SECTION 0A

GENERAL INFORMATION

FUEL SYSTEMS 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 propane to contact the skin. Propane is stored in the fuel tank as a liquid. When propane contacts the atmosphere, it immediately expands into a gas, resulting in refrigeration that can cause severe burns.

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

It is important to note that this manual contains various Warnings, Cautions and Notes that must be carefully observed in order to reduce the risk of personal injury during service or repair. Improper service or repair may damage the engine or render it unsafe or fail to make the engine emissions compliant. It is also important to warn of all hazardous consequences that might result from careless treatment of the engine. Failure to observe these items could influence terms of the warranty.

⚠ WARNING

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

⚠ CAUTION

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

IMPORTANT: Denotes situations which could influence safety or proper performance of the vehicle or component.

NOTICE: Significant item of information.

To reduce the chance of personal injury and/or property damage, the following instructions must be carefully observed.

- Proper service and repair are important to the safety of the service technician and the safe reliable operation of all engines. The service procedures recommended and described in this service manual are effective methods of performing service and repair. Some of these procedures require the use of tools specially designed for the purpose.
- If part replacement is necessary, the replacement part must be of the same part number or equivalent part. Do not use a replacement part of lesser quality. In the case of replacement parts for the emission control system use only genuine OEM replacement parts.
- Before using a replacement part, service procedure, or a tool which is not recommended by the engine manufacturer, it must first be determined that neither personal safety nor the safe operation of the engine will be jeopardized by the replacement part, service procedure or the tool selected.
- Special service tools shown in this service manaual that have tool product numbers beginning with “J” or “BT” are available for world wide distribution from:
    - Kent-Moore Tools
    - 28635 Mound Road
    - Warren, MI. 48092
    - 1-800-345-2233
- Special Tools which are required to service the LPG fuel system are listed below
    - Hand held diagnostic scanner
    - ITK-1 Fuel pressure test kit

  The tools are available from:

  IMPCO Engine System Division
  7100 East 15 Mile Road
  Sterling ‘Heights, MI. 48312
  1-586-276-4333

ENGLISH AND METRIC FASTENERS

⚠ CAUTION

Late model engines use a combination of English and Metric fasteners. The components affected are the starter motor, engine mounts, and flywheel housing mounting. Other components may also have a combination of fasteners, always verify that the proper fasteners are used whenever removing or replacing any components.

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

ADP: Adaptive Digital Processor.

Air/Fuel Ratio: The amount of air and fuel in the air fuel mixture, which enters the engine, shown in a ratio.

Analog 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.

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

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 ($C6H6$). Sometimes blended with gasoline to improve antiknock value. Benzene is toxic and suspected of causing cancer.

Bi-Fueled: A vehicle equipped to run on two fuels at the same time such as a fumigated diesel.

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 (blowby) escape down 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, $C4H10$ found in natural gas and petroleum. One of the five LP gases.

CAFE: Corporate Average Fuel Economy.

CARB: California Air Resources Board.

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

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

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

Circuit: A path of conductors through which electricity flows before it returns to its source.

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.

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 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.

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 directed flow of electrons through a conductor. Measured in amps.

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.

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

DTC: Diagnostic Trouble Code

DST: Diagnostic Scan Tool.

DVOM: Digital volt/ohmmeter.

ECT: Engine Coolant Temperature.

ECM : Electronic Control module

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

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 (C2H5OH), generally produced by fermenting starch or sugar crops.

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

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

FTV: Fuel Trim Valve.

FFV: Flexible Fuel 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 electrical 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 vehicle fuel that is a complex blend of hydrocarbons and additives. Typical octane level is 89.

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

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.

Hg: Chemical symbol for mercury. Used in reference to vacuum (in. of Hg).

Hydrocarbon: A chemical compound made up of hydrogen and carbon (HC). A major pollution emission of the internal combustion engine. Gasoline and almost all other fuels are hydrocarbons.

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

IAT: Intake Air Temperature

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 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. Can be caused by a

fuel with an octane rating that is too low or maladjusted 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.

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: This term is used to describe the drivability characteristics of a failed computer system

Liquified Petroleum Gas (LPG): A fuel commonly known as propane consisting mostly of propane (C3H8), 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 is 107.

LPG: Liquified Petroleum Gas.

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

Measurements of Pressure: 1 PSI=2.06 Hg (mercury) = 27.72" H2O (water column). At sea level atmospheric pressure is 29.92" Hg.

Methanol: Known as wood alcohol (CH3OH), a light, volatile, flammable alcohol commonly made from natural gas.

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

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

MPFI: Multi-Point 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.

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 (CH4) being the dominant component.

NGV: Natural Gas Vehicle.

Nox: See Oxides of Nitrogen.

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

OEM: Original Equipment Manufacturer, the vehicle 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: MTBE, ethanol and methanol. Oxygenates are added to gasoline to increase the oxygen content and therefore reduce exhaust emissions.

Ozone: A radical oxygen module (O3) 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.

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, colorless gas, C3H8, found in natural gas and petroleum.

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 varying numbers of oxygens, produced by the combustion of gasoline or any other fuel that contains sulfur. As sulfur oxides decompose in the atmosphere, they combine with water to form sulfuric acid.

System Pressure: The fuel pressure maintained in the system during normal engine operation.

Tap: An electrical term for a type of splice where the original circuit is not interrupted.

TBI: Throttle Body Injection. Any of several injection systems that have the fuel injector(s) mounted in a centrally located throttle body.

Throttle Body: Controls engine RPM by adjusting the engine manifold vacuum to the mixer. Consists of 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 C7H8.

TPS: Throttle Position Sensor.

ULEV: Ultra Low Emission Vehicle.

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 be 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.

Xylene: C6H4 (CH3)2. Any of three toxic flammable oily isomeric aromatic hydrocarbons that are dimethyl homologues of benzene and are usually obtained from petroleum or natural gas distillates.

