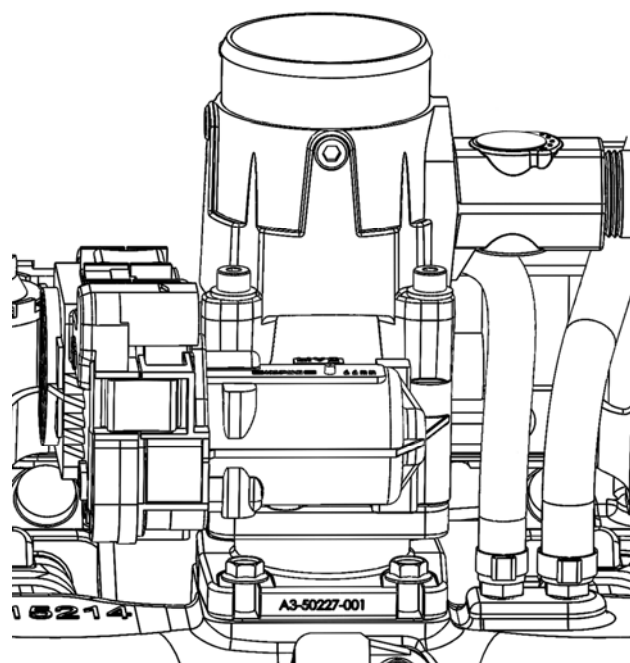
1. Clean the Venturi and Venturi Adapter to remove any dirt or debris that may enter the Throttle Body.
2. Place the Venturi in the Venturi Adapter, ensuring the engraved part number and

word "TOP" are visible, and it is properly seated on the bottom of the Adapter.

NOTE: There is no clock position for the Venturi. As long as it is properly seated, it can be rotated to any position.

3. Lightly add Loctite 242 to the threads on the Set Screw and thread into the Venturi Adapter.
Torque to 7-13 in.lbs. (0.8-1.5 Nm).
4. Reattach the air intake assembly to the Venturi Adapter.
5. Start the engine and let run until it reaches normal operating temperature.
6. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XVII. VENTURI ADAPTER/THROTTLE BODY



The Venturi Adapter, Throttle Body and Throttle Body Adapter shown assembled.

REMOVAL PROCEDURE

1. Turn the Fuel Supply Valve to OFF and Relieve the fuel system pressure. Refer to XXVI. FUEL SYSTEM PRESSURE RELIEF.
2. Disconnect the negative battery cable.
3. Remove the air intake from the Venturi Adapter.
4. Remove the electrical connector from the Throttle Body.
5. Remove the hoses connected to the Adapter fittings.
6. Remove hoses connected to the Regulator.

7. Remove the screw at the bottom of the clamp and open the clamp to release the pipe.
8. Disconnect fuel supply Hose.
9. Remove four Screws that secure the Venturi, Throttle Body and the Adapter to the Intake Manifold.
10. Remove the Venturi Adapter and Throttle body assembly (complete with the fuel pipe and Regulator still attached).
11. If the Venturi Adapter, Throttle Body or the seal are to be replaced, separate the two.

NOTE: Unless the Adapter, Throttle body or the Seal between the two require replacement, keep the Venturi Adapter and Throttle Body together as an assembly to maintain the Seal between the Throttle Body and Venturi Adapter.

IMPORTANT: Place tape, a clean cloth or some other covering over the Intake Manifold to prevent debris from entering and causing permanent engine damage.

12. Remove the pipe from the Venturi Adapter and place the Regulator assembly aside.
13. If Venturi Adapter is to be replaced, remove the Venturi and the fittings. Refer to XVI. *VENTURI & ADAPTER*.

INSTALLATION PROCEDURE

1. Inspect Venturi Adapter Gasket. Replace if necessary.
2. Clean components of any loose debris. Ensure that all mating surfaces are smooth, clean and free of any old gaskets or gasket material.
3. Insert Venturi if removed. Refer to XVI. *VENTURI & ADAPTER*. If the Venturi Adapter was replaced, ensure the Plug, Elbows and Set Screw are installed. Apply a light coat of Loctite 567 or equivalent pipe thread sealant on the threads of the Plug and nylon Elbows and insert into the Adapter. **Torque until tight.** Continue turning the nylon elbow until it is in the correct clock position.



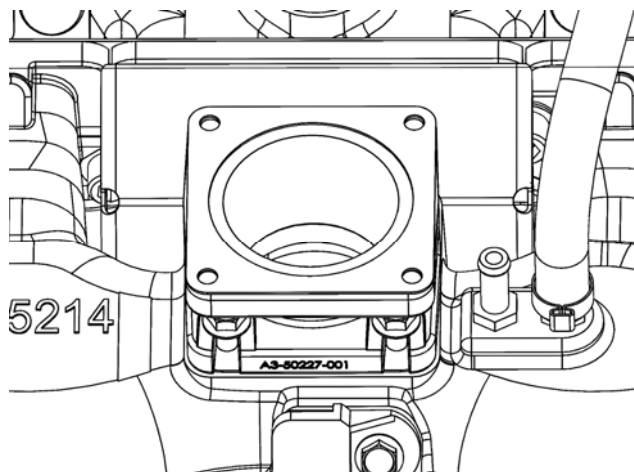
WARNING

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.

4. Place Loctite 567 or equivalent pipe thread sealant on the threads of the pipe (on the Regulator assembly) and thread the Adapter on to the pipe until tight, then continue turning until both the Adapter and the Regulator match the same clock position.
5. If the Venturi Adapter and Throttle Body were separated, verify the Throttle Body Seal is not crushed, cracked or otherwise damaged. If so, replace. Refer to XIX. *VENTURI ADAPTER/THROTTLE BODY SEAL REPLACEMENT*.
6. Place on top of Throttle Body, Throttle Body gasket and Throttle Body Adapter, then insert four hex screws and finger tighten.
7. Ensure the fuel pipe is properly cradled in the Regulator Support Clamp and finger tighten the screw on the Regulator Support Clamp.
8. **Torque the four hex screws securing the Throttle Body/Venturi Adapter assembly to 7-9 ft.lbs. (9.5-12.2 Nm).**
9. **Torque the screw of the Regulator Support Clamp to tight.**
10. Connect Fuel Hose and secure with clamp.
11. Connect the two vacuum hoses to the Regulator and secure with clamps.
12. Connect the electrical connector to the Throttle Body.
13. Attach the air intake to the Venturi Adapter.
14. Inspect all mating surfaces ensuring that all components and gaskets are properly seated and no air leaks may exist.
15. Reconnect negative battery cable.
16. Start Engine and verify correct operation in all throttle ranges.
17. Using the DST, clear DTC information from the ECM.
18. Turn the Ignition OFF and wait 30 seconds.
19. Start the engine and let run until it reaches normal operating temperature. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XVIII. THROTTLE BODY ADAPTER AND/OR GASKET

REMOVAL PROCEDURE



The Throttle Body Adapter, shown mounted to the Intake Manifold with the Throttle Body and Gasket removed.

1. Disconnect the negative battery cable. Remove Venturi Adapter/Throttle Body assembly. Refer to XVII. VENTURI ADAPTER/THROTTLE BODY.
2. Remove Throttle Body/Throttle Body Adapter seal.
3. Remove four screws securing the Throttle Body Adapter to the Intake Manifold and remove Adapter and Gasket.

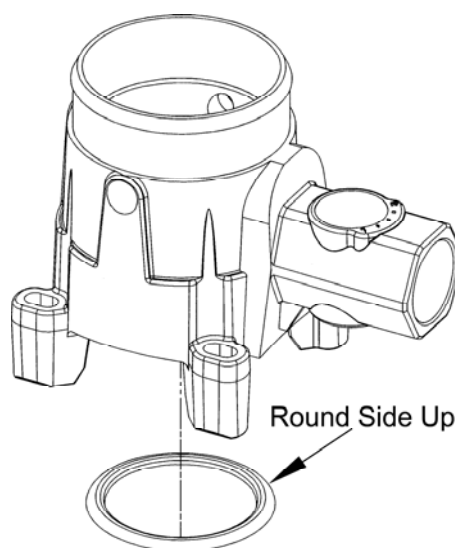
IMPORTANT: Place tape, a clean cloth or some other covering over the Intake Manifold to prevent debris from entering the engine and causing permanent engine damage.

INSTALLATION PROCEDURE

1. Place Gasket on top of Intake Manifold.
2. Insert four Screws on the Intake Manifold and **torque to 7-9 ft.lbs. (9.5-12.2 Nm).**
3. Replace Throttle Body and Adapter. Refer to Venturi Adapter/Throttle Body assembly Refer to XVII. VENTURI ADAPTER/THROTTLE BODY.
4. Inspect all mating surfaces ensuring that all components and gaskets are properly seated and no air leaks may exist.
5. Reconnect the negative battery cable.
6. Start Engine and verify correct operation in all throttle ranges.

7. Using the DST, clear DTC information from the ECM.
8. Turn the Ignition OFF and wait 30 seconds.
9. Start the engine and let run until it reaches normal operating temperature. If a DTC code is found, refer to the Electrical Section for further diagnosis

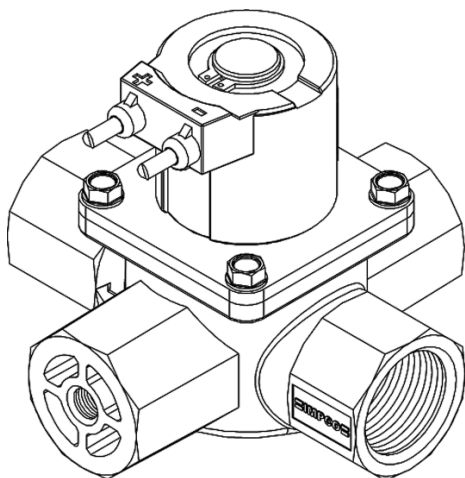
XIX. VENTURI ADAPTER/THROTTLE BODY SEAL REPLACEMENT



The Venturi Adapter/Throttle Body Gasket is inserted into the bottom of the Venturi Adapter, round or curved side up.

1. Completely remove the old Seal, using care not to scratch or damage the inside of the Adapter or the Venturi.
2. Verify that the Seal seat on the Venturi Adapter is clean and free of grease.
3. Apply Loctite 480 to the top (round or curved side) of the Seal and insert into the Venturi Adapter, ensuring the Seal is properly seated. Remove any excess Loctite 480 around the Seal using acetone.
4. Mount the Venturi Adapter on top of the Throttle Body in the proper clock position. Refer to XVII. VENTURI ADAPTER/THROTTLE BODY.

XX. SHUT-OFF VALVES



One of the two low pressure fuel Shut-off Valves

REMOVAL PROCEDURE

1. Relieve the fuel system pressure. Refer to *XXVI. FUEL SYSTEM PRESSURE RELIEF*.
2. Disconnect the negative battery cable.
3. Disconnect Shut-Off Valve electrical connectors.
4. Disconnect fuel inlet line.
5. Remove Shut-Off Valve, 90° Elbow and Fuel Line Fitting as an assembly by unscrewing the Elbow at the threaded port located at the top of the Regulator.
6. Remove 90° Elbow and Fuel Line Fitting from the Shut-Off Valve.

INSTALLATION PROCEDURE

1. Add Loctite 567 or equivalent thread sealer to all male pipe threads, including the Elbow, Hose Adapter, Fuel Inlet Fittings, etc.



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.

2. Connect Elbow and other fittings, making sure that the Elbow has the correct orientation to the Shut-Off Valve.

3. Connect Elbow, Shut-Off Valves and Fuel Pipes together. **Torque until tight**, then continue until each component is aligned to its proper clock position.
4. Make electrical connections to the Shut-off Valves.
5. Connect the Fuel Inlet Line to the Shut-Off Valve Fitting.
6. Reconnect negative battery cable.
7. Slowly turn the Fuel Supply Valve ON. Check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
8. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
9. If a DTC code is found, refer to the Electrical Section for further diagnosis

TEST PROCEDURE

1. Close the fuel source valve.
2. Start and run the engine until the engine stalls from lack of fuel.
3. Turn the ignition switch to OFF.
4. Remove the plug from the pipe nipple after the second Shut-off Valve.



WARNING

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

5. Zero and/or calibrate the test gauge.
6. Connect then test port fitting to the plug opening, then connect a hose and the gauge to the fitting.
7. Slowly turn the Fuel Supply Valve ON.
8. Start engine and note pressure reading on gauge. If the fuel pressure noted was close to zero and/or the engine fails to start, check electrical connection on both Shut-off Valves. Refer to the *Minimum and Maximum Recommended Inlet Pressure Specifications* for additional information on testing the Shut-Off Valves.
9. Turn engine and Ignition switch to OFF.
10. Close the fuel Source valve.

11. Start and run the engine until the engine stalls from lack of fuel.
12. Remove the test port fitting, Hose and gauge. Apply Loctite 567 or equivalent thread sealer to male threads on the plug and Replace.



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.

13. Slowly turn the Fuel Supply Valve ON.
14. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
15. If a DTC code is found, refer to the Electrical Section for further diagnosis

XXI. FUEL SUPPLY PRESSURE TEST

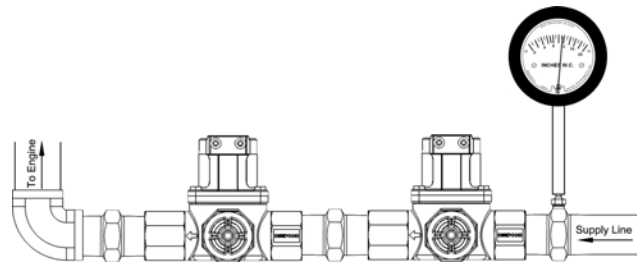
1. Turn the Manual Supply Valve to OFF and Relieve the system fuel pressure. Refer to XXVI. FUEL PRESSURE RELIEF.
2. Remove the plug on the Test Port Fitting between the Manual Supply Valve and the first Shut-off Valve.



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 test gauge.
5. Attach the hose to the test port fitting and the 0-20" W.C. gauge. Note that the test port fitting, hose and gauge are included with test kit, ITK-1-IND.
6. 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.

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



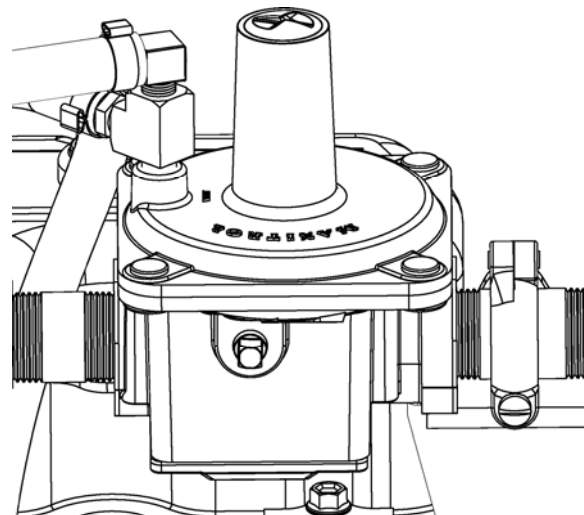
WARNING

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

9. Apply Loctite 567 to the test port plug and insert into the test port. **Torque until tight.**
10. Refer to XX. 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.

XXII. LOW PRESSURE REGULATOR

Important: The Low Pressure Regulator features tamper resistant caps and fasteners and cannot be serviced, rebuilt or adjusted.



The Low Pressure Regulator

REMOVAL PROCEDURE

1. Turn off fuel source and Relieve the fuel system pressure. Refer to *XXVI. FUEL SYSTEM PRESSURE RELIEF*.
2. Disconnect Negative battery cable.
3. Disconnect hoses attached to the brass T 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.
6. Remove the Venturi Adapter, fuel pipes (including the Fuel Selector Switch) and Regulator together as an assembly. Refer to *XVII. VENTURI ADAPTER/THROTTLE BODY*.

Note: Be sure to spin the Regulator on the pipe and avoid placing any side pressure on the Regulator that may damage the Venturi Adapter or one of its seals.

7. Remove the fuel pipes attached to the Regulator.
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 all male threads of the fuel pipes.



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.

2. Assemble the fuel pipes and elbow in the regulator and **torque until tight**.

NOTE: The longer pipe is attached to the inlet side of the Regulator and the shorter one to the outlet side.

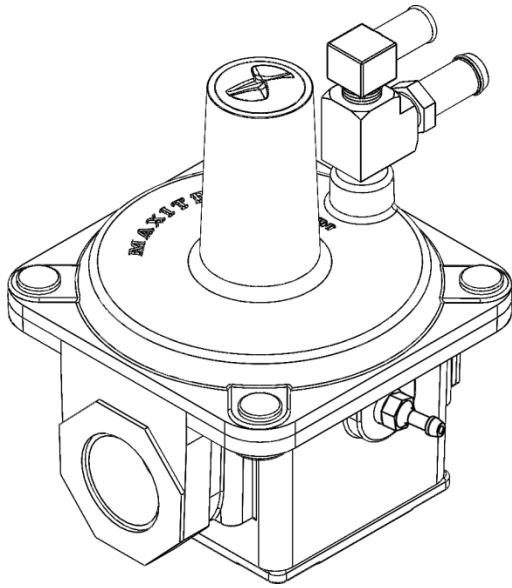
3. Insert the fuel pipe end of the Regulator and fuel pipe assembly into the Venturi Adapter and **torque until tight**, then continue to turn

so the Regulator and Venturi Adapter are in the same clock position.

Note: Be sure to spin the Regulator on the pipe and avoid placing any side pressure that may damage the Venturi Adapter or one of its seals.