ZEV: Zero Emission Vehicle.

SECTION OB

MAINTENANCE

MAINTENANCE

The maintenance of the engine and its related components is critical to the life of the engine and optimum performance during its useful life. All engines require a certain amount of maintenance. The suggested maintenance requirements are contained in this section. Industrial engines operate in various environments from extremely dusty environments, to hot and cold temperature environments and clean environments. The recommended schedule is a recommended guide line for the owner and servicing agency to follow, however certain environmental operating conditions may require more frequent inspection and maintenance. In addition the owner may have installed additional equipment to the equipment which may also increase the requirements for service on certain components. Therefore the owner and servicing agent should review the operating condition of the equipment and determine if more frequent inspections and maintenance cycles maybe required.

⚠ WARNING

When performing maintenance on the engine, shut off the engine and disconnect the battery negative cable to avoid injury or damage to the engine.

The engine installed in this equipment may use one or both accessory drive belt configurations. The drive belt may be incorporated to drive the water pump, alternator and addition pumps or devices. It is important to note, the drive belt is an integral part of the cooling and charging system and should be inspected at a minimum according to the maintenance schedule in this section and in extremely hot and dirty environments more often.

When inspecting the belts 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 an OEM replacement belt.

V-BELT SYSTEMS

Check the belt tension by pressing down on the midway point of the longest stretch between two pulleys. The belt should not depress beyond 13mm (1/2 inch). If the depression is more than allowable adjust the tension. Do not over tighten the tension of the belt. Over tightening may cause overload on the bearings and pulleys of the drive belt components.

⚠ WARNING

Alcohol or Methanol base antifreeze or plain water are not recommended for use in the cooling system at anytime.

SERPENTINE BELT SYSTEM

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

IMPORTANT:

The engine manufacturer does not recommend the use of "belt dressing" or "anti slipping agents" on either belt configuration.

COOLING SYSTEM

It is important to remember that the cooling system of this engine be maintained properly to insure the longevity of the engine. Maintenance of the cooling system is critical to not only the engine but the fuel system as well. Because the LPG vaporizer is connected into the cooling system low coolant levels and restricted or plugged radiator cores can impact the performance of the fuel system. Therefore proper maintenance of the cooling system should include removing dust, dirt and debris from the radiator core on regular intervals. To properly maintain the cooling system follow the recommend maintenance schedule in this section.

Cooling system inspections should be performed as prescribed when inspecting the cooling system check for the following:

- Plugged or restricted radiator core clean with compressed air, blow dust and debris from the core and the fan shroud
- Check the radiator cap to insure proper sealing if damage replace

- Check for coolant leaks at the radiator tank seams and inlet joints repair or replace as necessary

> **WARNING**
>
> Do not remove the cooling system pressure cap when the engine is hot. Allow the engine to cool and then remove the cap slowly allowing pressure to vent. Hot coolant under pressure may discharge violently

- Check for leaks at the radiator hose connections, tighten hose clamps if necessary
- Check Radiator hoses for swelling, separation, cracks deterioration in the hoses, or hardening, if any of these conditions exist the hose should be replaced with the OEM replacement parts
- Check coolant level if low add with 50/50 mixture, Do not add plain water
- Replace coolant per the recommended schedule at the end of this section

Checking the Coolant Level

1. Check coolant level in coolant recovery tank. Add specified coolant as required.

IMPORTANT:

The engine manufacturer and the fuel system supplier 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.

If the radiator requires repair insure that the radiator core repairs did not result in a significant reduction in the cooling capacity of the radiator.

The engine manufacturer recommends the cooling system be filled with a 50/50 mixture of ethelyene glychol anitfreeze and water.

This GM industrial engine can utilize any type of permanent antifreeze or any brand antifreeze solution that meets GM Specification 1825M or 1899M which will not damage aluminum parts.

ENGINE ELECTRICAL SYSTEM MAINTENANCE

The engine electrical system incorporates computers to control certain functions of the equipment. 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 battery connection clean and insure that connectors are tight.
- Check battery for cracks or damage to the case replace if necessary.
- Check Positive and Negative cables for corrosion, rubbing, chaffing and insure tight connections at both ends.
- Check engine wire harness for rubbing, chaffing, pinching, and cracks or breaks in the wiring.
- Check engine harness connectors, check to insure fitted and locked by pushing the connector together then pull on the connector halves to insure they are locked.
- Check ignition coil wire for hardening, cracking, arcing, chaffing, separation, split boot covers and proper fit.
- Check spark plug wires for hardening, cracking, chaffing, separation, split boot covers and proper fit.
- Replace spark plugs at the required intervals per the recommended maintenance schedule
- Check to insure all electrical components are securely mounted and retained to the engine or chassis.
- Check to insure any additional electrical devices installed by the owner are properly installed in the system.
- Check the MIL, charging, and oil pressure lights for operation by starting the engine and checking that the light illuminates for the prescribe period of time before turning out.

ENGINE CRANKCASE OIL

OIL RECOMMENDATION

Prior to changing the oil, select oil based on the prevailing daytime temperature in the area in which the equipment will be operated. The chart in figure 1 is a guide to selecting the proper crankcase oil.

IMPORTANT:

Oils containing “solid” additives, non-detergent oils, or low quality oils are not recommended by the engine manufacturer.

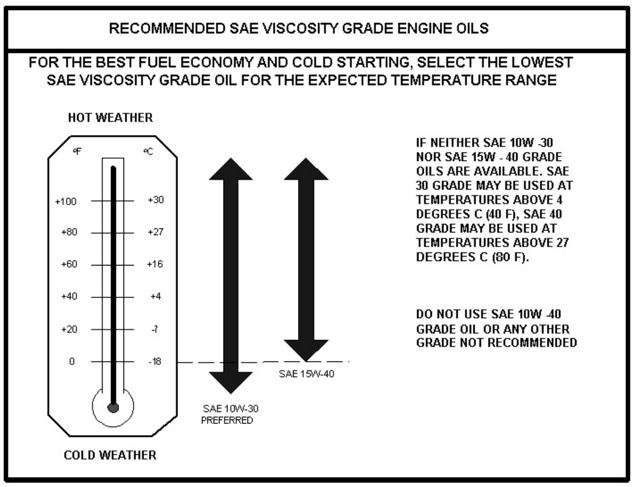


Figure 1 *Engine Oil Viscosity Recommendation*

USE OF SUPPLEMENTAL ADDITIVES

Use of the oils recommended by the engine manufacturer already contains a balanced additive treatment. The uses of supplemental additives which are added to the engine oil by the customer are not necessary and may be harmful. The engine manufacturer, fuels system suppliers and engine distributors do not review, approve or recommend such products.

SYNTHETIC OILS

Synthetic oils have been available for use in industrial engines for a relatively long period of time. Synthetic oils may offer advantages in cold temperature pumpability and high temperature oxidations resistance. However, synthetic oils have not proven to provide operational or economic benefits over conventional petroleum-based oils in industrial engines. Their use does not permit the extension of oil change intervals.

CHECKING/FILLING ENGINE OIL LEVEL

CAUTION

Overfilled crankcase (oil level being to high) can cause an oil leak, a flucuation or drop in the oil pressure and rocker arm “clatter” on engines. The overfill condition results in the engine crankshaft splashing and agitating the oil, causing it to foam (become aereated). The aereated oil causes the hydraulic lifters to “bleed down”. This results in rocker arm clatter and loss of engine performance due to valves not opening properly.

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 if in use
2. Allow sufficient time (approximately 5 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 oil level.
5. Oil level must be between the “FULL” and “ADD” marks.

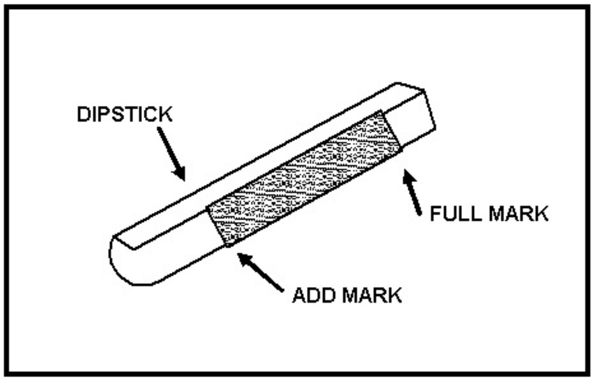


Figure 2 *Engine Oil Dip stick (Typical)*

6. If the oil level is below the "ADD" mark, proceed to Step 7 and 8, and reinstall the dipstick into the dipstick tube.
7. Remove the oil filler cap from the valve rocker arm cover
8. Add the required amount of oil to bring the level up to but not over the "FULL" mark on the dipstick
9. 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.

IMPORTANT:

Change oil when engine is warm from operation as it flows more freely, carrying away more impurities.

2. Stop engine.

IMPORTANT:

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

FUEL SYSTEM INSPECTION AND MAINTENANCE

PROPANE FUEL SYSTEM

The Propane fuel system installed on this industrial engine has been designed to meet the emission standard applicable for this equipment for 2004 model year. To ensure compliance to these standards follow the recommended maintenance schedule contained in this section.

INSPECTION AND MAINTENANCE OF THE FUEL STORAGE CYLINDER

The fuel storage cylinder should be inspected daily or at the beginning of each operational shift for any leaks, external damage, adequate fuel supply and to insure the manual service valve is open. Fuel storage cylinders should always be securely mounted, inspect the securing straps or retaining devices for damage insure that all locking devices are closed and locked. Check to insure that the fuel storage cylinder is positioned with the locating pin in the tank collar on all horizontally mounted cylinders this will insure the proper function of the cylinder relief valve.

When refueling or exchanging the fuel cylinder check the quick fill valve for thread damage. Insure the o-ring is in place, check the o-ring for cracking, chunking or separation, replace if damaged before filling. Check the service line quick coupler for any thread damage. Insure the o-ring is in place, check the o-ring for cracking, hardening, chunking or separation. Replace if damaged.

IMPORTANT:

When refueling the fuel cylinder, wipe clean both the female and male connection with a clean rag prior to filling. This will prevent dust, dirt and debris from being introduced to the fuel cylinder and prolong the life of the fuel filter.

INSPECTION AND REPLACEMENT OF THE FUEL FILTER

The Propane system on this emission certified engine utilizes an in-line replaceable fuel filter element. This element should be replaced, at the intervals specified in the recommended maintenance schedule. When inspecting the fuel filter check the following:

- Check for leaks at the inlet and outlet fittings, using a soapy solution or an electronic leak detector, if leaks are detected make repairs
- Check to make sure filter is securely mounted.
- Check filter housing for external damage or distortion, if damaged replace fuel filter

To replace the filter use the following steps:

1. Move the equipment to a well ventilated area and insure all external ignition sources are not present.
2. Start the engine.
3. With the engine running close the manual valve.
4. When the engine runs out of fuel turn OFF the key when the engine stops and disconnect the battery negative cable.

IMPORTANT:

A small amount of fuel may still be present in the fuel line, use gloves to prevent burns, wear proper eye protection. If liquid fuels continues to flow from the connections when loosened check to make sure the manual valve is fully closed.

5. Slowly loosen the inlet fitting and disconnect.
6. Slowly loosen the outlet fitting and disconnect.
7. Remove the filter housing form the equipment.
8. Check for contamination.
9. Tap the opening of the filter on a clean cloth.
10. Check for debris.
11. Check canister for proper mounting direction.
12. Reinstall the filter housing to the equipment.
13. Tighten the inlet and outlet fittings to specification.
14. Open the manual valve.