4. Attach the elbow and fuel hose barb to the fuel pipe.
5. Place the assembly on top the Throttle Body. Refer to *XVII. VENTURI ADAPTER/THROTTLE BODY*.
6. Secure fuel pipe to bracket. **Torque screws to 30-36 ft.lbs. (41-49 Nm)**.
7. Place the elbow on the fuel pipe and turn until tight, then continue to turn until it is positioned in line with the fuel hose.
8. Place Loctite 567 or equivalent thread sealer on threads of the hose barb. Insert into elbow and **torque until tight**.
9. Place Loctite 567 or equivalent thread sealer on the threads of the brass T and insert into the top of the regulator. **Torque until tight**, then continue turning until the T is pointed towards the engine.
10. Place Loctite 567 or equivalent thread sealer on the threads of the Vacuum hose barb adapter. Insert into the brass T and **torque until tight**.
11. Place Loctite 567 or equivalent thread sealer on the male threads of the nylon elbow, then insert into brass T. **Torque until tight**, then continue to turn until it points to the Fuel Control Valve.
12. Place Loctite 567 or equivalent thread sealer on the male threads of the nylon elbow, then insert into brass T. **Torque until tight**.
13. Reconnect vacuum hoses to the barb fittings. The Fittings may require some minor turning to meet the direction of the hoses.
14. Reconnect negative battery cable.
15. Slowly turn the Fuel Supply Valve ON.
16. 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.
17. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XXIII. REGULATOR TEST PORT/OUTLET FUEL PRESSURE



The Regulator with Test Port Installed.

1. Turn the Fuel Supply Valve to OFF and Relieve the fuel system pressure. Refer to **XXVI. FUEL SYSTEM PRESSURE RELIEF.**
2. Disconnect the negative battery cable.
3. Remove one of the two test port plugs (one is on each side of the pressure regulator).
4. Insert the test port fitting (included in the test kit ITK-1-IND) and connect the hose to the test port and 0-10" W.C. gauge.
5. Reconnect the negative battery cable.
6. Slowly turn the Fuel Supply Valve ON.
7. Start the engine and note the fuel pressure. Refer to the *Minimum and Maximum Recommended Inlet Pressure Specifications.*
8. Turn the Fuel Supply Valve OFF and relieve the fuel system pressure. Refer to **XXVI. FUEL SYSTEM PRESSURE RELIEF.**
9. Remove gauge, hose and Test Port Fitting



WARNING

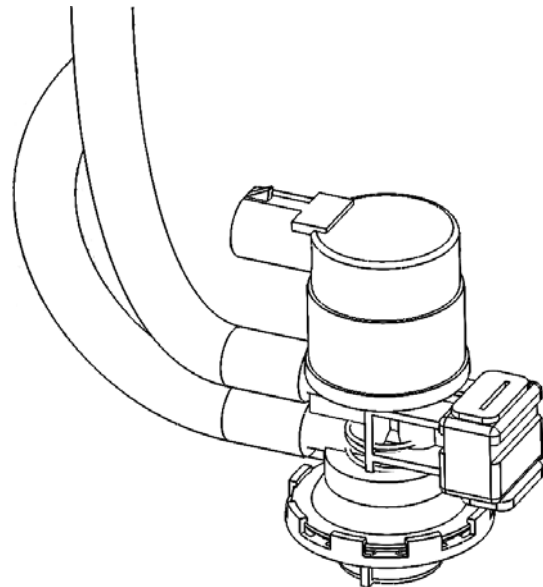
Residual vapor pressure will be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

10. Apply Loctite 567 or equivalent thread sealer to male threads on the plug and

Replace. **Torque to tight.**

11. Slowly turn the Fuel Supply Valve ON
12. 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.
13. If a DTC code is found, refer to the Electrical Section for further diagnosis.

XXIV. FUEL CONTROL VALVE



The Fuel Control Valve, Shown with Hoses.

REMOVAL PROCEDURE

1. Disconnect the negative battery cable.
2. Disconnect electrical connector
3. Disconnect Vacuum Hoses
4. 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. Connect the negative battery cable.
5. 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.

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

XXV. FUEL CONTROL VALVE BRACKET

REMOVAL PROCEDURE

1. Remove Screws securing the Bracket and remove Bracket.

INSTALLATION PROCEDURE

1. Place Bracket on top of the Main Bracket, align in position and secure with two Screws. **Torque to 4-6 ft.lbs. (5.4-8.1Nm).**

XXVI. FUEL SYSTEM PRESSURE RELIEF

1. Turn the Fuel Supply Valve to OFF.
2. Start and run the engine until the engine stalls from lack of fuel.
3. Turn the engine and Ignition switch to OFF.
4. Disconnect the negative battery cable.



WARNING

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



WARNING

Never use an open flame of any type to check for fuel 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.

XXVII. FUEL SYSTEM LEAK TEST

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

IMPORTANT

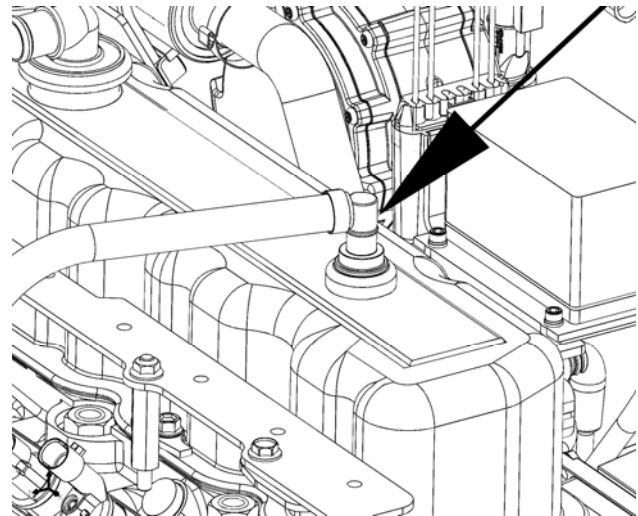
When using both methods, use the electronic leak detector first to avoid contamination by the liquid leak detector.

2. If leaks are detected, make repairs

XXVIII. FUEL CONTROL SYSTEM CHECK

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

XXIX. CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS



The PCV, shown mounted on top of the valve cover.

Refer to *Crankcase Ventilation System Inspection/Diagnosis Results of Incorrect Operation* 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 or valve cover.
2. Operate the engine under 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.

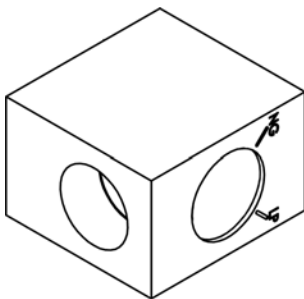
FUNCTIONAL CHECK

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 under 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.

Also refer to the *CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS RESULTS OF INCORRECT OPERATION*.

XXX. FUEL SELECTOR SWITCH



Fuel Selector Switch (shown with expansion plug)

Fuel Selector Switch

NOTE: The Fuel Selector Switch is factory set using a special tool and cannot be changed.

REMOVAL

1. Remove the Low Pressure Regulator assembly, including the pipes and Fuel Selector Switch. Refer to *XXII. LOW PRESSURE REGULATOR*.
2. Remove the Pipes on both sides of the Fuel Selector Switch.

INSTALLATION

1. Verify that the Fuel Selector Switch is set for the correct fuel and install the expansion plug.
2. Apply Loctite 567 to the male threads of the Fuel Pipes.
3. Thread the pipes into each side of the Fuel Selector Switch and torque until tight.
3. Reinstall the Low Pressure Regulator assembly. Refer to *XXII. LOW PRESSURE REGULATOR*.

XXXI. COOLANT HOSE

REMOVAL PROCEDURE

1. Drain coolant.



WARNING

Do not remove the cooling system pressure cap (radiator cap) or another coolant system component 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 Hose Clamps from both ends and remove.

INSTALLATION PROCEDURE

IMPORTANT

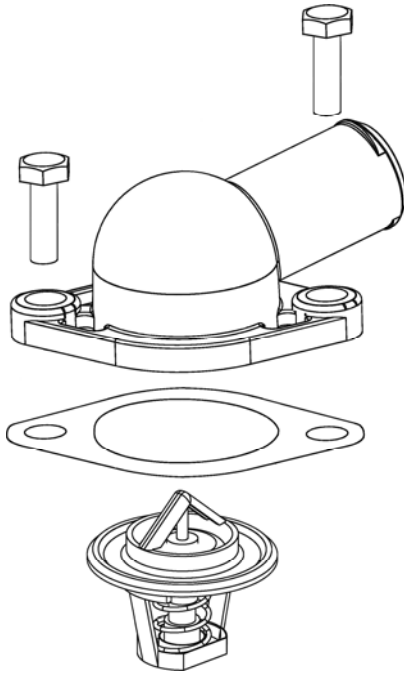
Coolant hoses are specifically designed for a specific application. **DO NOT** use hose material or length other than the OEM specified parts. **DO NOT** mix the inlet or outlet ends of the Hose when reinstalling.

1. Slide Clamps over each end of the Hose.
2. Place Hose over each barb, ensuring the hose is relaxed and not twisted or kinked.
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.

XXXII. THERMOSTAT & HOUSING



Thermostat, housing, gasket and bolts.

REMOVAL PROCEDURE

1. Drain Coolant.



WARNING

Do not remove the cooling system pressure cap (radiator cap) or another coolant system component 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 coolant may be hot. Use caution to prevent contact.

2. Remove radiator hose from thermostat housing.
3. Remove two bolts securing the thermostat housing and remove housing, gasket and thermostat.

INSTALLATION PROCEDURE

1. Clean gasket mounting surfaces and place the thermostat in place and a new gasket on top.
2. Place the thermostat housing on top the gasket, align the housing and gasket to the holes and insert bolts. **Torque the bolts to 21 ft.lbs (28Nm).**
3. Attach radiator hose to thermostat housing and secure with clamp.
4. Refill coolant.
5. Start engine and inspect for coolant leaks. Repair if necessary.
6. Allow engine to cool and add coolant if necessary.

XXXIII. FUEL VAPOR HOSE

REMOVAL PROCEDURE

1. Relieve the fuel system pressure. Refer to *XXVI. FUEL SYSTEM PRESSURE RELIEF.*
2. Disconnect negative battery cable.
3. Remove Hose Clamps.
4. Remove Hose from barbs at both ends.



WARNING

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

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

10. Slide Hose Clamps over each end and towards the middle of the Fuel Hose.
11. Place Fuel Hose over each barb, ensuring the hose is relaxed and not twisted or kinked.
12. 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.

13. Slowly turn the Fuel Supply Valve ON.
14. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs.
15. If a DTC code is found, refer to the Electrical Section for further diagnosis

XXXIV. 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.

XXXV. OETIKER CLAMPS



A Used or Compressed Oetiker Hose Clamp

IMPORTANT

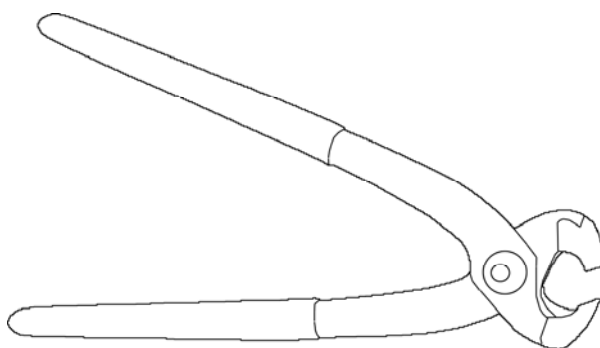
Oetiker Clamps can be used only once. Once removed, they can no longer be reused and should be discarded.

REMOVAL PROCEDURE

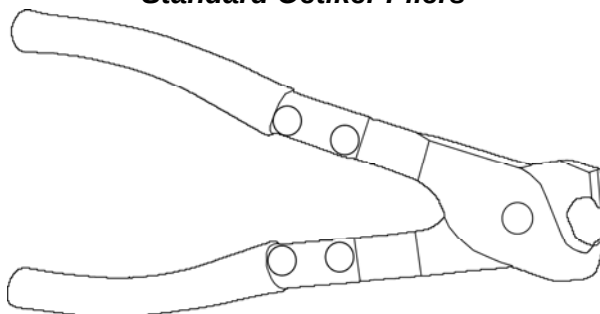
1. Place the pincer jaws or diagonal wire cutters across the ear and cut through it.
2. Remove clamp and discard.

INSTALLATION PROCEDURE

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



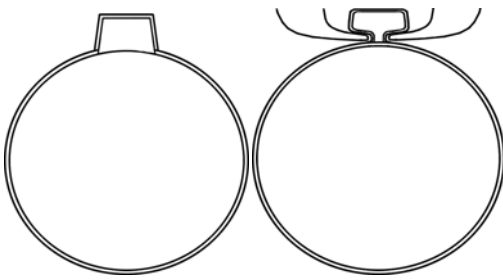
Standard Oetiker Pliers



Side Jaw Oetiker Pincers

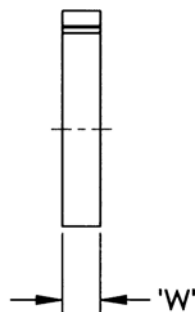
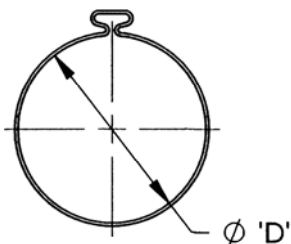
Only use recommended tools to close Oetiker clamp ears. The ears of the clamp should be closed with a uniform force, sufficient to pinch the two sides of the ear together while applying enough compression on the hose to keep it snug on the barb without crushing. The deformation of the clamp ear provides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

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.

1. Always inspect the hose connections 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 -15.7
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.

XXXVI. MAIN BRACKET ASSEMBLY

REMOVAL PROCEDURE

1. Remove Fuel Control Valve and Bracket. Refer to XXIV. *FUEL CONTROL VALVE* and XXV. *FUEL CONTROL VALVE BRACKET*.
2. Remove the nut securing the bracket to the stud located towards the front of the engine.
3. Remove the two bolts and nuts on the Upper Support Bracket near the back of the engine.
4. Remove the Nut securing the Upper Support Bracket near the rear of the engine and the Nut on the heat shield. Remove heat shield.
5. Remove two Screws securing the Main Supporting Bracket and remove bracket.

INSTALLATION PROCEDURE

1. Mount the Upper Support Bracket and Heat Shield on Stud and secure with Nut and **torque to 30.4-36.1 ft.lbs. (41-49Nm)**.
2. Thread in Stud near front of engine and **torque to 27.3-33.2 ft.lbs. (37-45Nm)**.
3. Replace the Fuel Control Valve and Bracket. Refer to XXIV. *FUEL CONTROL VALVE* and XXV. *FUEL CONTROL VALVE BRACKET*.

XXXVII. INTAKE & EXHAUST MANIFOLDS AND/OR GASKET



WARNING

The Exhaust Manifold, engine and other components may be hot. Allow the engine to cool prior to servicing and use caution when removing these components to prevent contact when hot.

1. Remove Vacuum Hoses from the top of the Intake Manifold. Refer to XXXIV. *VACUUM HOSE*.
2. Remove four screws securing the Throttle Body Adapter to the intake Manifold. Refer to XVII. *VENTURI ADAPTER/THROTTLE BODY* and XVIII. *THROTTLE BODY ADAPTER AND/OR GASKET*.
3. Remove two screws securing Maxifuse and Maxifuse Mount and remove.
4. Remove nuts and screws securing Heat Shields to the manifolds.
5. Remove TMAP from Intake Manifold. Refer to VII. *TEMPERATURE MANIFOLD PRESSURE*

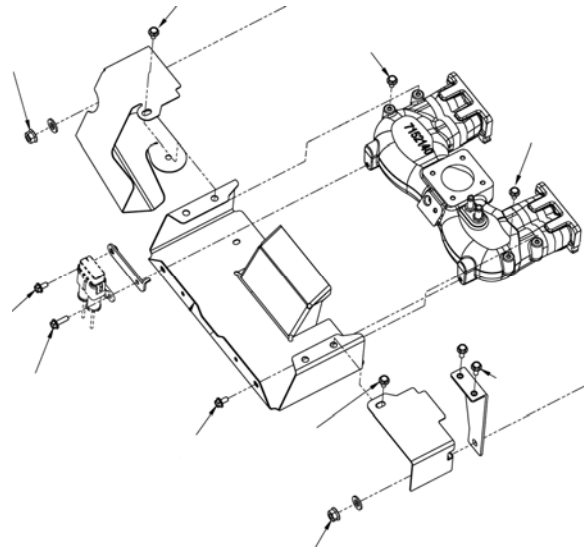
SENSOR (TMAP).

6. Remove HEGO. Refer to IX. *HEATED EXHAUST GAS OXYGEN SENSOR (HEGO)*.
7. Remove the exhaust pipe connection with the Exhaust Manifold.
8. Remove remaining four screws that secure the manifolds.
9. Remove Intake and Exhaust Manifolds.
10. Remove Gasket.

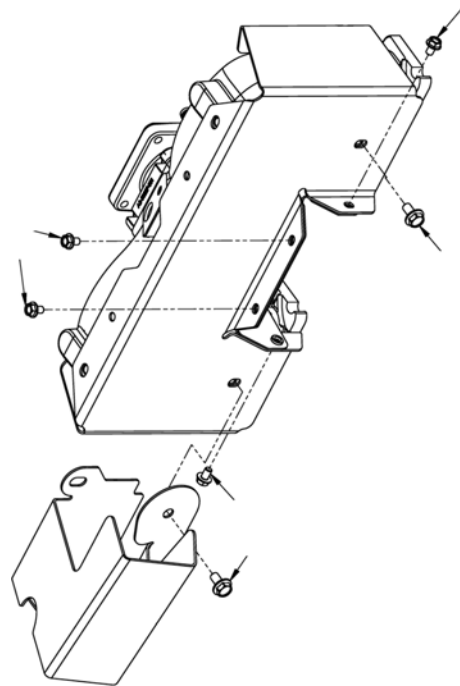
INSTALLATION PROCEDURE

Clean the Manifolds and inspect for the following:

1. Damage to the gasket sealing surfaces.
2. Cracks or damage.
3. Damage to threaded bolt holes.
4. Place Gasket on the engine.
5. Place the Exhaust Manifold over the studs.
6. Apply anti-seize compound to the studs and four screws that secure the Intake and Exhaust Manifolds.
7. Place the Intake Manifold against block and secure with four bolts. **Torque to 30-36 ft.lbs. (41-49 Nm).**
8. Starting with the large center one shield, install nuts and screws securing Heat Shields to the manifolds, including the Maxifuse and its mounting Bracket. **Torque Screws to 7-9 ft.lbs. (9.5-12.2 Nm) and Nuts to 30-36 ft.lbs. (41-49 Nm).**
9. Connect Exhaust Manifold to Exhaust Pipe.
10. Install HEGO. Refer to IX. *HEATED EXHAUST GAS OXYGEN SENSOR (HEGO)*.
11. Install TMAP Sensor on the Intake Manifold. Refer to VII. *TEMPERATURE MANIFOLD PRESSURE SENSOR (TMAP)*.



Heat shield assembly, showing fasteners (top view).



Heat shield assembly, showing fasteners (bottom view).

1. Secure Throttle Body Adapter to the Intake Manifold with four screws Refer to XVII. *VENTURI ADAPTER/THROTTLE BODY* and XVIII. *THROTTLE BODY ADAPTER AND/OR GASKET*.
2. Install vacuum lines to the barbs on the Intake Manifold and secure with new clamps.
3. Start engine and check for leaks around the Intake Manifold, Thermostat housing, Oil Sensor and all other serviced fittings and

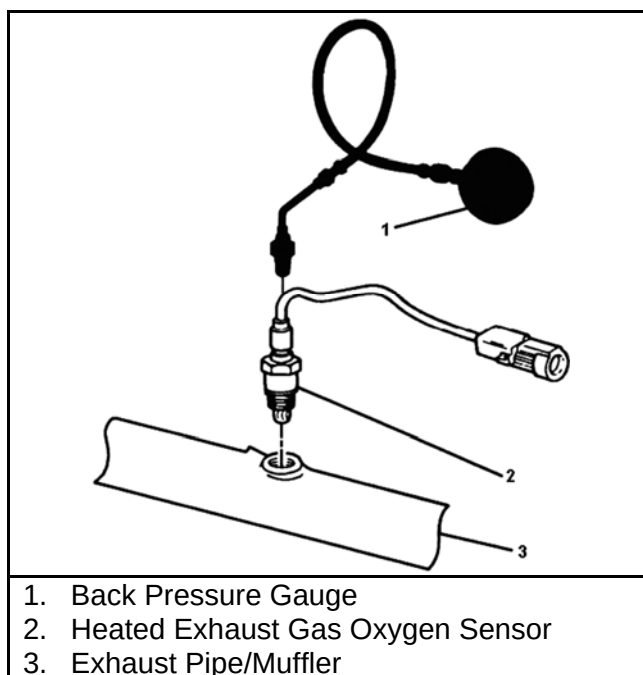
components. If leaks are found, repair as necessary.

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

XXXVIII. RESTRICTED EXHAUST SYSTEM DIAGNOSIS

TEST PROCEDURE

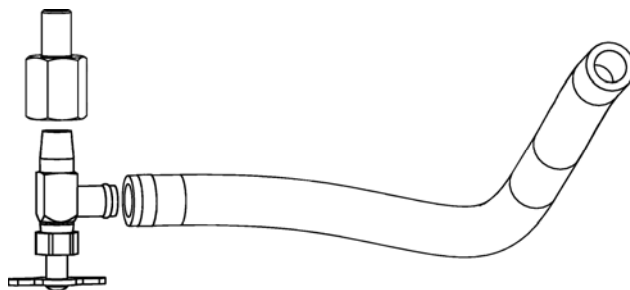
1. Carefully remove the HEGO.
2. Install Exhaust Back Pressure Test Gauge (J35314-A) in place of the HEGO.
3. Run the engine at 1,800 RPM with no more than 25% load and observe gauge. Reading should not exceed 13.8 kPa (2 psi).
4. If the back pressure exceeds specification, a restricted exhaust system is indicated.
5. Inspect the entire exhaust system for a collapsed pipe or heat distress.
6. Connect DST and look for closed loop operation as shown by switching of the HEGO.
7. If a DTC code is found, refer to the Electrical Section for further diagnosis.



Exhaust Back Pressure Test

1. Reinstall the Vacuum Hose to each fitting and secure with clamp, if used originally.
2. Start engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected make repairs.

XXXIX. 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.

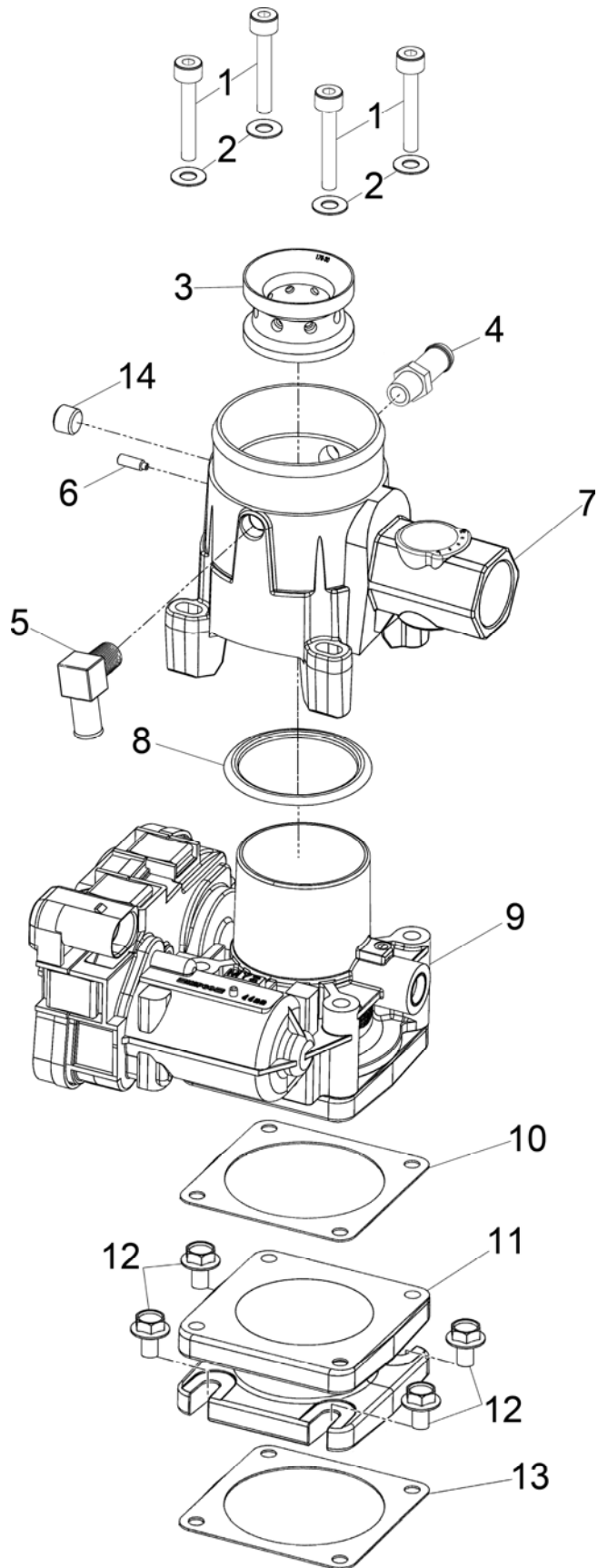
1. Drain Oil. Refer to *Changing the Oil* in the General Information section.
2. Remove Hose Clamp and Hose from Drain Valve.
3. Remove Drain Valve and Adapter together by turning the Adapter counterclockwise.
4. Remove Valve from Adapter.
5. Catch any oil dripping from the oil pan and any other oil spilled and dispose of oil in a safe and responsible 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 $\frac{1}{4}$ " from the end of the hose. Refer to XXXV. *Oetiker Clamps*.
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.
7. If a DTC code is found, refer to the Electrical Section for further diagnosis.

Service Parts Manual

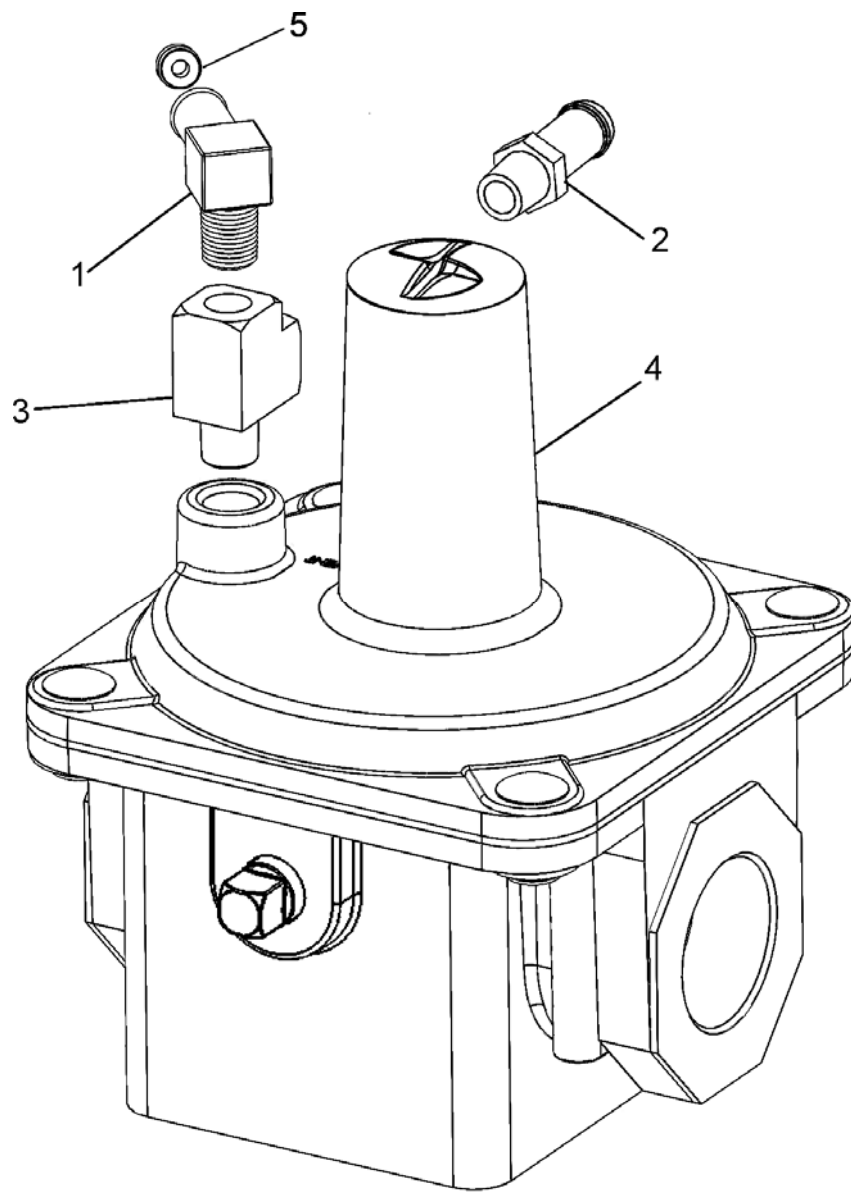
VENTURI AND THROTTLE BODY ASSEMBLY



VENTURI AND THROTTLE BODY ASSEMBLY

Item #	Description	Qty	Part Number
1	Screw, socket HD M6 x 75mm	4	S1-30295-0675
2	Washer, Conical M6	4	W1-31039-006
3	Venturi	1	V4-51758-08-136-03
4	Fitting 1/8 NPT 3/8 Hose Brass	1	2H-103B
5	Fitting 1/8 NPT 3/8 Hose 90 Elbow Nylon	1	F4-12
6	Screw, Set, Dogpoint	1	S1-30327-0412
7	Adapter, Venturi to Throttle Body	1	AA3-50029-003
8	Seal, Adapter to 44mm Throttle Body	1	S3-50033-001
9	Throttle Body, 44mm	1	AT2-50010-44
10	Gasket, Throttle Body Mixer	1	G1-21
11	Adapter, Intake to Throttle Body	1	A3-50227-001
12	Screw	4	S1-30871-02-0620
13	Gasket, Bosch	1	G1-50449-001
14	Plug, 1/8" NPT	1	P3-46

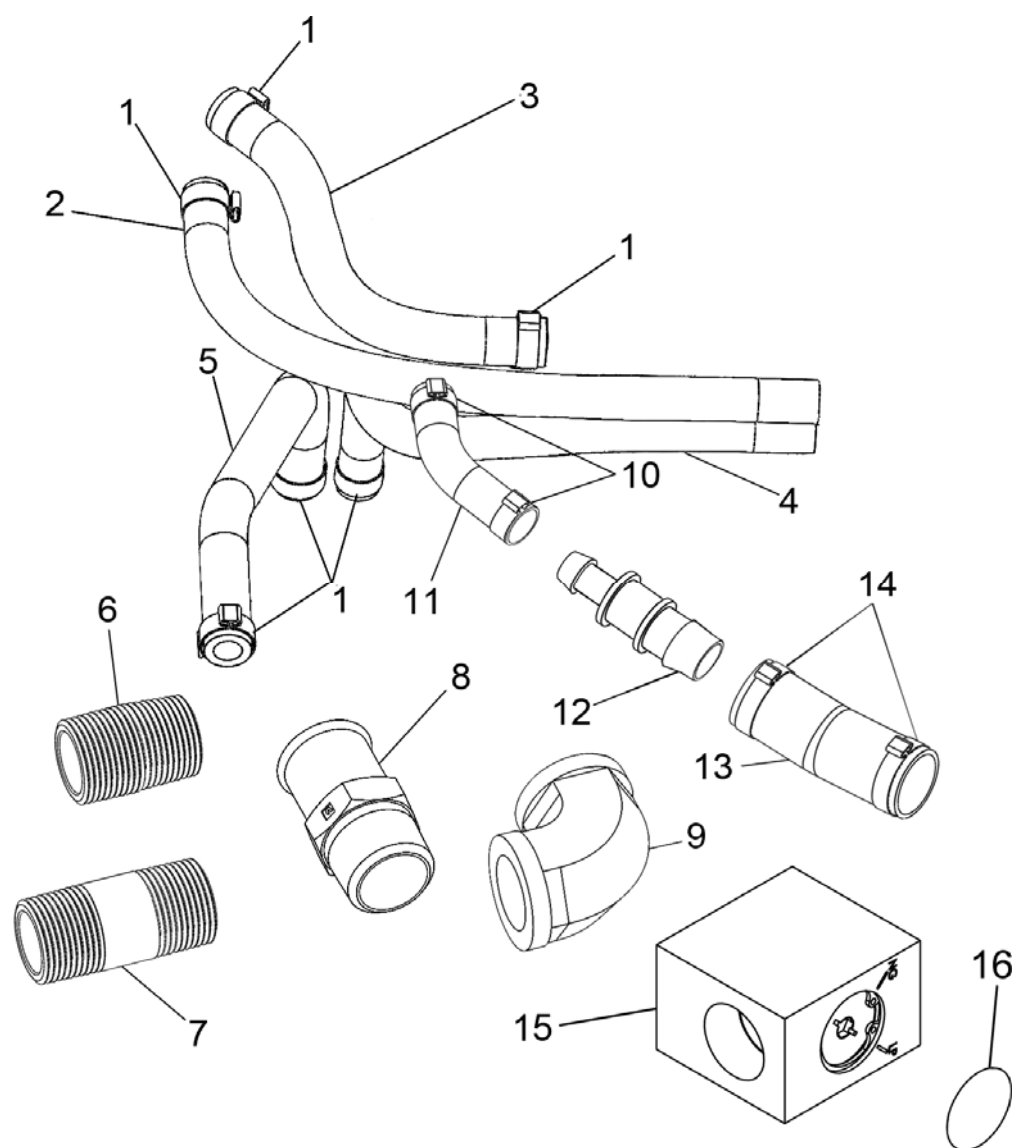
REGULATOR



REGULATOR

Item#	Description	Qty	Part Number
1	Fitting, 1/8 NPT x 3/8 90 Nylon	1	F4-12
2	Fitting, 1/8 NPT x 3/8 Hose Brass	1	2H-103B
3	Fitting, 1/8 NPT Street T Brass	1	3750X2
4	Regulator	1	AR7-51949-001
5	Jet, Feed Back	1	J1-21