IMPORTANT: The fuel cylinder manual valve contains an "Excess Flow Check Valve" open the manual valve slowly to prevent activating the "Excess Flow Check Valve".

15. Check for leaks at the inlet and outlet fittings, and the filter housing end connection using a soapy solution or an electronic leak detector, if leaks are detected make repairs.

LOW PRESSURE REGULATOR MAINTENANCE AND INSPECTION

IMPORTANT:

The Low Pressure Regulator (LPR) components have been specifically designed and calibrated to meet the fuel system requirements of the emission certified engine. The regulator should not be disassembled or rebuilt. If the LPR fails to operate or develops a leak the LPR should be 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 the coolant supply lines for hardening, cracking, chaffing or splits. If any of these conditions exist replace coolant lines.
- Check coolant supply hose clamp connections, ensure they are tight.
- Check the to ensure the Pressure Trim Valve (PTV) mounting bolts are secure.
- Check PTV for external damage.
- Check PTV electrical connection to ensure the connector is seated and locked.
- Check to ensure the regulator is securely mounted.

CHECKING/DRAINING OIL BUILD-UP IN THE LOW PRESSURE REGULATOR

During the course of normal operation oil or “heavy ends” may build inside the secondary chamber of the Low Pressure Regulator (LPR). These oil and heavy ends may be a result of poor fuel quality, contamination of the fuel supply chain, or regional variation of the fuel make up. If the build up of oil becomes significant this can affect the performance of the secondary diaphragm response. The *Recommended Maintenance Schedule* found in this section recommends that the oil be drained periodically.

IMPORTANT:

Draining the regulator when the engine is warm will help the oils to flow freely from the regulator.

To drain the LPR use the following steps:

1. Move the equipment to a well ventilated area and ensure no external ignition sources are present.
2. Start the engine.
3. With the engine running close the manual valve.
4. When the engine runs out of fuel turn OFF the key when the engine stops and disconnect the battery negative cable.

IMPORTANT:

A small amount of fuel may still be present in the fuel line, use gloves to prevent burns, wear proper eye protection. If liquid fuels continues to flow from the connections when loosened check to make sure the manual valve is fully closed.

5. Slowly loosen the inlet fitting and disconnect.
6. Loosen the hose clamp at the outlet hose fitting and remove the hose.
7. Remove and retain the locking pin in the outlet fitting and remove the outlet fitting from the LPR
8. Disconnect PTV connection and disconnect the vacuum hose.
9. Remove the two LPR mounting bolts and retain.
10. Place a small receptacle in the engine compartment.
11. Rotate the LPR to 90° so that the outlet fitting is pointing down into the receptacle and drain the LPR.
12. Inspect the secondary chamber for any large dried particles and remove.
13. Remove the receptacle and reinstall the LPR with the two retaining bolts and tighten to specifications.
14. Reinstall the outlet fitting and secure with the previously removed locking pin.
15. Reconnect the PTV electrical connection push connector until lock “Click”, pull on the connector to ensure it is locked, connect the vacuum line.
16. Reconnect the outlet hose and secure the hose clamp.
17. Reinstall the fuel inlet line and tighten connection to specification.
18. Slowly open the manual service valve.

IMPORTANT:

The fuel cylinder manual valve contains an “Excess Flow Check Valve” open the manual valve slowly to prevent activating the “Excess Flow Check Valve”.

19. Check for leaks at the inlet and outlet fittings using a soapy solution or an electronic leak detector, if leaks are detected make repairs. Check coolant line connections to ensure no leaks are present.
20. Start engine recheck for leaks at the regulator.
21. Dispose of any drained material in safe and proper manner.

AIR FUEL MIXER/THROTTLE CONTROL DEVICE MAINTENANCE AND INSPECTION

IMPORTANT:

The Air Fuel Mixer components have been specifically designed and calibrated to meet the fuel system requirements of the emission certified engine. The mixer should not be disassembled or rebuilt. If the mixer fails to operate or develops a leak the mixer should be replaced with the OEM recommended replacement parts.

When inspecting the mixer check for the following items:

- Check for any fuel leaks at the inlet fitting.
- Check the fuel inlet hose for cracking, splitting or chaffing, replace if any of these condition exist.
- Check to ensure the mixer is securely mounted.
- Check air inlet hose connection and insure clamp is tight, check inlet hose for cracking, splitting or chaffing, replace if any of these condition exist.

- Check air cleaner element according to the Recommended Maintenance Schedule found in this section.
- Check fuel line to Throttle body mounted Fuel Trim Valve (FTV) for cracking, splitting or chaffing, replace if any of these condition exist.
- Check Throttle body return action to ensure throttle shaft is not sticking repair if necessary.
- Check FTV electrical connection to ensure connector is fully seated and locked.
- Check for leaks at the throttle body and intake manifold.
- Check Throttle cable for damage, rubbing, and kinking and free movement repair if necessary.

EXHAUST SYSTEM AND CATALYTIC CONVERTER INSPECTION AND MAINTENANCE

IMPORTANT:

The exhaust system on this emission certified engine contains an Exhaust Gas Oxygen Sensor (EGO) which provides feed back to the ECM on the amount of oxygen present in the exhaust stream after combustion. The measurement of oxygen in the exhaust stream is measured in voltage and sent to the ECM. The ECM then makes corrections to the fuel air ratio to ensure the proper fuel charge and optimum catalytic performance. Therefore it is important that the exhaust connections remain secured and air tight.

IMPORTANT:

The EGO sensor is sensitive to silicone or silicone based products. Do not use silicone sprays or hoses which are assembled using silicone lubricants. Silicone contamination can cause severe damage to the EGO.