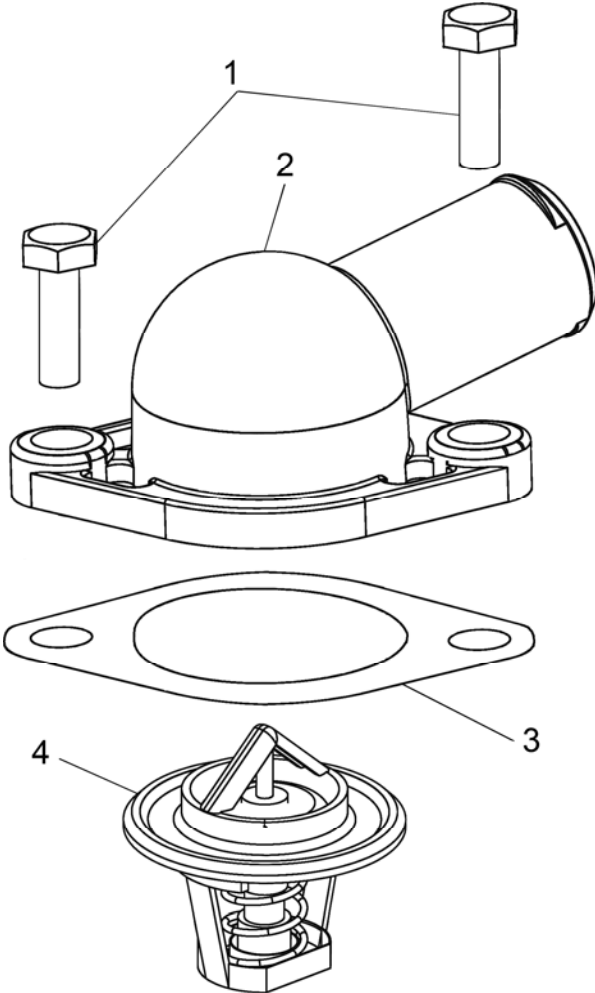
VACUUM/FUEL HOSES



VACUUM/FUEL HOSES

Item #	Description	Qty	Part Number
1	Ear Clamp	5	C2-51552-07-170
2	Hose, 5/16" ID (299mm) Fuel/Oil FCV to Regulator	1	H1-19231-003-0321
3	Hose, 3/8" ID (210mm) Fuel/Oil FCV to Regulator	1	H1-19231-004-0220
4	Hose, 5/16" ID (179mm) Fuel/Oil Intake to FCV	1	H1-19231-003-0274
5	Hose, 3/8" ID (219mm) Fuel/Oil Intake to PCV	1	H1-19231-004-0220
6	Pipe 1.5" x 3/4" NPT Schedule 80	2	F4-51799-80-0150
7	Pipe 2.5" x 3/4" NPT Schedule 80	1	F4-51799-80-0250
8	Fitting, 3/4 NPT x 1"	1	F4-50498-001
9	Elbow, 3/4 NPT Street 90 Deg	1	F4-51801-001
10	Ear Clamp	2	C2-51552-07-170
11	Hose, 3/8" (74mm) Fuel/Oil FCV to Regulator	1	H1-19231-004-0074
12	Adaptor	1	A4-50082-003
13	Hose, 3/4" ID (81mm) Fuel/Oil Venturi to PCV Elbow	1'	H1-19231-007-0081
14	Ear Clamp	2	C2-51552-07-301
15	Fuel Selector Switch	1	AB1-52055-005
16	Plug, Expansion	1	P3-17956-19

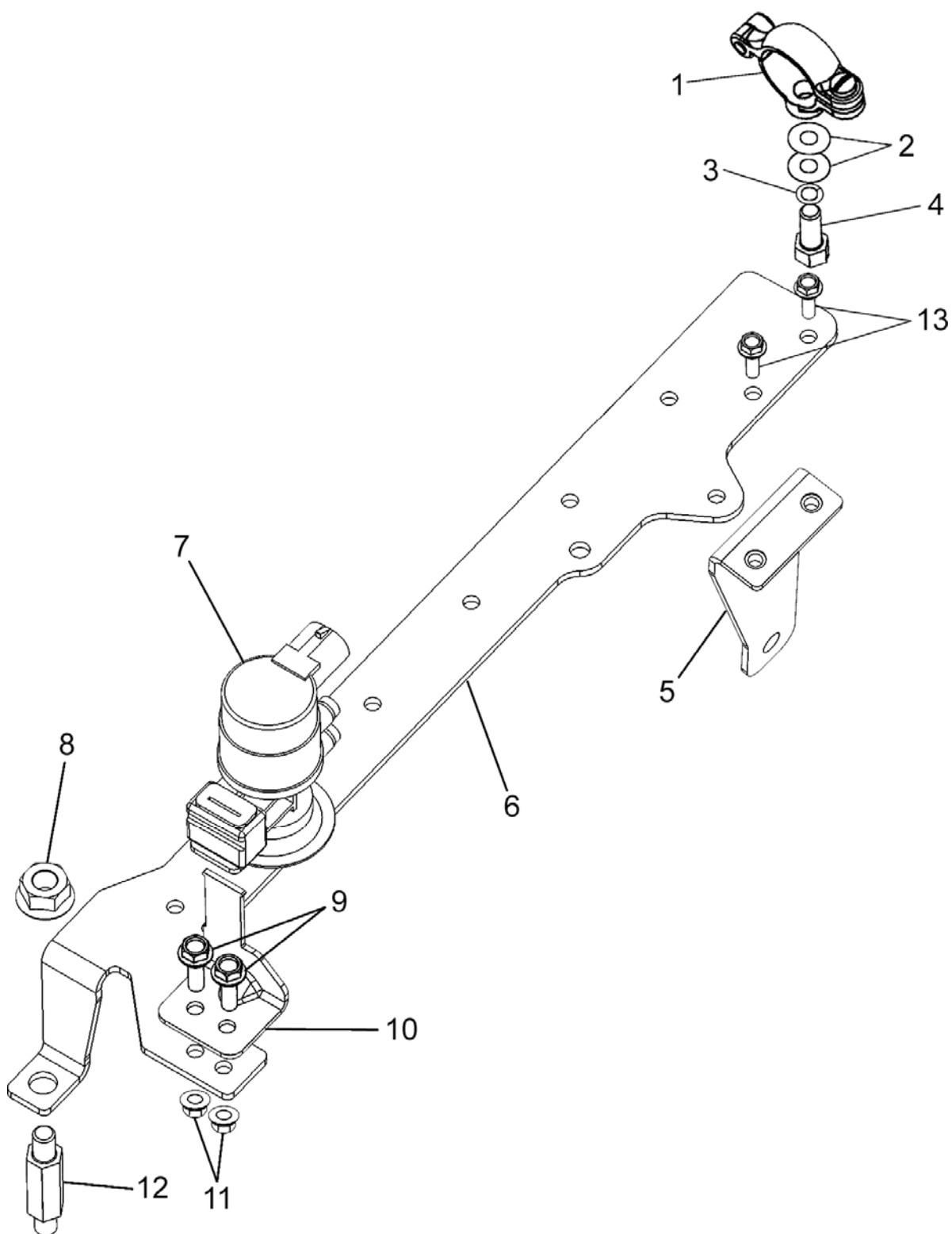
THERMOSTAT & HOUSING



THERMOSTAT & HOUSING

Item #	Description	Qty	Part Number	GM Part Number
1	Bolt	2	09424320	09424320
2	Thermostat Housing	1	7140330	14096853
3	Gasket, Thermostat Housing	1	7140310	10105135
4	Thermostat	1	7140340	10220957

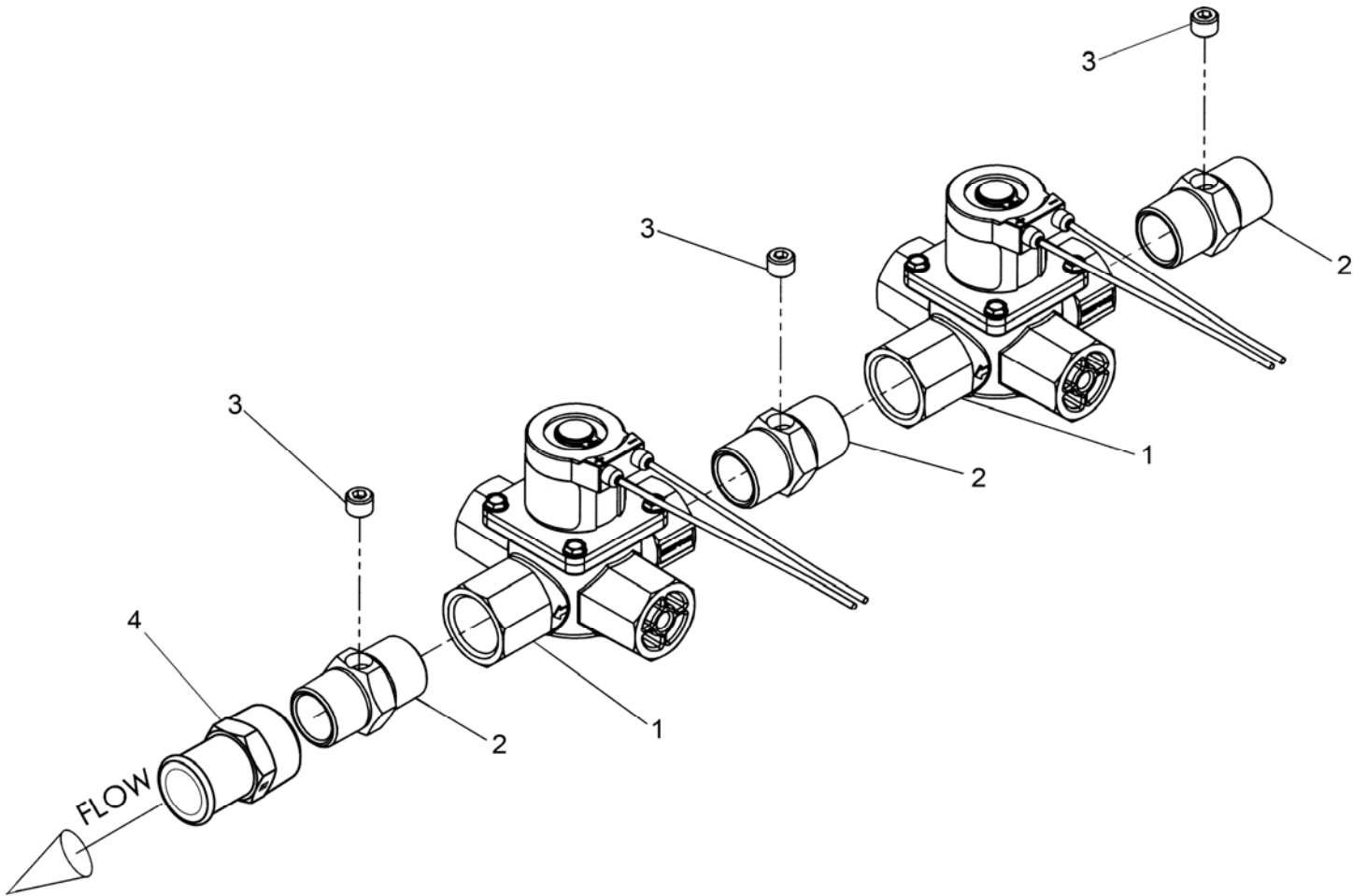
FUEL CONTROL VALVE & BRACKETS



FUEL CONTROL VALVE & BRACKETS

Item #	Description	Qty	Part Number
1	Clamp, Regulator Support	1	C2-51802-001
2	Washer	2	92300000
3	Washer, Lock	1	93300000
4	Bolt	1	90305075
5	Brkt, Support	1	B4-51196-001
6	Bracket, Main	1	B4-51195-001
7	Valve, Regulator Control	1	V3-51771-001
8	Nut, Hex M6 x 1.0	1	N1-30876-037
9	Screw, Hex Flange M5-0.8 x 16	2	S1-50237-20-0516
10	Bracket, PWM Valve, Genset 3.0L	1	B4-51718-001
11	Nut, Hex M6 x 1.0	2	N1-30876-M05
12	Stud, M6 x 40mm	1	S3-50937-001
13	Bolt, Hex 3/8-16x1 Grade 5	2	S1-30871-02-0616

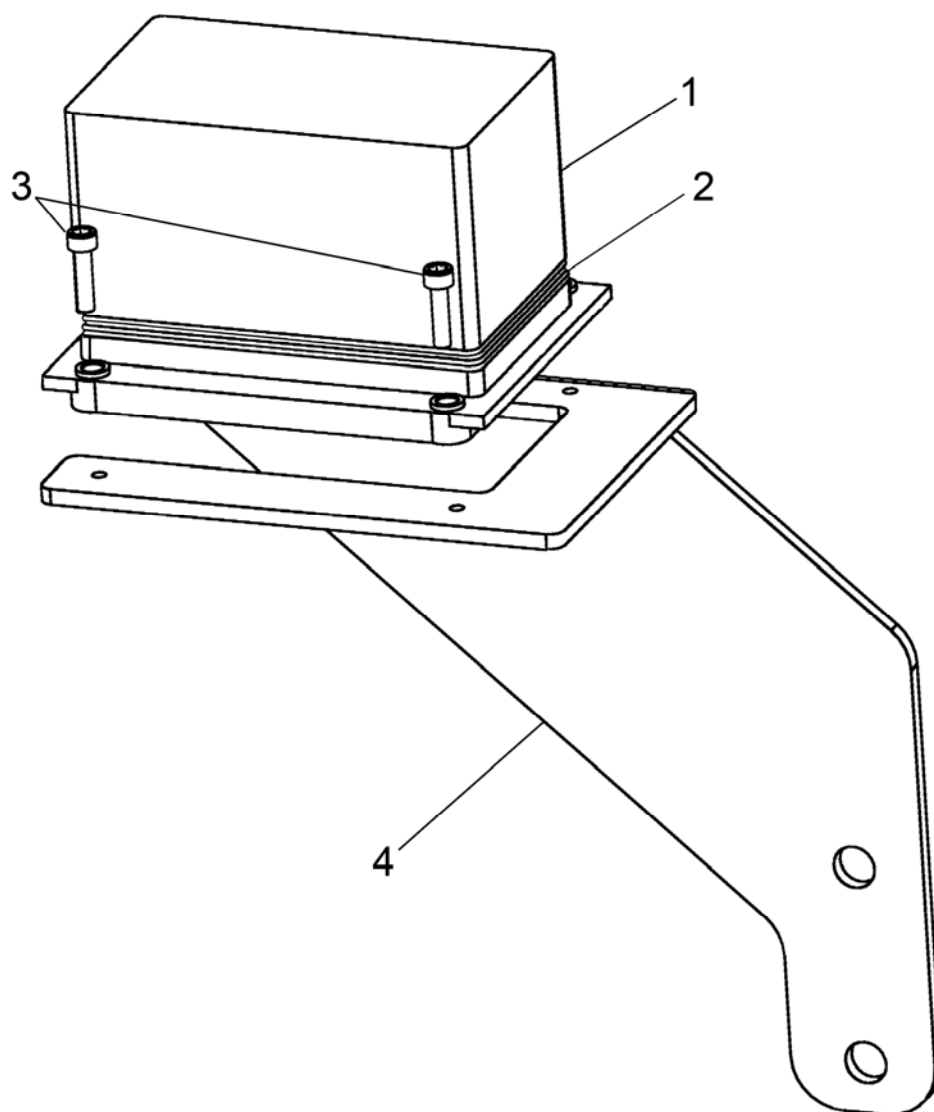
SHUT-OFF VALVES



SHUT-OFF VALVES

Item #	Description	Qty	Part Number
1	Shut-Off (Lock-Off) Valve	2	FL-50046-001
2	Pipe Nipple	3	F4-51904-001
3	Plug, 1/8" NPT Socket Head Brass	3	P3-46
4	Fitting, 3/4 NPT x 1"	1	F4-50498-001

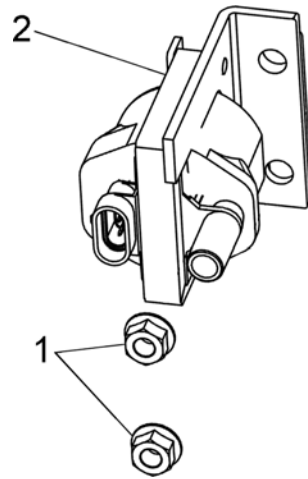
FUSE BOX & BRACKET



FUSE BOX & BRACKET

Item #	Description	Qty.	Part Number
1	Fuse Box Cover	1	C1-52520-001
2	Seal, Fuse Box	1	S3-52522-001
3	Screw, Hex M4 x 16mm	4	S1-30295-0416
4	Bracket, ECM	1	B4-51789-001

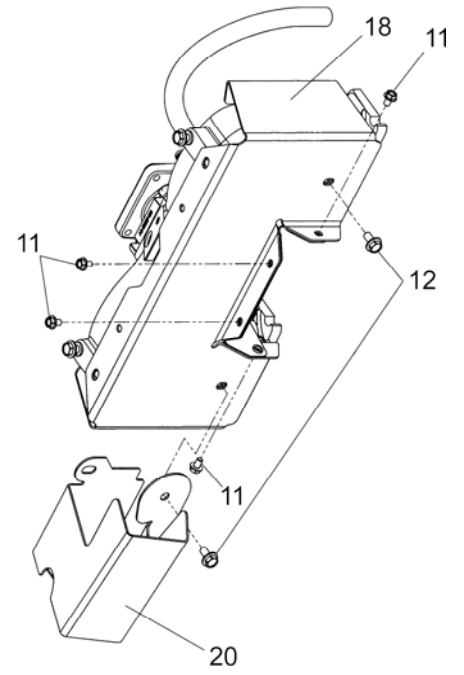
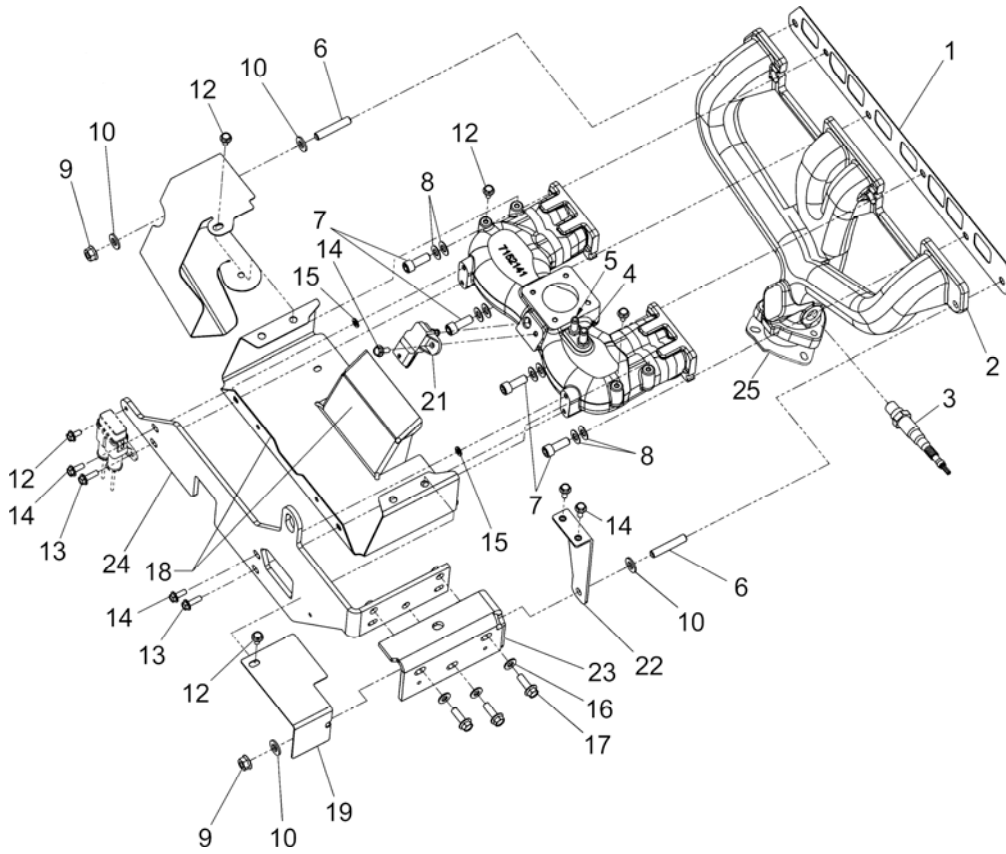
IGNITION COIL



IGNITION COIL

Item #	Description	Qty.	Part Number
1	Nut, Hex Flange Serrated	2	N1-30876-037
2	Coil, Ignition	1	7245530

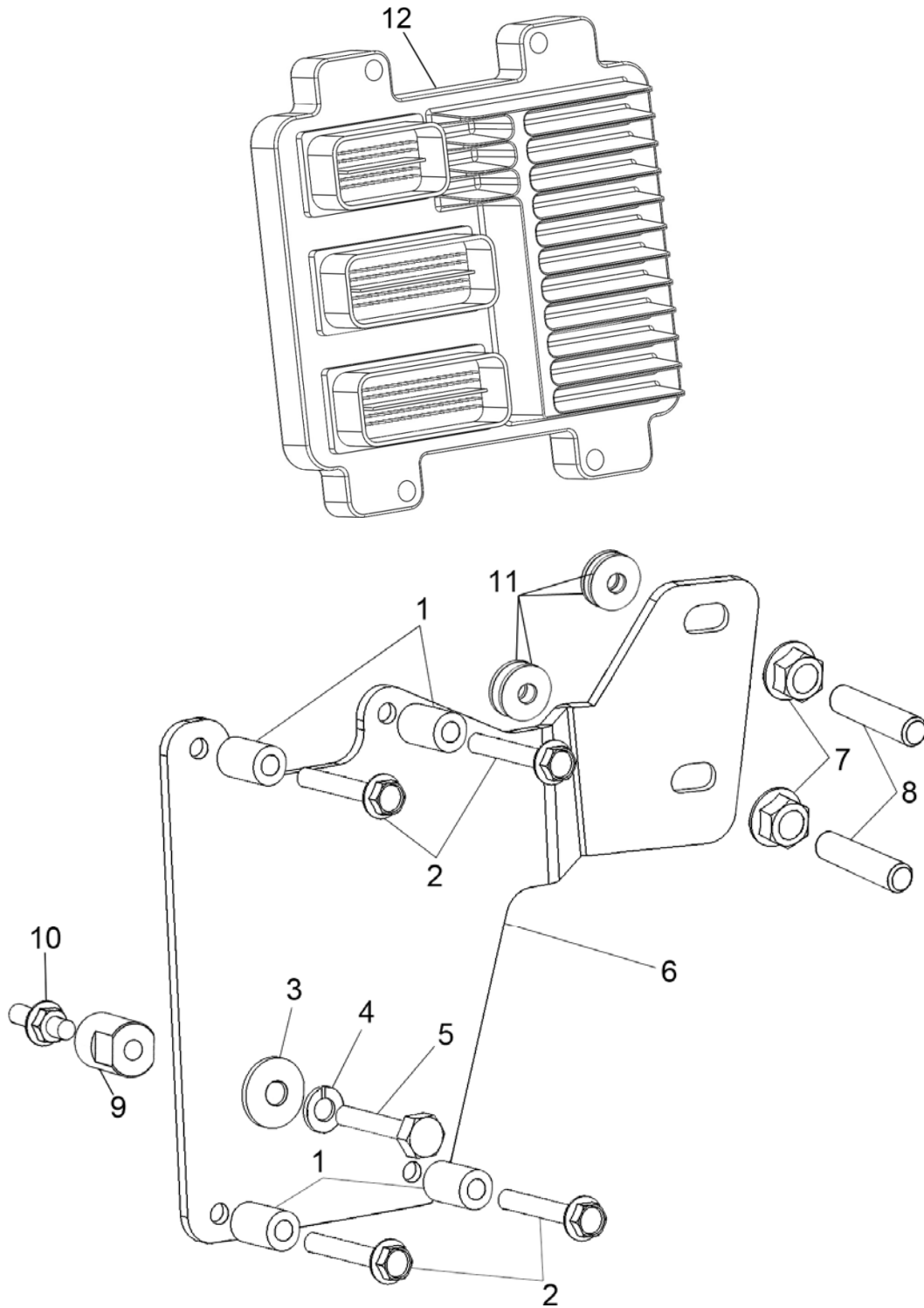
MANIFOLDS



MANIFOLDS

Item #	Description	Qty.	Part Number
1	Gasket, Int/Ext	1	7152170
2	Manifold, Exhaust GM 3.0L	1	7152150
3	Intake Manifold	1	7152141
4	Fitting, 1/8 NPT 3/8 Hose Brass	1	2H-103B
5	Fitting 1/8" NPT 3/8 Hose Plastic	1	15928-1
6	Stud, 3/8-16 x 2"	2	S3-50596-001
7	Bolt, Socket Head 3/8 x 16 Grade 8	4	90368100
8	Washer, Belleville 3/8"	8	W1-50595-037
9	Nut, Serrated	2	N1-30876-037
10	Washer, 3/8 Type A Hard	4	92300101
11	Screw, Hex Flange M5-0.8 8x8	4	S1-50237-20-0508
12	Screw, Hex Flange M6 x 12mm	8	S1-30871-02-0612
13	Screw Hex Flange M6-1.0 x 12mm	5	S1-50237-02-0620
14	Screw, Hex Flange M6-1.0x x 16mm	3	S1-30871-02-0616
15	Washer, Split lock, M6	1	W1-1988-001
16	Washer, Flat M8	1	92930000
17	Screw, Hex Flange, M8 x 25MM	3	S1-30871-02-0825
18	Shield, Heat-GM 3.0L 2 Piece	1	7152160
19	Shield, Heat, 3.0L RB Exhaust, GS	1	G4-52294-001
20	Heat Shield, Alternator 3.0L	1	G4-50068-001
21	TMAP Sensor	1	E1466001
22	Brkt, Support Harness Bracket	1	B4-51196-001
23	Brkt, Support 3.0L	1	B4-52291-001
24	Brkt, Support 3.0L	1	B4-52335-001
25	Gasket, Exhaust Flange	1	7152175

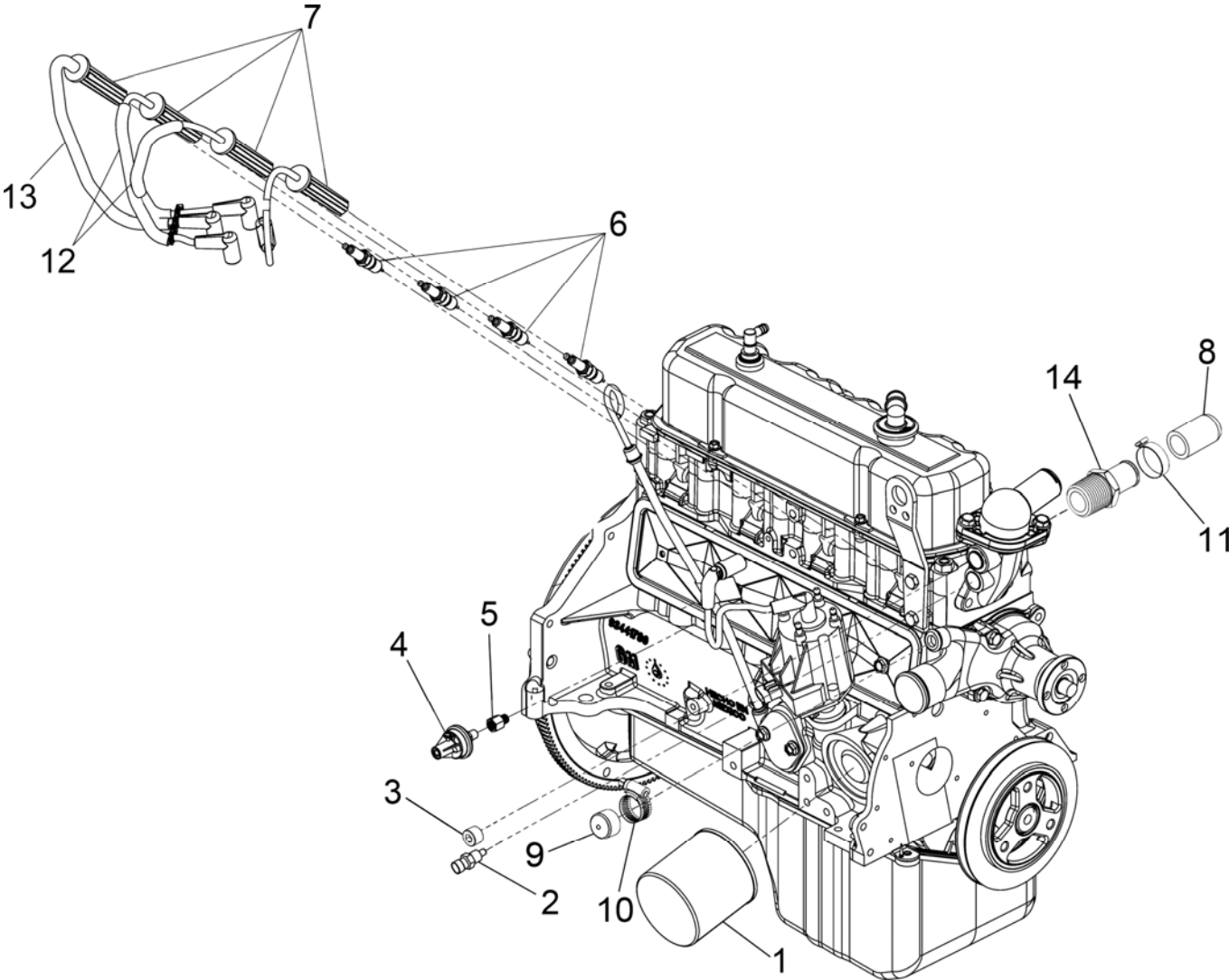
ENGINE CONTROL MODULE & BRACKET



ENGINE CONTROL MODULE & BRACKET

Item #	Description	Qty	Part Number
1	Spacer, ECM 1.0"	1	S3-50626-001
2	Screw, Hex, Flange M6 x 50mm	4	S1-50237-20-0650
3	Washer, 5/16	1	92200000
4	Washer, Lock Med 5//16"	1	93200000
5	Bolt, 5/16 x 24 x $\frac{3}{4}$	1	90215075
6	Bracket, ECM	1	B4-51719-001
7	Nut	2	N1-30876-037
8	Stud	2	S3-50596-001
9	Spacer, 12.7 OD x 6.6 IS x 20	1	S3-50066-001
10	Stud, Dipstick 5/16-18 x 5/16-24	1	7100450
11	Washers	4	92300000
12	ECM, MEFI 5 (Includes Calibration or Software)	1	4312802

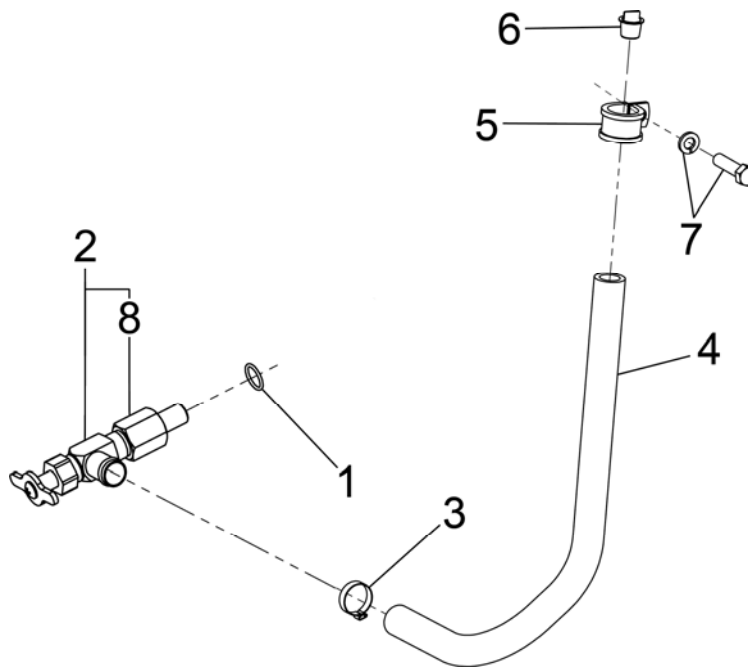
MISCELLANEOUS ENGINE



MISCELLANEOUS ENGINE

Item #	Description	Qty	Part Number	GM Part Number
1	Oil Filter PF454	1	7110851	
2	Coolant Temperature Sensor	1	700427	
3	Plug ½-14 NPT	1	P3-14	
4	Switch, Oil Pressure	1	S10-50352-001	
5	Plug ½-14 NPT	1	7242360	
6	Spark Plug, R42	4	78092	
7	Spark Plug Wire Set	1	7241830	
8	Cap	1	7110970	15544596
9	Cap, Vinyl Orange	1	C2-15137-003	
10	Clamp, Hose Combo, SAE Hex 10	1	C2-14106-006	
11	Clamp, Ear, Oetiker	1	C2-51552-07-241	01470030
12	Conduit, Splice Cut	2	W3-51584-009-0170	
13	Conduit, Splice Cut	1	W3-51584-009-0305	
14	Fitting, ½ NPT 5/8" Hose Brass	1	F4-17920	

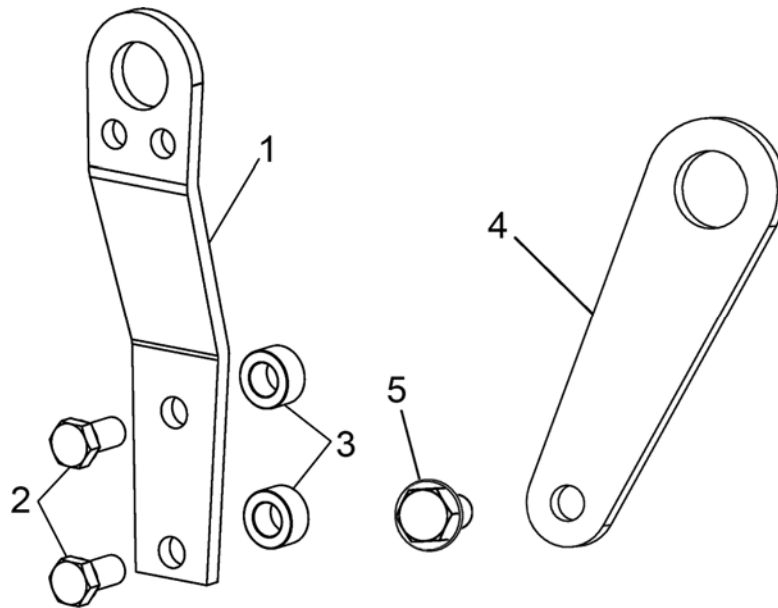
OIL DRAIN TUBE



OIL DRAIN TUBE

Item #	Description	Qty	Part Number
1	O-ring Nitrile	1	S3-1524-AA-015
2	Module, Valve Oil Drain (Includes #8 Adapter)	1	MD-51987-001
3	Ear Clamp, Stepless 20.9-24.1	1	C2-51552-07-241
4	Hose 5/8"ID (457mm) Fuel/Oil	1	H1-19231-006-0457
5	Clamp, Loop Cushioned 3/8" x .94"	1	C2-50848-015
6	Cap, Center Pull	1	C2-51908-003
7	See Engine Mounts		-
8	Adapter, 3/8" 1/2-20	1	A4-51763-001