When inspecting the Exhaust system check the following:

- Check the exhaust manifold at the cylinder head for leaks and that all retain bolts and shields (if used) are in place.
- Check the manifold to exhaust pipe fasteners to ensure they are tight and that there are no exhaust leaks repair if necessary.
- Check EGO electrical connector to ensure connector is seated and locked, check wires to ensure there is no cracking, splits chaffing or “burn through” repair if necessary.
- Check any exhaust pipe extension connector for leaks tighten if necessary
- Visually inspect converter to insure muffler is securely mounted and tail pipe is properly aimed.
- Check for any leaks at the inlet and outlet of the converter

CERTIFIED ENGINE MAINTENANCE REQUIREMENTS										
	Install	Interval Hours								
	Date	Daily	250	500	750	1000	1250	1500	1750	2000
General Maintenance Section										
Visual check for leaks		X								
Check engine oil level		X								
Check coolant level		X								
Change engine oil and filter	**Every 100 hours or 60 days of operation**									
Check Fuel system for leaks	**Prior to any service or maintenance activity**									
Inspect Accessory Drive belts						X				X
Inspect electrical system										X
Inspect all vacuum lines and fitting										X
Inspect all fuel lines and fitting										X
Engine Coolant Section										
Check coolant level		X								
Clean debris from radiator core	**Every 100 hours or 60 days of operation**									
Change coolant						X				X
Inspect coolant hoses for cracks, swelling or deterioration						X				X
Engine Ignition System										
Inspect Battery case for damage						X				X
Inspect battery cables						X				X
Check all electrical connectors						X				X
Check ignition timing and adjust										X
Replace spark plugs										X
Check spark plug wires										X
Fuel System Maintenance										
Replace fuel filter						X				X
Inspect lock off for leaks										X
Ensure lock off closing										X
Test LPG/Gas regulator pressure										X
Inspect LPR for oil build up	**Annually or every 2000 hours**									
Inspect LPR for coolant leaks	**Annually or every 2000 hours**									
Check air induction system for leaks										X
Check manifold for vacuum leaks										X
Check FTV electrical connection										X
Check throttle shaft for sticking										X
Check injector & rails for leaks										X
Inspect air cleaner	**Every 200 hours, or every 100 hours in dusty environment**									
Replace filter element	**Annually, or Bi-annually in dusty environments**									
Engine Exhaust System										
Inspect exhaust manifold for leaks										X
Inspect exhaust piping for leaks										X
Inspect catalyst inlet and outlet										X
Check HEGO sensor connector										X

The maintenance schedule represents manufacturers recommended maintenance intervals to maintain proper engine/equipment function. Specific state and federal regulations may require equipment operators to conduct comprehensive engine/equipment inspections at more periodic intervals than those specified above. This maintenance schedule has no regulatory value and should not be considered representative of any state or federal engine/equipment maintenance requirement.

SECTION 1A1

LPG FUEL SYSTEM OPERATION

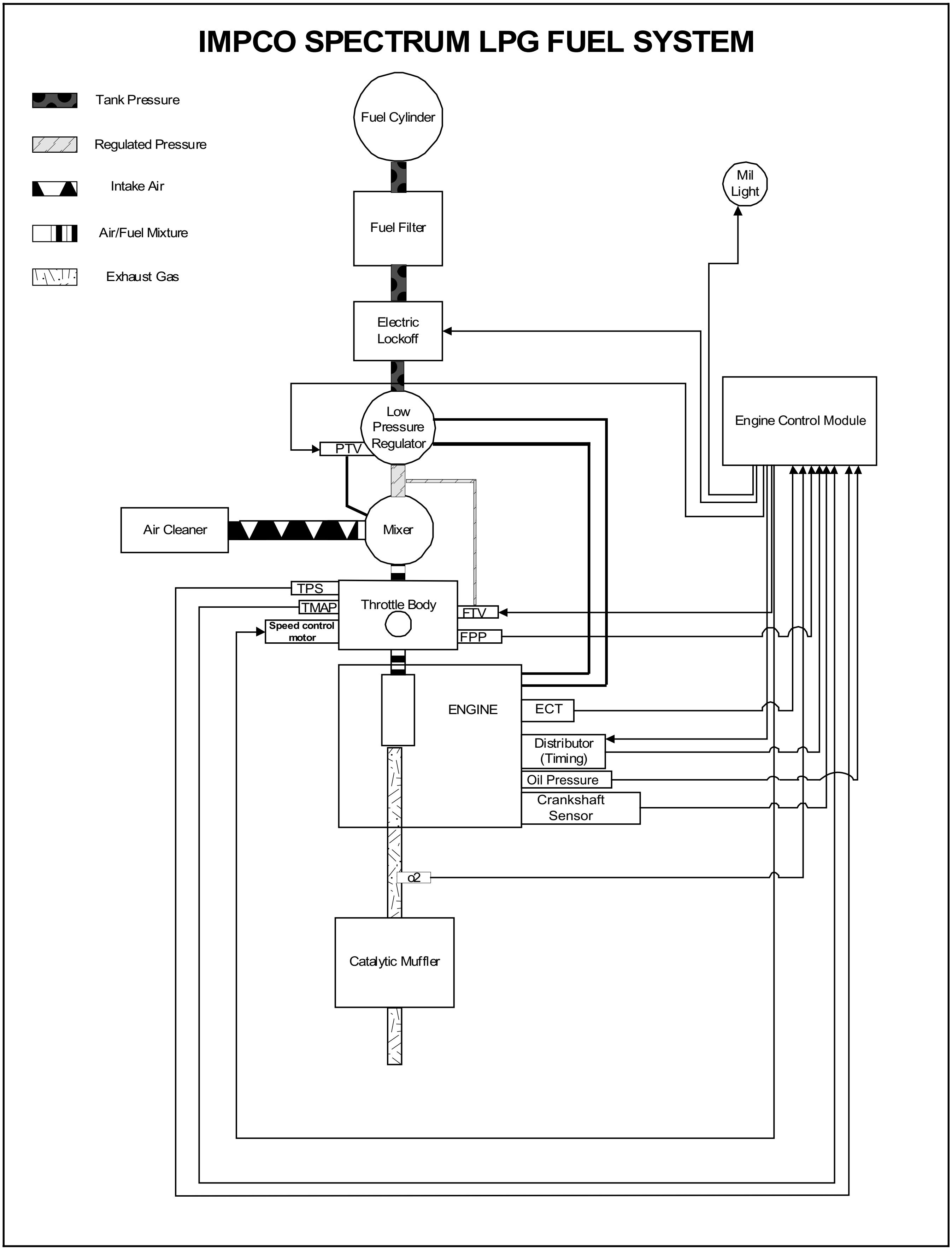


Figure 1 Typical Fuel System Schematic

DESCRIPTION AND OPERATION OF THE FUEL SYSTEMS

PROPANE FUEL SYSTEM

The primary components of the propane fuel system are the fuel storage tank, low pressure regulator (LPR), fuel mixer module with throttle control device, electric fuel lock-off solenoid, engine control module (ECM) fuel trim valve (FTV) pressure trim valve (PTV) and Three Way Catalytic (TWC) converter. The system operates at pressures which range from 355.60 mm (14.0 inches) of water column up to 21.5 BAR (312 psi). Figure 1 *Typical Fuel System Schematic.*

LPG FUEL TANK

Propane is stored in the fuel tank as a liquid. The approximate pressure of the fuel in the tank is 16.5 bar (240 psi) when the tank is full at an ambient temperature of 27° C (81°F). The boiling point, (temperature at which the liquid fuel becomes vapor) is approximately -40° C (-40° F). When the fuel changes from liquid to vapor the fuel expands and creates pressure inside the tank. When the tank service valve is opened the pressure inside the tank forces the liquid fuel out though the pick up tube located near the bottom of the fuel cylinder. Because the Propane is stored under pressure the tank is equipped with a safety valves which are normally set at 25.8 bar (375 psi) to prevent tank rupture due to over-pressurization of the cylinder. The service valve mounted in the end of the cylinder controls the flow of fuel from the tank. By turning the handle to its "open" position, fuel flows out of the tank and into the service line. The service valve is also equipped with a safety feature called an "excess flow check valve". This feature reduces the flow from the service valve in the event of a rupture of the fuel line or any down stream component.

1. Liquid Outage valve w/quick disconnect coupling	11. Vapor Withdrawal Tube (when applicable)
2. Filler Valve	12. 80% Limitor Tube
3. Pressure Relief Valve	13. Fuel Level Float
4. Liquid Outage Fill Check Valve	14. Liquid Withdrawal Tube
5. Fuel Gauge	

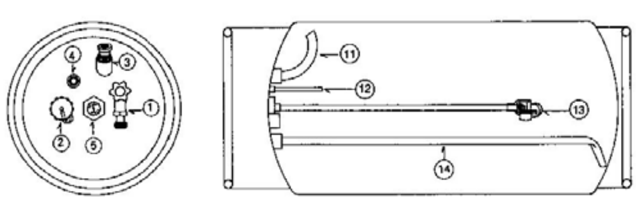


Figure 2 Typical Propane Cylinders

SERVICE LINE

Propane flows from the fuel tank to the electric lock via the service line. The service line is connected to the tank utilizing a quick coupler. The other end of the service line is connected to a "bulkhead connector" mounted on the equipment sheet metal. This bulkhead connector allows for a safe means of passing through the equipments engine compartment sheet metal and into the engine compartment. If a bulkhead connector is used a pressure relief device is mounted in the service line or the connector itself to prevent over pressurization of the service line. The service line is made of high pressure hose with special material or possibly tubing which is compatible with the LPG fuel and should always be replaced with an OEM supplied part.

CAUTION

The bulkhead assembly should never be removed and a service line run throught the sheet metal.

FUEL FILTER

Propane fuel like all other motor fuels is subject to contamination from outside sources. Refueling of the equipments tank and removal of the tank from the equipment can inadvertently introduce dirt and other foreign matter into the fuel system. It is therefore necessary to filter the fuel prior to entering the fuel system components down stream of the tank. An inline fuel filter has been installed in the fuel system to remove the dirt and foreign matter from the fuel. The inline filter is replaceable as a unit only. Maintenance of the filter is critical to proper operation of the fuel system and should be replaced as defined in the *Maintenance Schedule,* SECTION 0B. In severe operating condition more frequent replacement of the filter may be necessary.

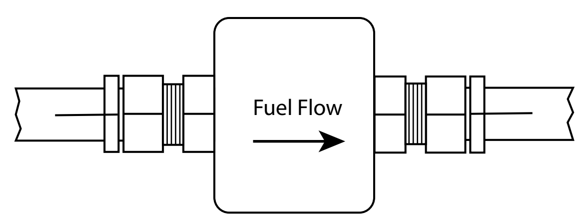


Figure 3 Inline Fuel Filter

ELECTRIC LOCK OFF

The Electric Lock Off device is an integrated assembly. The electric lock assembly is a 12 volt normally closed valve. The solenoid is mounted to the valve body. When energized the solenoid opens the valve and allows the Propane fuel to flow through the device. The valve opens during cranking and run cycles of the engine. The lock off supply voltage is controlled by the engine control module (ECM).