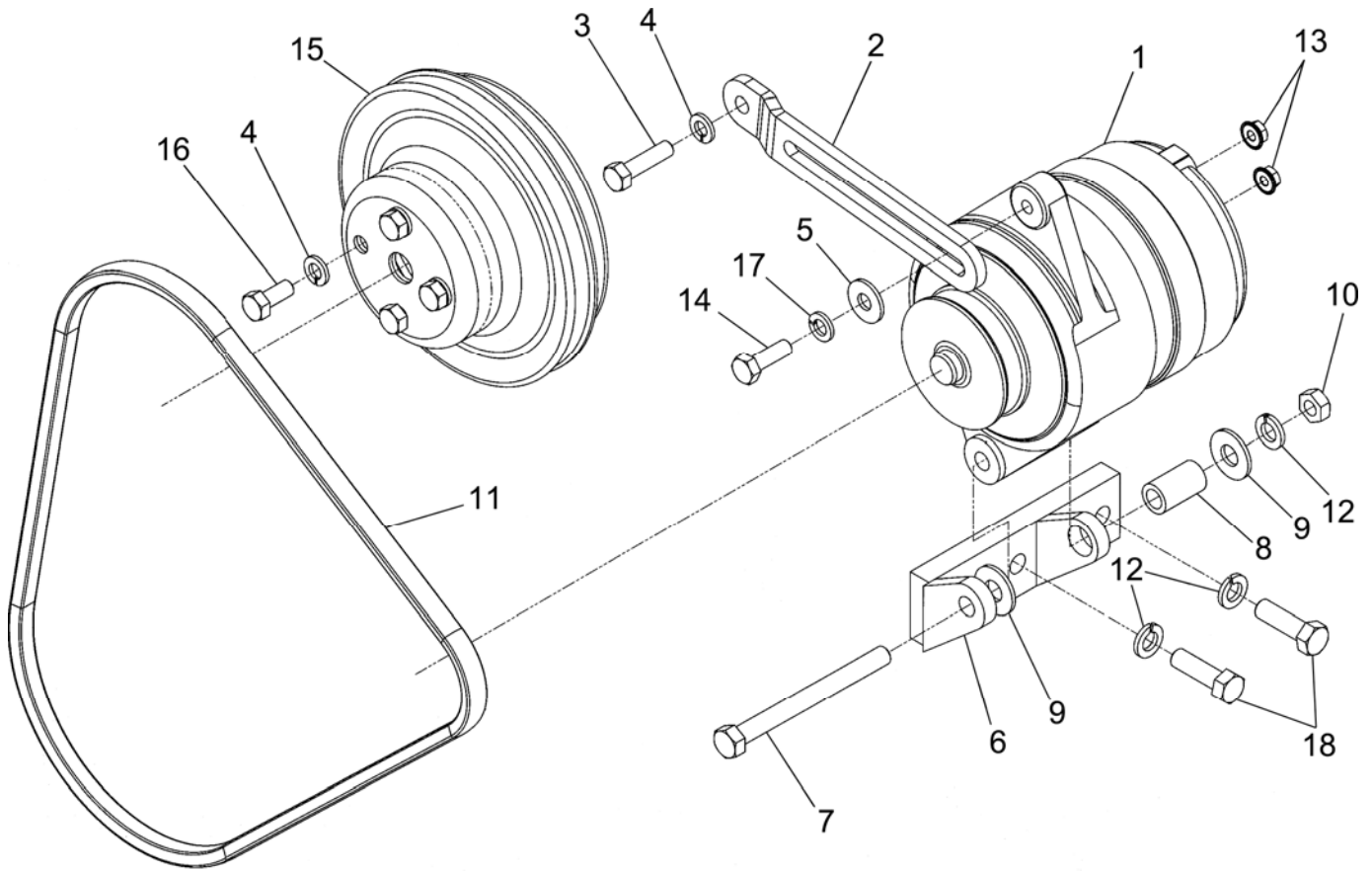
ENGINE HANGERS



ENGINE HANGERS

Item #	Description	Qty	Part Number	GM Part Number
1	Engine Hanger	1	06273484	06273484
2	Bolt	2	09442963	09439905
3	Spacer, Idler Mount	2	7143810	
4	Strap, Lifting Eye	1	7010130	
5	3/8-16 x 3/4"	1	90325075	

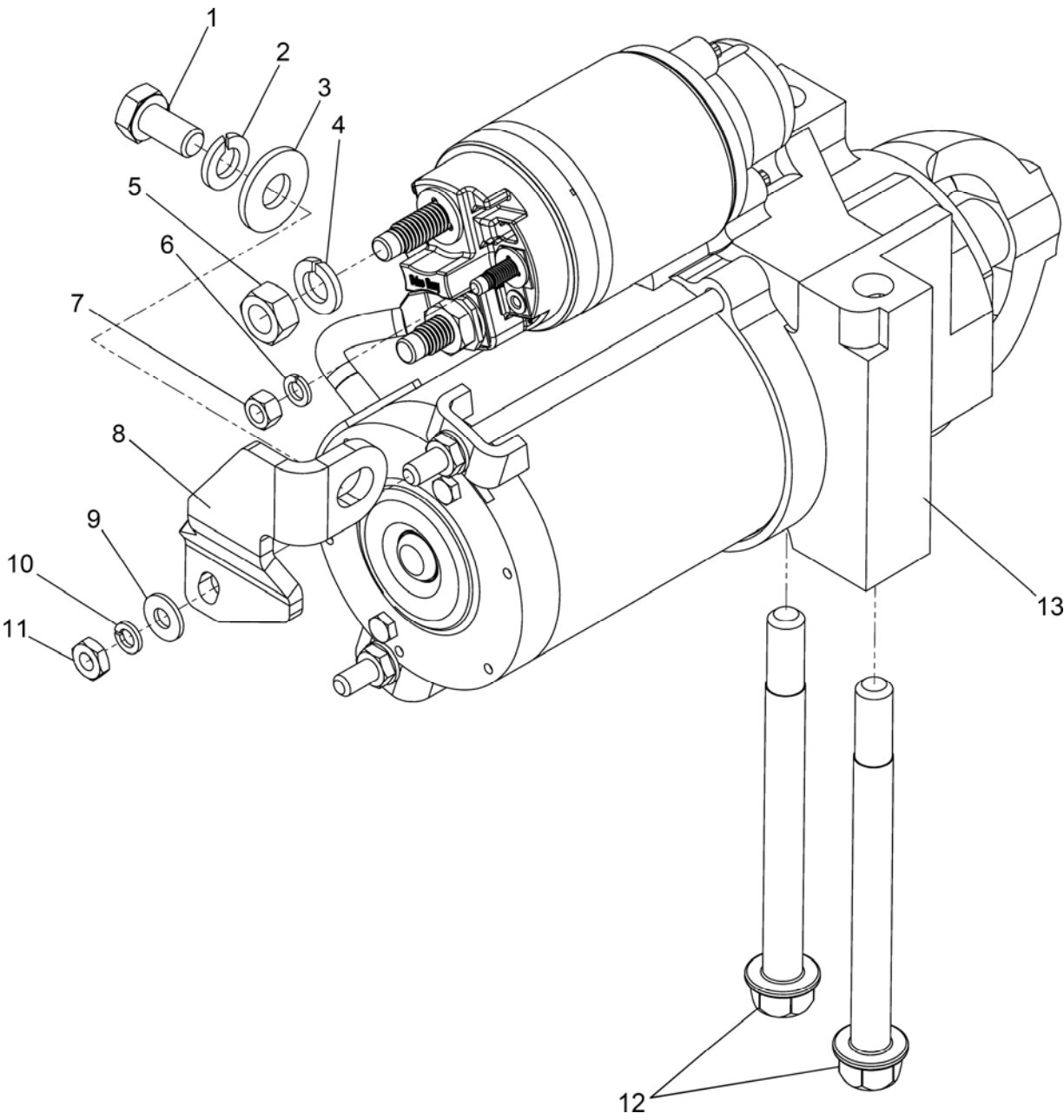
ALTERNATOR



ALTERNATOR

Item #	Description	Qty	Part Number
1	Alternator, 7SI	1	7244700
2	Bracket Alternator, Upper	1	7144570
3	5/16-18 x 1-1/4" Bolt Grade 5	1	90205125
4	Washer, Lock, 5/6"	2	93200000
5	Washer, Flat, Heavy 5/16"	1	92200020
6	Bracket, Alt Lower	1	7244560
7	Bolt, Hex 3/8-16 x 4" Grade 5	1	90305400
8	Spacer, Alternator Brkt	1	7244570
9	Washer, Flat 3/8"	2	92300000
10	Nut, 3/8"-16 Grade 5	1	95300000
11	Belt, Alternator	1	7144070
12	Washer, 3/8"	3	93000000
13	Nut, Hex Flange Serrated M5 x 1.0	2	N1-30876-M06
14	Bolt, M8-1.25 Hx Head Grd 10.9	1	98333025
15	Pulley, Water Pump	1	7144130
16	5/16"-18 x 3/4" Grade 5	1	90215075
17	Washer, Lock, M8	1	93930000
18	Bolt, Hex 3/8-16 x 1 1/2" Grade 5	2	90305150

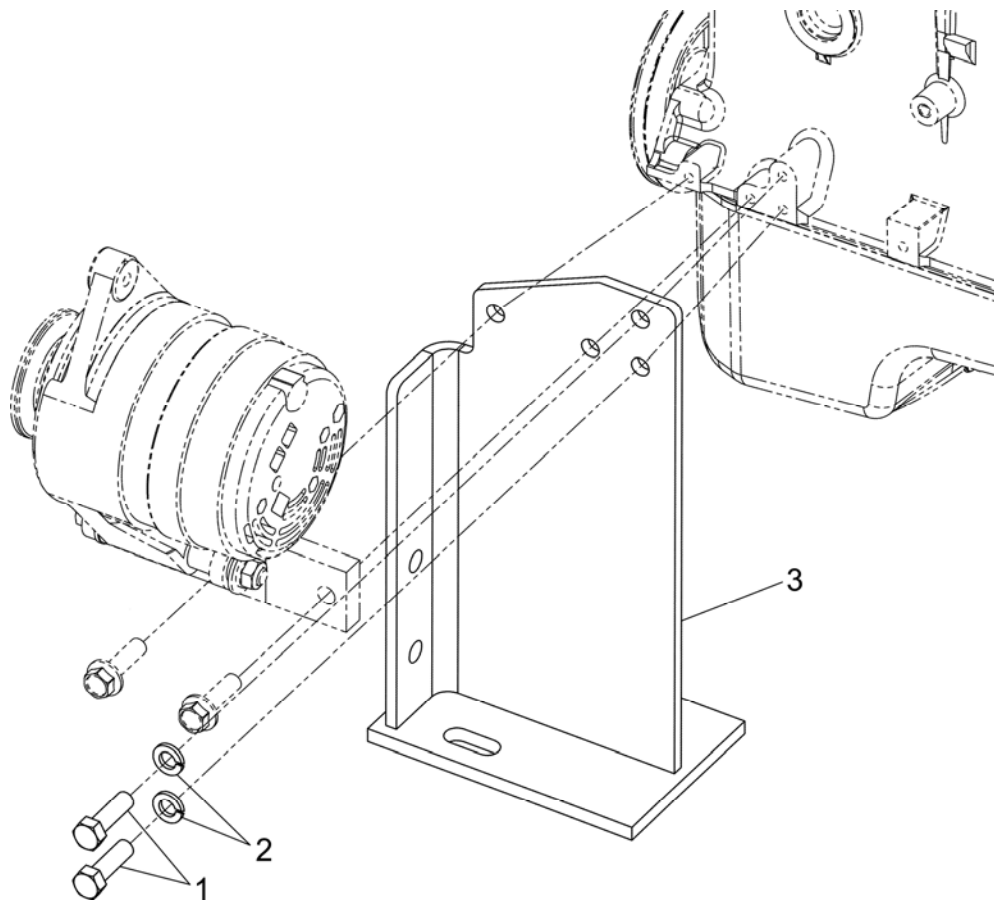
STARTER



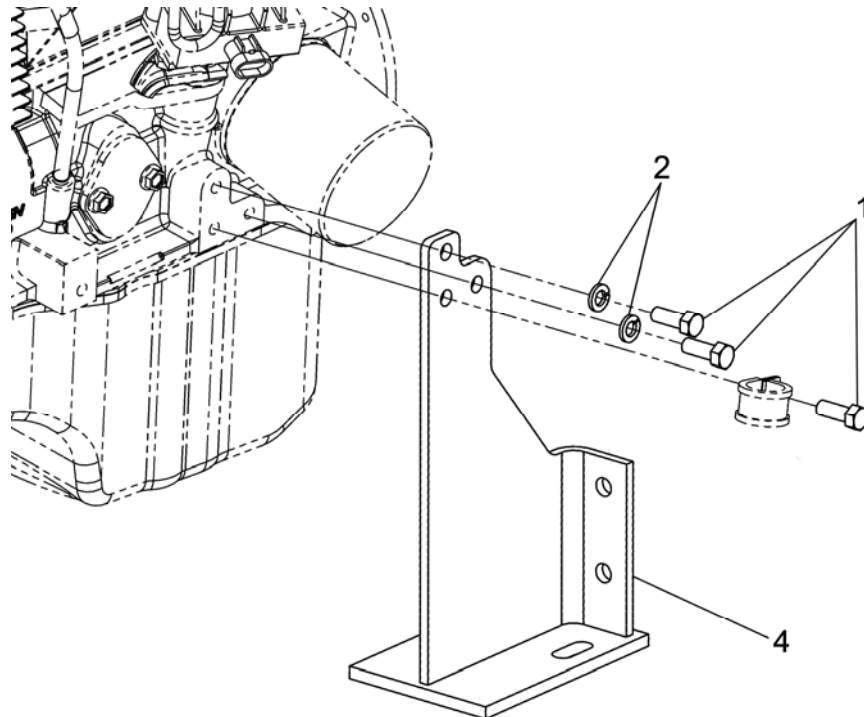
STARTER

Item #	Description	Qty	Part Number
1	Bolt 5/16-18 x ¾"	1	90205075
2	Lockwasher, Medium 5/16"	1	93200000
3	Washer, Flat SAE 5/16"	1	92200000
4	Washer, Lock Med M8 Zn	1	93930000
5	Nut, Hex M8 x 1.25 Brass	1	97331000
6	Washer, Lock Bronze #10	1	93003000
7	5/16-18 x ¾" bolt hex Grade 5	1	97111000
8	Bracket, Starter	1	B4-50330-001
9	Washer, Flat #10	1	92000000
10	Washer, Lock #10	1	93000000
11	Nut, Hex #10-24	1	95000000
12	Bolt, Starter 5/16"-18 x ¾" Hex Grade 5	2	7242530
13	Starter Motor	1	S19-50263-001

ENGINE MOUNTING BRACKETS



LEFT

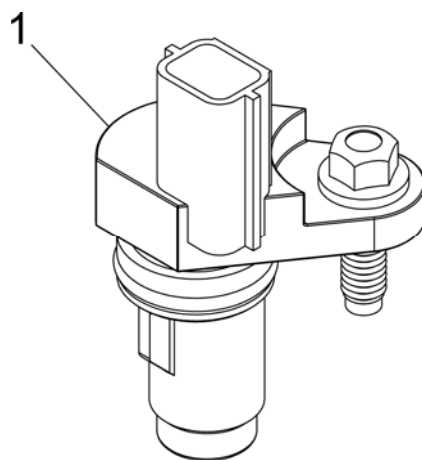


RIGHT

ENGINE MOUNTING BRACKETS

Item #	Description	Qty	Part Number
1	Bolt, 3/8"-16 Hex Head Grade 5	5	90305100
2	Washer, Lock 3/8"	4	9300000
3	Bracket, Engine Mount, LH	1	B4-51795-001
4	Bracket, Engine Mount, RH	1	B4-51796-001

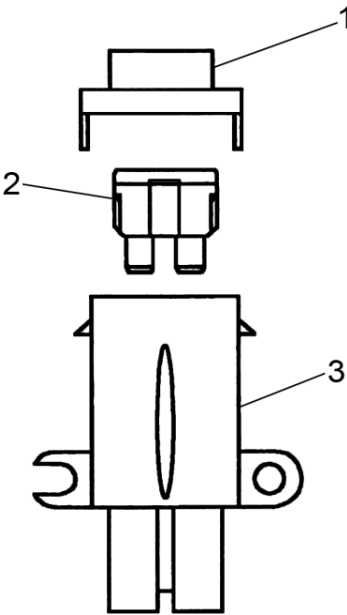
CRANK SENSOR



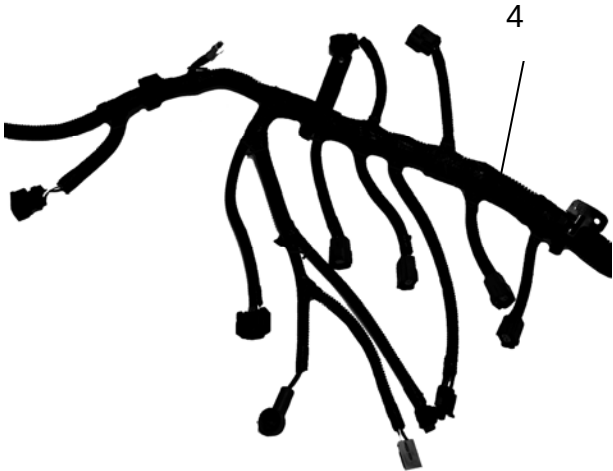
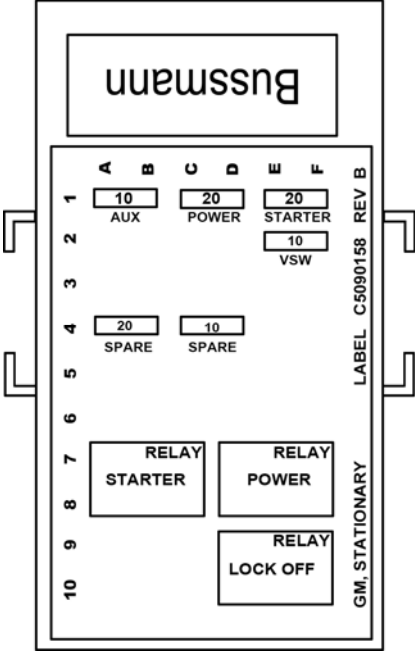
CRANK SENSOR