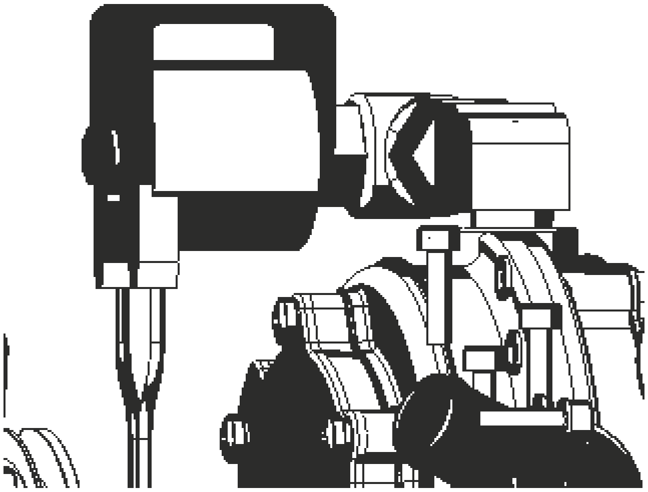


Figure 4 Electric Fuel Lock Off

LOW PRESSURE REGUALTOR (LPR)

The LPR is a combination vaporizer, pressure regulating device. The LPR is a negative pressure two stage regulator that is normally closed when the engine is not running. When the engine is cranking or running a partial vacuum is created in the fuel line which connects the regulator to the mixer. This partial vacuum opens the regulator permitting fuel to flow to the mixer.

Propane fuel enters the primary port of the LPR and passes through the primary jet and into the primary/exchanger chamber. As the propane passes through the heat exchanger the fuel expands and creates pressure inside the chamber. The pressure rises as the fuel expands when the pressure rises above 10.34 kpa (3.5 psi), sufficient pressure is exerted on the primary diaphragm to cause the diaphragm plate to pivot and press against the primary valve pin thus closing off the flow of fuel. This action causes the flow of fuel into the regulator to be regulated. When the engine is cranking, sufficient vacuum will be introduce into the secondary chamber from the mixer drawing the secondary diaphragm down onto the spring loaded lever and opening the secondary valve allowing vaporized fuel to pass to the mixer. Increased vacuum in the secondary chamber increases the downward action on the secondary lever causing it to open wider allowing more fuel to flow to the mixer.

The regulator utilized on this emission certified engine is equipped with a unique Pressure Trim Valve (PTV) which is directly mounted to the regulator. This solenoid is a 12 volt normally closed solenoid. The function of this solenoid is to regulate a specific amount of venture vacuum to the atmospheric side of the secondary diaphragm. By introducing vacuum to the top side of the secondary diaphragm during regulator operation the amount of fuel being delivered to the mixer can be "trimmed" or reduced to allow for correction to the air fuel ratio for closed loop fuel control. The solenoid receives a reference signal from the ECM which causes the solenoid to be pulsed fast or slow depending on the amount of fuel to be trimmed.

CAUTION

The LPR is an emission control device. Components inside the regulator are specifically calibrated to meet the engine emissions requirements and should never be disassembled or rebuilt. If the LPR fails to operate, replace with an OEM replacement part.

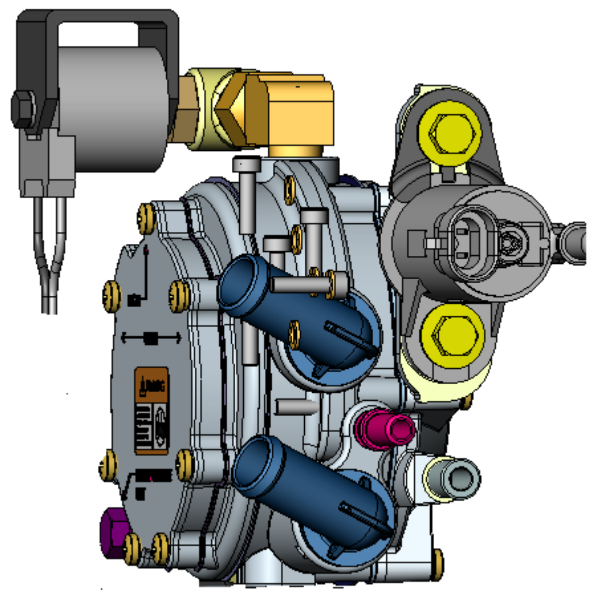


Figure 5 Low pressure regulator

AIR FUEL MIXER

The air valve mixer is an air-fuel metering device and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop to draw fuel into the mixer from cranking to full load. The mixer is mounted in the air stream ahead of the throttle control device.

When the engine begins to crank it draws in air with the air valve covering the inlet, negative pressure begins to build. This negative pressure signal is communicated to the top of the air valve chamber through 4 vacuum ports in the air valve assembly. A pressure/force imbalance begins to build across the air valve diaphragm between the air valve vacuum chamber and the atmospheric pressure below the diaphragm. The air valve vacuum spring is calibrated to generate from 101.6 mm (4.0 inches) of water column at start to as high as 355.60 mm (14.0 inches) of water column at full throttle. The vacuum being created is referred to as Air Valve Vacuum (AVV). As the air valve vacuum reaches 101.6mm (4.0 inches) of water column, the air valve begins to lift against the air valve spring. The amount of AVV generated is a direct result of the throttle position. At low engine speed the air valve vacuum is low and the air valve position is low thus creating a small venturi for the fuel to flow. As the engine speed increases the AVV increases and the air valve is lifted higher thus creating a much larger venturi. This air valve vacuum is communicated from the mixer venturi to the LPR secondary chamber via the low pressure fuel supply hose. As the AVV increases in the secondary chamber the secondary diaphragm is drawn further down forcing the secondary valve lever to open wider.

The mixer is equipped with a low speed mixture adjustment which is retained in a tamper proof housing. The mixer has been preset at the factory and should not require any adjustment. In the event that the idle adjustment should need to be adjusted refer to the *Fuel System Repair* section of this manual.