Item #	Description	Qty	Part Number	GM Part Number
1	Crank Sensor	1	S8-51822-001	12567712

WIRE HARNESS/FUSES/FUSE BOX COVER



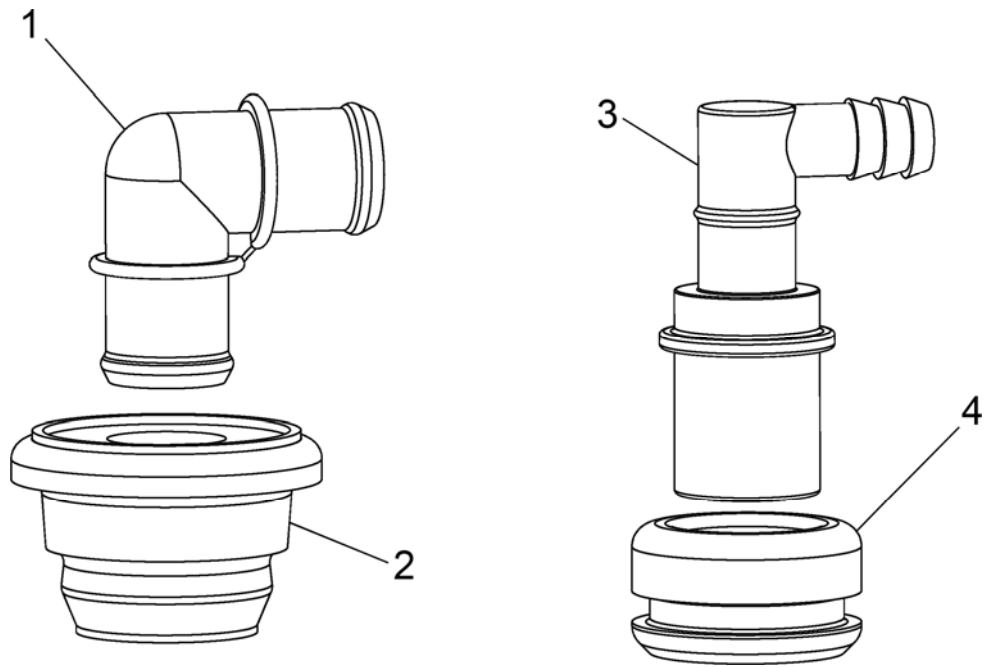
Fuse Box Layout



WIRE HARNESS/FUSES/FUSE BOX COVER

Item #	Description	Qty	Part Number	Manufacturer Part Number
1	Cover	1		Littelfuse 1520007Z
2	Fuse 70A	1	1054112	Littelfuse 299070
3	Fuse Holder	1		Littelfuse 1520004Z
4	Wire Harness, Genset 4 Cyl	1	AW-51866-001	
Auxiliary	10A Minifuse	1	914584	Littelfuse 297010
Power Fuse	20A Minifuse	1	7381270	Littelfuse 297020
Starter Fuse	20A Minifuse	1	7381270	Littelfuse 297020
VSW	10A Minifuse	1	914584	Littelfuse 297010
Starter Relay	Starter Relay	1		3011CCR1U0112VDC
Power Relay	Power Relay	1		3011CCR1U0112VDC
Shut Off Valve Relay	Lock Off	1		3011CCR1U0112VDC

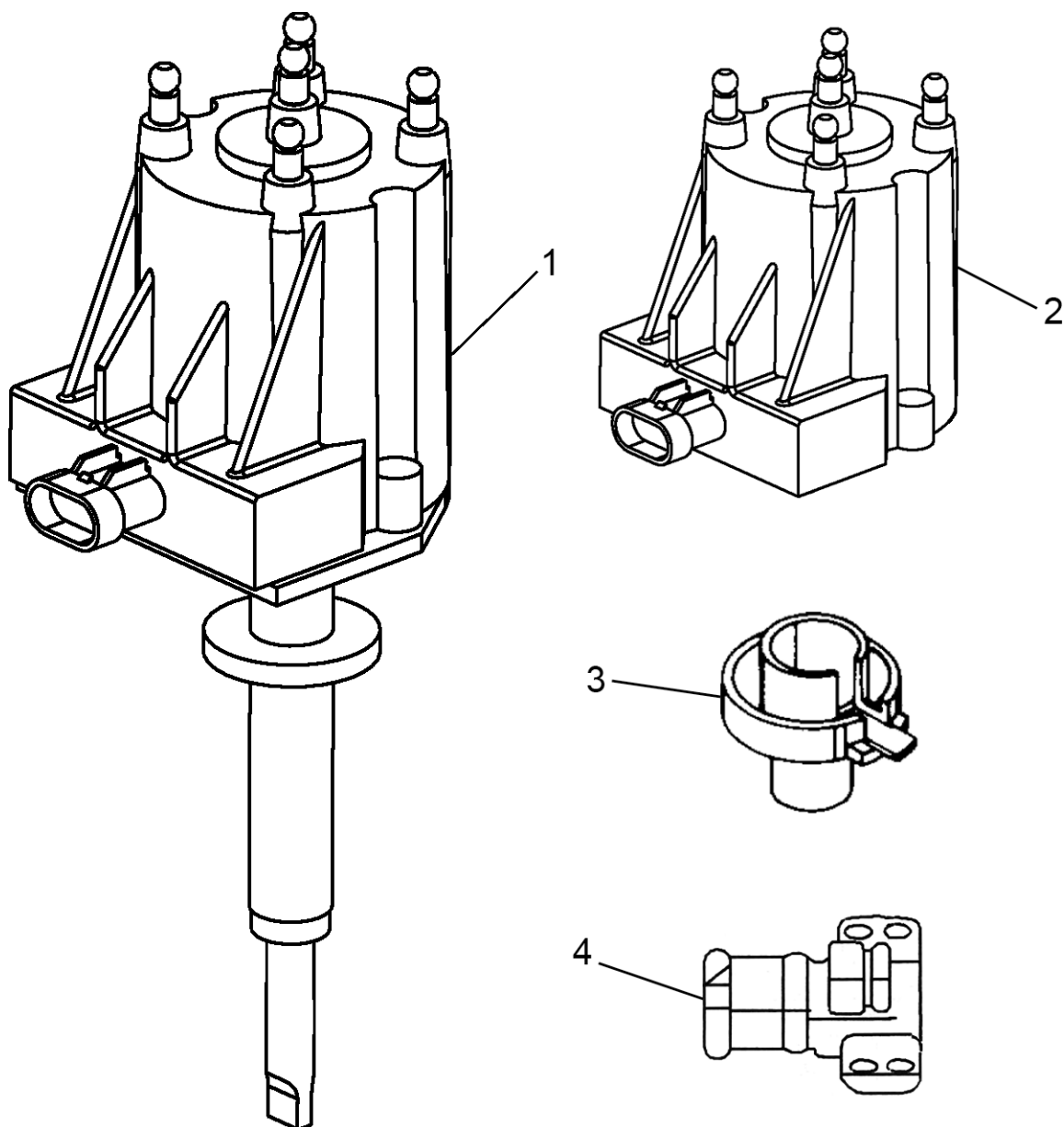
PCV VENT & VALVE



PCV VENT & VALVE

Item #	Description	Qty	Part Number	GM Part Number
1	Vent, Elbow	1	F4-51936-001	06487779
2	Grommet oil filter cap	1	G3-51937-001	14050440
3	PCV	1	V3-51806-001	06487779
4	Grommet, PCV Valve	1	7120140	14001875

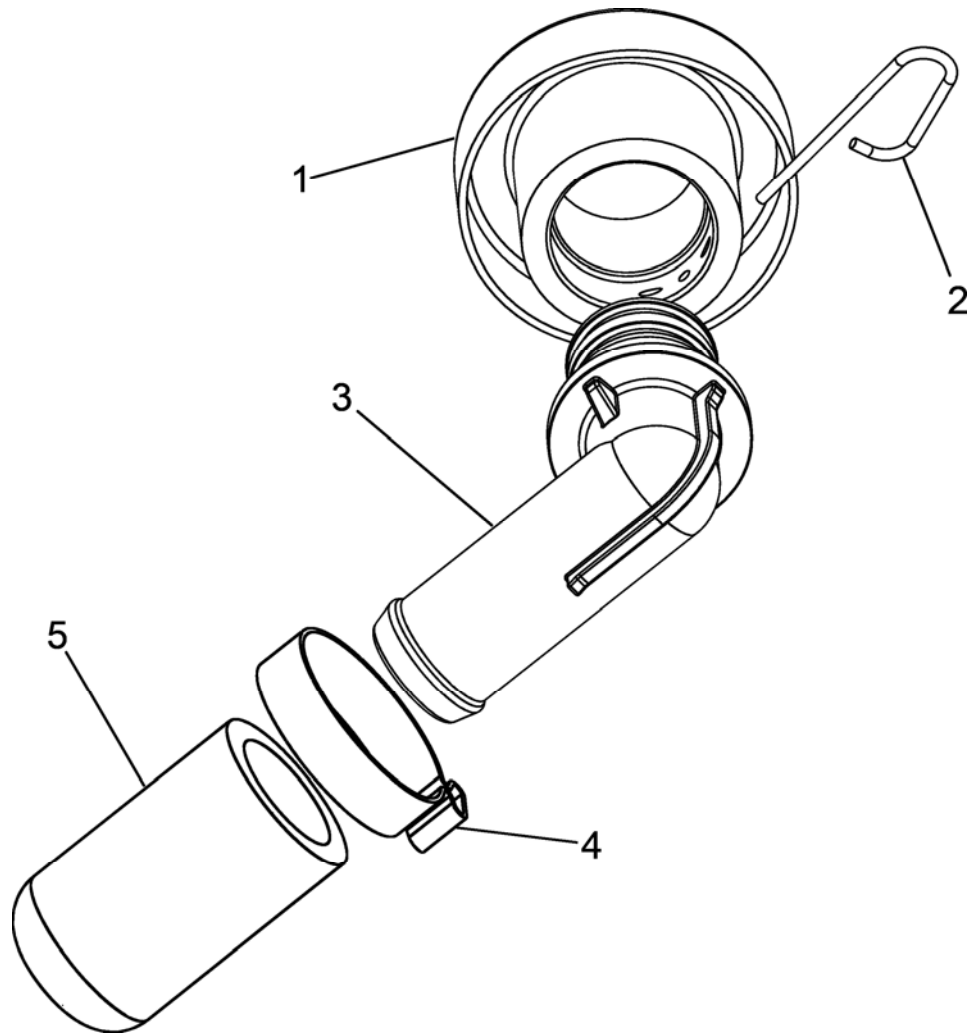
DISTRIBUTOR & SPARK PLUG WIRES



DISTRIBUTOR & SPARK PLUG WIRES

Item #	Description	Qty.	Part Number	GM Part Number
1	Distributor	1		93442429
2	Distributor Cap	1	89060454	89060454
3	Rotor	1		10467546
4	Module/Sensor	1		10485432

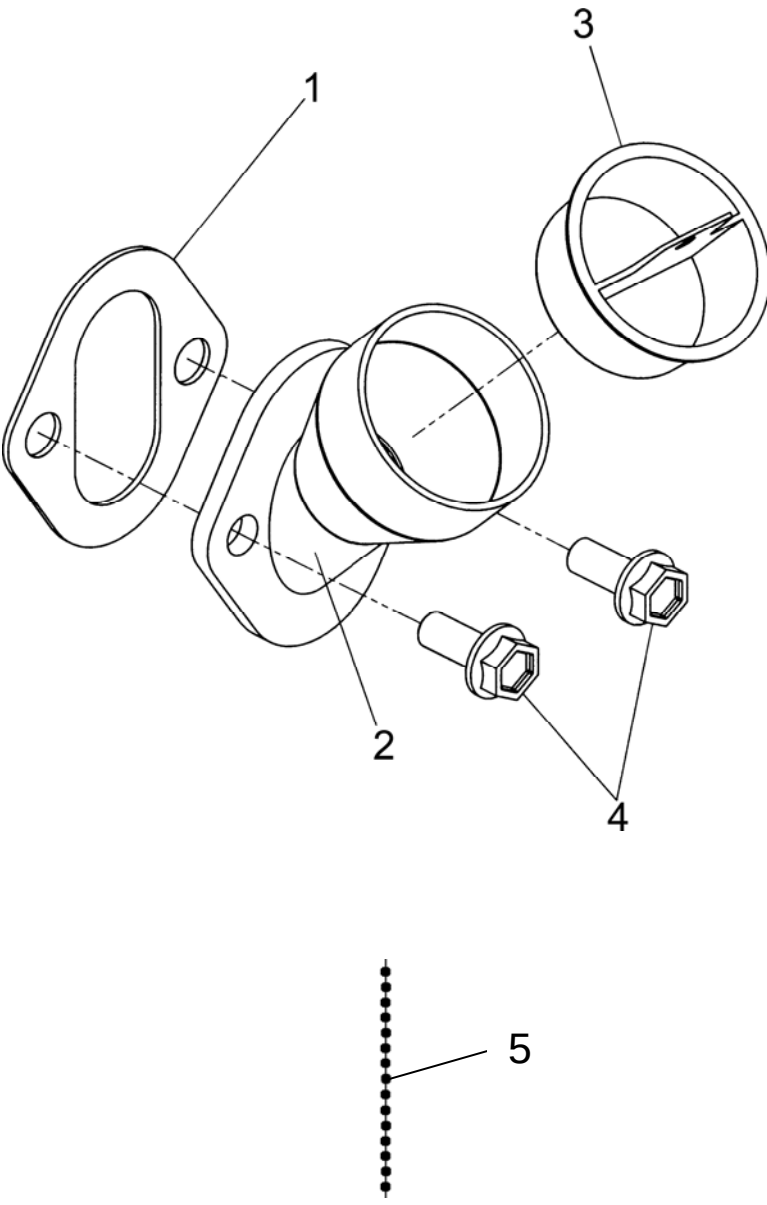
WATER PORT



WATER PORT

Item #	Description	Qty.	Part Number
1	Adapter, Freeze Plug O-ring	1	A4-51798-001
2	Clip, Retaining	1	P1-30559
3	Fitting, 5/8 x 90 x .78"	1	AF4-30733-001
4	C2-51552-07-241	1	C2-51552-07-241
5	Cap, 5/8" Rubber Plug	1	7110790

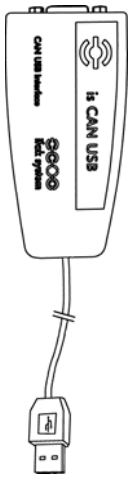
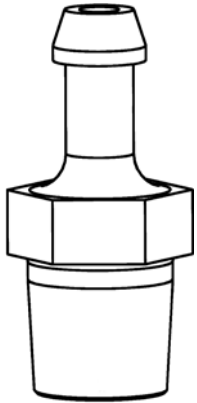
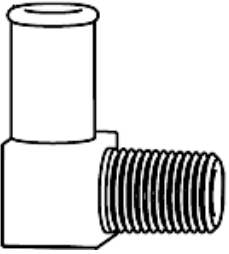
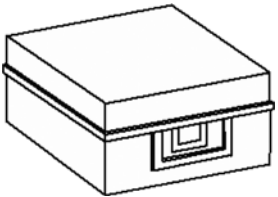
OIL FILL ADAPTER

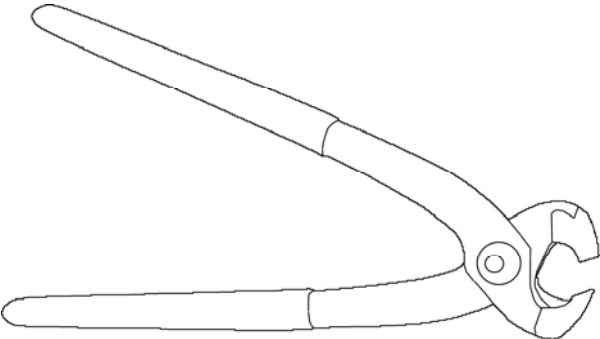


OIL FILL ADAPTER

Item #	Description	Qty.	Part Number	GM Part Number
1	Gasket	1		93802517
2	Adapter, Oil Fill	1	A4-51764-001	
3	Cap, Oil Fill	1	C2-51908-001	
4	5/16"-18 x 3/4" Grade 8	2		09424877
5	Chain	1	R6-51912-001	

IMPCO ITK-1-IND TOOL KIT & ACCESSORIES

 1	 2	 3	 4	 5
 6	 7	 8	 9	



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, 1/4" Unf 1/4" Hs Vac Nip	1	F4-2
4	Fitting, 1/8" NPT 3/16" Hs Nip Brs	2	F4-4
5	Fitting, 1/8" NPT 1/4" 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. It applies to 2010-2011 model year 3.0L GM Emission Certified Engines

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 setup 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.

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 Warranty at t2warranty@impcotechnologies.com.

All warrantable engine parts and labor costs to exceed \$700 must be pre-approved by IMPCO Warranty. Engine warranty claims exceeding \$700 and not pre-approved may be denied.

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.

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 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	1F	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	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 SENDER AND/OR ADAPTER-REPLACEMENT	J4590	0.5
ENGINE COOLANT TEMP SENSOR-REPLACEMENT	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
VENTURI 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 PIPE/FUEL SELECTOR SWITCH (EACH)	F1104	0.2
FUEL CONTROL VALVE	F1105	0.4
FUEL CONTROL VALVE BRACKET	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
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 AND/OR GASKET-REPLACEMENT	J0108	1.0
VALVE COVER AND/OR GASKET-REPLACEMENT <i>Includes: R&R intake manifold.</i>	J0308	0.3
ROCKER ARM-REPLACEMENT <i>Includes: R&R intake manifold and rocker cover(s).</i> ADD: Replace all rocker arms:	J0358	0.4 0.3
STUD, VALVE ROCKER ARM BALL-REPLACEMENT ADD: To replace an additional stud	J0388	0.5 0.3
CYLINDER HEAD GASKET-REPLACEMENT <i>Includes: R&R intake manifold, rocker covers(s) and compression test.</i>	J0508	2.3
CYLINDER HEAD-REPLACEMENT <i>Includes: R&R intake manifold, rocker cover(s) and compression test.</i>	J0518	3.0
VALVE-RECONDITION OR REPLACEMENT ADD: Each additional cylinder ADD: To recondition all valves ADD: To ream and fit guides for oversize stems	J0528	2.9 0.4 0.9 0.2
VALVE SPRING, CAP AND/OR SEALS-REPLACEMENT <i>Includes: R&R rocker cover(s)</i> ADD: Each additional cylinder ADD: All springs, caps and/or seals	J0548	2.5 0.3 0.9
PUSH ROD-REPLACEMENT, ONE CYLINDER <i>Includes: R&R rocker cover(s)</i> ADD: To replace all push rods:	J0588	0.8 0.2
LIFTER, VALVE-REPLACEMENT, ONE CYLINDER <i>Includes: R&R rocker cover(s)</i> ADD: To replace all lifters:	J0628	0.9 0.3

FUEL SYSTEM LABOR OPERATIONS

Engine–Internal Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
TIMING COVER OIL SEAL–REPLACEMENT <i>Includes: R&R balancer</i>	J0750	0.7
TIMING COVER AND/OR GASKET–REPLACEMENT <i>Includes: R&R balancer</i>	J0780	2.0
TIMING CHAIN–REPLACEMENT	J0820	1.6
ADD: Replace crankshaft gear		0.2
CAMSHAFT TIMING GEAR–REPLACEMENT	J0840	3.9
ADD: Replace crankshaft gear		0.2
CAMSHAFT–REPLACEMENT	J0850	6.0
OIL PAN AND/OR GASKET–REPLACEMENT <i>Includes: Fluid replacement</i>	J1000	2.2
PUMP, ENGINE OIL–REPLACEMENT <i>Includes: R&R engine oil pan and fluid replacement</i>	J1020	2.5
SEAL, REAR MAIN BEARING–REPLACEMENT <i>Includes: R&R engine oil pan and fluid, replace lower seal and repack upper seal</i>	J1120	2.8
BEARING, CRANKSHAFT MAIN–REPLACE ONE <i>Includes: R&R engine oil pan and fluid, and use of plastic type gauge</i>	J1200	4.1
ADD: Replace main bearings		
Each additional (NOT to equal or exceed ALL)		0.5
All main bearings		1.2
ADD: Replace connecting rod bearings	J1200	
Each additional (NOT to equal or exceed ALL)		0.3
All rod bearings		1.2

FUEL SYSTEM LABOR OPERATIONS

Engine-Internal Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
BEARING, CONNECTING ROD-REPLACE ONE <i>Includes: R&R engine oil pan and fluid, and use of plastic type gauge</i> 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 <i>Note: Use appropriate labor operation(s) for removal of necessary component(s) to gain access to plug</i>	J1600	0.3
PLUG, OIL GALLERY-REPLACEMENT <i>Note: Use appropriate labor operation(s) for removal of necessary component(s)</i>	J1640	0.3

ENGINE REPAIR OPERATIONS

Engine-Replacement

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
BLOCK, ENGINE FITTED-REPLACEMENT <i>Includes: R& R all components, fluids and accessories</i> ADD: To recondition all valves and guides	J1800	9.0 2.6
ENGINE, PARTIAL-REPLACEMENT <i>Includes: R& R all components, fluids and accessories</i> ADD: To recondition all valves and guides	J1820	7.2 2.6
ENGINE, ASSEMBLY-REPLACEMENT <i>Includes: R&R all <u>components</u>, fluids and accessories</i>	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 <u>Prior Approval</u> 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

VEHICLE 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		
<i>(Attach additional sheets if necessary)</i>		
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.

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: A vehicle equipped to run on two fuels.

BLM: Block Learn Memory

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 LPG 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.

CAN Bus: Controller Area Network

CNG: Compressed Natural Gas.

CKP: Crankshaft Position Sensor

CMP: Camshaft Position Sensor

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 LPG 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.

ETC: Electronic Throttle Control

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 Vehicle.

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

FMVSS: Federal Motor Vehicle 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 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 Vehicle.

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. Also refer to as MAT.

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 Vehicle.

IMPCO: Imperial Machine Products Company.

IMPCO Technologies, Inc. A manufacturer of both 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 Vehicle.

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

LEV: Low Emission Vehicle.

Limp-in or Limp Home: A mode where the ECM or a component has failed, but the vehicle 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: Liquified Natural Gas.

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

MAP: Manifold Absolute Pressure

MAT: Manifold Air Temperature. Also refer to as IAT.

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.

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 molecule (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.

Pre-Cat O2 Sensor Voltage Sensor 1 is a parameter shown in the DST for the primary oxygen sensor signal.

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.

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 Data Mode: A state in which the DST is connected to an engine and enabled to receive constant data from the ECM.

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 Vehicle.

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 Vehicle.

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 LPG.

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: Vehicle 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 Vehicle.

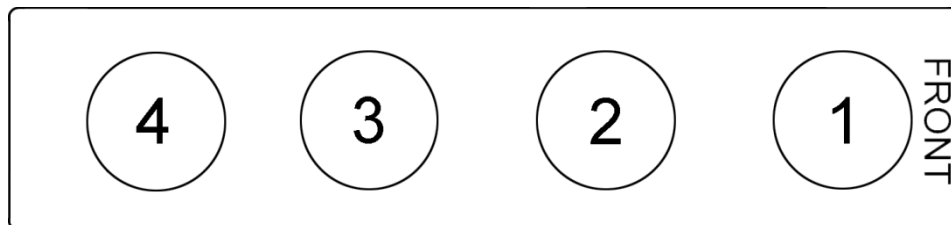
Appendix

3.0L Electrical & Ignition System Specifications

Firing Order	1-3-4-2
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.

- Controller: Delphi MEFI 5
- Ignition system – HVS Electronically Controlled HVS Distributor and Coil
- Electronically Controlled Throttle Body: Magneti Marelli
- Battery charging alternator:
 - Negative Ground
 - 12 Volts DC
 - 70A Rating
- Battery:
 - Recommended 630 Cold Cranking Amps –at 18⁰C (0°F)
 - Battery Voltage: 12V DC

3.0L GM Engine Cylinder Layout



The cast iron engine block has four cylinders arranged in line. Starting at the front side of the engine block (end with pulleys), the cylinders are numbered 1-2-3-4. The firing order of the cylinders is 1-3-4-2. The cylinders are encircled by coolant jackets.

GM Fastener Tightening Specifications

Application	N•m	Lb Ft	Lb In
Camshaft Retainer Bolts	9		80
Coolant Inlet Housing Bolt	34-40	25-30	
Coolant Temperature Sensor	20	15	
Coolant Thermostat Housing Bolts	24-31	18-23	
Connecting Rod Cap Nuts	61	45	
Crankshaft Main Bearing Cap Bolts	88	65	
Crankshaft Position Sensor Retaining Bolt	10		88
Crankshaft Rear Oil Seal Retainer Nuts	15		135
Cylinder Head Bolts	130	96	
Distributor Hold Down Bolt	27	20	
Flywheel Bolts	88	65	
Front Cover Bolts	4-Mar		27-35
Fuel Rail to Fuel Rail Bracket Bolts	12		106
Ignition Coil Bracket Attaching Bolts	25	18	
Ignition Coil Module to Bracket Bolts	2		18
Intake to Exhaust Manifold Attaching Nuts and Bolt	27-34	20-25	
Intake/Exhaust Manifold to Head (2 center)	27-34	20-25	
Intake/Exhaust Manifold to Head (outer)	20-27	15-20	
Lift Bracket Bolts	54	40	
Oil Level Bracket Nut	9		80
Oil Pan Nuts (rear)	19		165
Oil Pan Bolts (to crankcase)	9		80
Oil Pan Bolts (to front cover)	5		45
Oil Pan Studs to Oil Seal Retainer or Crankcase	2		15
Oil Pump Cover	8		72
Oil Pump to Block	14		120
Oil Pump Pickup	7		60
Pushrod Cover Bolts	5		40
Rocker Arm Cover Bolts	5		40
Spark Plugs	30	22	
Water Pump Bolts	20	15	
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Spark Plugs	30	22	
Water Pump Bolts	20	15	

Sealers, Adhesives and Lubricants

GM Part Number	Type of Material	Application
1052080	Sealant	Rear camshaft bearing hole plug
1052080	Sealant	Cylinder head bolt threads
1052914	Sealant	Oil pan sealing surfaces
1052365	Lubricant	Valve train component prelube
1052080	Sealant	Valve rocker arm stud threads
1052080	Sealant	Oil level indicator tube

Fluid Capacities and Types

- Oil: SAE 10W-30. Capacity 4.0 qt (3.8L) w/out filter and 4.3 qt (4.1L) with filter.
- Coolant: Engine only capacity 1.8 gal, GM 6277M specification (Dexcool) 50-50 mixture with distilled water

Engine Mechanical Specifications

- Manufacturer: General Motors
- Engine: Model RT / AS2, Industrial Powertrain
- 3.0 L, 4-Cycle, Inline 4.
- Naturally Aspirated
- Displacement: 3.0 L (181 cu.in.)
- Bore and Stroke: 101.6mm x 91.4m (4.0" x 3.6")
- Compression Ratio: 10.5:1
- Piston Speed: 329 m / min. (1080 ft / min.)
- Main Bearing Caps: 2-Bolt Cast Iron
- Cylinder Head Material: Cast Iron with sintered powder metal exhaust valve seat inserts
- Piston Material: High Silicon Aluminum
- Crankshaft Material: Nodular Cast Iron
- Governor Type: Electronic
- Frequency Regulation: No-Load to Full-Load Isochronous
- Frequency Regulation: Steady State $\pm 0.5\%$
- Air Cleaner Type: Dry

Engine Specifications

Lubrication System		
Oil Pump Type	Gear Driven	
Cylinder Block		
Bore Diameter	101.5873-101.6635 mm	3.9995-4.0025 in
Bore Out-of-Round Production	0.0254 mm (Maximum)	0.001 in (Maximum)
Bore Out-of-Round Service Limit	0.0508 mm (Maximum)	0.002 in (Maximum)
Bore Taper Thrust Side Production	0.0127 mm (Maximum)	0.0005 in (Maximum)
Bore Taper Thrust Side Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Bore Taper Relief Side Production	0.0127 mm (Maximum)	0.0005 in (Maximum)
Bore Taper Relief Side Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Runout - Rear Face of Block to Crankshaft Center Line	0.05 mm (Maximum)	0.002 in (Maximum)
Piston		
Piston-To-Bore Clearance Production	0.0635-0.0889 mm	0.0025-0.0035 in
Piston Rings		
Piston Compression Ring Groove Clearance Production Top	0.03048-0.07366 mm	0.0012-0.0029 in
Piston Compression Ring Groove Clearance Production 2nd	0.03048-0.07366 mm	0.0012-0.0029 in
Piston Compression Ring Groove Clearance Service Limit	0.09906 mm (Maximum)	0.0039 in (Maximum)
Piston Compression Ring Gap Top Production *	0.254-0.508 mm	0.01-0.02 in
Piston Compression Ring Gap 2nd Production *	0.4318-0.635 mm	0.017-0.025 in
Piston Compression Ring Gap Top Service Limit *	0.88 mm (Maximum)	0.035 in (Maximum)
Piston Compression Ring Gap 2nd Service Limit *	0.88 mm (Maximum)	0.035 in (Maximum)
Piston Oil Ring Groove Clearance Production	0.0254-0.1524 mm	0.001-0.006 in
Piston Oil Ring Groove Clearance Service Limit	0.1778 mm (Maximum)	0.007 in (Maximum)
Piston Oil Ring Gap Production *	0.25-0.76 mm	0.01-0.03 in
Piston Oil Ring Gap Service Limit *	1.016 mm (Maximum)	0.04 in (Maximum)
Piston Pin		
Diameter	23.545-23.548 mm	0.9270-0.927 in
Clearance in Piston Production	0.00762-0.01651 mm	0.0003-0.00065 in
Clearance in Piston Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Fit in Connecting Rod	0.02032-0.050292 mm (Interference)	0.0008-0.00198 in (Interference)
Crankshaft		
Crankshaft Journal Diameter (All)	58.3666-58.4047 mm	2.2979-2.2994 in
Crankshaft Journal Taper Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Crankshaft Journal Taper Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Crankshaft Journal Out-of-Round Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Crankshaft Journal Out-of-Round Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Crankshaft Bearing Clearance Production #1 - #4	0.0254-0.06096 mm	0.001-0.0024 in
Crankshaft Bearing Clearance Production #5	0.0406-0.0889 mm	0.0016-0.0035 in
Crankshaft Bearing Clearance Service Limit #1 - #4	0.0254-0.0635 mm	0.001-0.0025 in
Crankshaft Bearing Clearance Service Limit #5	0.0381-0.0889 mm	0.0015-0.0035 in
Crankshaft End Play	0.05-0.1524 mm	0.002-0.006 in
Crankshaft Sprocket Runout	0.07 mm (Maximum)	0.003 in (Maximum)

Engine Mechanical Specifications

Connecting Rod		
Connecting Rod Journal Diameter	53.2892-53.3273 mm	2.0980-2.0995 in
Connecting Rod Journal Taper Production	0.00762 mm (Maximum)	0.0003 in (Maximum)
Connecting Rod Journal Taper Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Connecting Rod Journal Out-of-Round Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Connecting Rod Journal Out-of-Round Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Rod Bearing Clearance Production	0.04318-0.06858 mm	0.0017-0.0027 in
Rod Bearing Clearance Service Limit	0.0762 mm (Maximum)	0.003 in (Maximum)
Rod Side Clearance	0.1524-0.4318 mm	0.006-0.017 in
Camshaft		
Journal Diameter	47.440-47.490 mm	1.8677-1.8697 in
End Play	0.0762-0.2032 mm	0.003-0.008 in
Camshaft Sprocket Runout	0.1 mm (Maximum)	0.004 in (Maximum)
Timing Sprocket Teeth Backlash	0.10-0.15 mm	0.004-0.006 in
Lobe Lift Intake	6.4247 mm	0.25294
Lobe Lift Exhaust	6.4247 mm	0.25294
Lobe Lift Service Limit	±0.0254 mm	±0.001 in
Valve System		
Valve Lifter	Hydraulic	
Valve Rocker Arm Ratio	1.75:1	
Valve Lash	Half to One Turn Down From Zero Lash	
Face Angle	45 Degrees	
Seat Angle	46 Degrees	
Seat Runout	0.05 mm (Maximum)	0.002 in (Maximum)
Seat Width Intake	1.27-1.778 mm	0.050-0.070 in
Seat Width Exhaust	1.524-2.032 mm	0.060-0.080 in
Stem Clearance Intake Production	0.0254-0.06858 mm	0.001-0.0027 in
Stem Clearance Exhaust Production	0.01778-0.06858 mm	0.0007-0.0027 in
Stem Clearance Intake Service Limit	0.09398 mm (Maximum)	0.0037 in (Maximum)
Stem Clearance Exhaust Service Limit	0.1193 mm (Maximum)	0.0047 in (Maximum)
Valve Spring Free Length	52.324 mm	2.06 in
Valve Spring Pressure Closed	444-490 N at 40.89 mm	100-110 lb at 1.61 in
Valve Spring Pressure Open	925-987 N at 30.99 mm	208-222 lb at 1.22 in
Valve Spring Installed Height Intake	41.91 mm	1.65 in
Valve Spring Installed Height Exhaust	41.91 mm	1.65 in
Valve Lift Intake	11.25 mm	0.443 in
Valve Lift Exhaust	11.25 mm	0.443 in
Cylinder Head Warpage		
Cylinder Head Deck (measured within a 152.4 mm (6.0 in) area)	0.0762 mm	0.003 in
Cylinder Head Deck (measuring the overall length of the cylinder head)	0.1778 mm	0.007 in

Extended ECT Temperature vs. Resistance

Degrees F.	Degrees C.	Ohms±10%
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	12,300
14	-10	16,180
5	-15	21,450
-4	-20	28,680
-22	-30	52,700
-40	-40	100,700

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