CAUTION

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

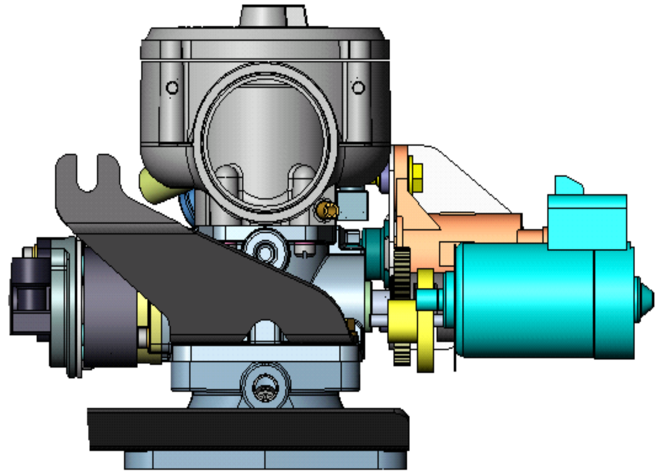


Figure 6 Air Fuel Mixer

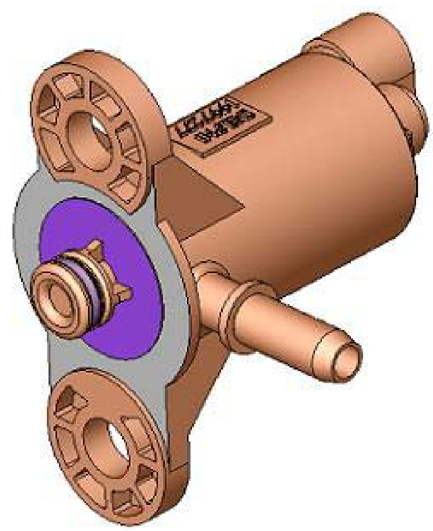


Figure 7 Pressure Trim Valve and Fuel Trim Valve

THROTTLE CONTROL DEVICE

Drive By Cable

Engine speed control is maintained by the amount of pressure applied to a foot pedal located in the operator's compartment. A cable is utilized to connect the foot pedal to the throttle shaft in the engine compartment. A coil spring mounted to the pedal and the throttle shaft will keep the throttle shaft in a "normally closed" position. When the foot pedal is depressed the throttle shaft is rotated opening the "butterfly" in the venturi of the throttle body allowing more air and fuel to enter the engine. When the ECM detects that the engine has reached maximum governed speed or requires adjustment for load, the ECM will correct the throttle plate position by overriding the throttle shaft with the electronic governor.

The air fuel mixer is attached to the throttle control device or "throttle body assembly" which is then connected to the intake manifold of the engine. The Throttle body maintains control of engine speed by increasing or decreasing the opening angle of the throttle blade in the throttle body bore thus increasing or decreasing the fuel air mixture to the engine. The throttle blade shaft is connected to a spring loaded cable connector which is connected to the foot pedal in the operator's compartment. The shaft incorporates a return spring to insure the blade position returns to idle when the operator removes his foot from the pedal. Also attached to the throttle shaft is a Throttle Position Sensor (TPS), which provides a signal to the ECM to indicate the throttle blade angle for speed control and load control as well as emission control. On the end opposite the TPS is the Foot Pedal Position (FPP) sensor which operates the foot pedal override command.

Also mounted to the throttle control device is an integrated electronic governor. The throttle control is maintained by a foot pedal located in the operator's compartment and connected to the throttle control device by a cable. The governor is controlled by the ECM and has no external adjustments. When the ECM determines load adjustment or maximum engine speed has been achieved the governor overrides the foot pedal and corrects the throttle plate position.

Also mounted on throttle body assembly is the Fuel Trim Valve (FTV). The FTV is a 12 volt normally closed solenoid valve. During closed loop operation the ECM sends a pulse signal to the FTV to open to allow more or less fuel to be introduced below the throttle blade to correct the air fuel mixture for proper emission control.

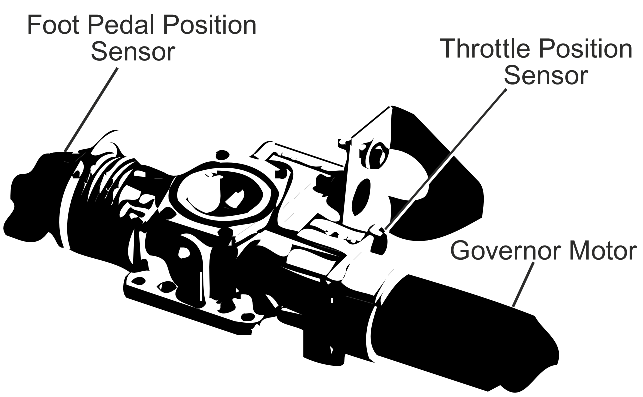


Figure 8 Throttle control device "LPG Drive by cable throttle body assembly"

THREE WAY CATALYTIC MUFFLER

The emission certified engine has been designed and calibrated to meet the emission standards in effect for 2004. To help meet the emission requirements the vehicle has been equipped with a Three Way Catalytic (TWC) muffler. The catalyst muffler is a three way catalyst, sound damping and spark arresting unit. Besides controlling the noise created from the combustion process, and preventing sparks from escaping from the exhaust system the most important function is treating the exhaust gases which are created from the combustion process. The three-way catalyst consists of a honeycomb coated with a mixture of platinum, palladium, and rhodium. The hot gases flow through the catalyst sections where an oxidation and reduction reactions take place. These chemical reactions reduce the amount of CO, HC and NOX in the engines exhaust. The exhaust gas then flows through the outlet.

Figure 9 Three way catalytic converter

ENGINE CONTROL MODULE

To obtain maximum effect from the catalyst and accurate control of the air fuel ratio the emission certified engine is equipped with an onboard computer or Engine Control Module (ECM). The ECM is a 32 bit controller which receives input data from sensors fitted to the engine and fuel system and then outputs various signals to control engine operation.

One specific function of the controller is to maintain "closed loop fuel control". Closed loop fuel control is accomplished when the Heated Exhaust Gas Oxygen sensor (HEGO) mounted in the exhaust system sends a voltage signal to the controller. The controller then calculates any correction that may need to be made to the air fuel ratio. The controller then outputs signals to PTV or the FTV or both mounted in the fuel system to change the amount of fuel being delivered from the regulator or mixer or to the engine.

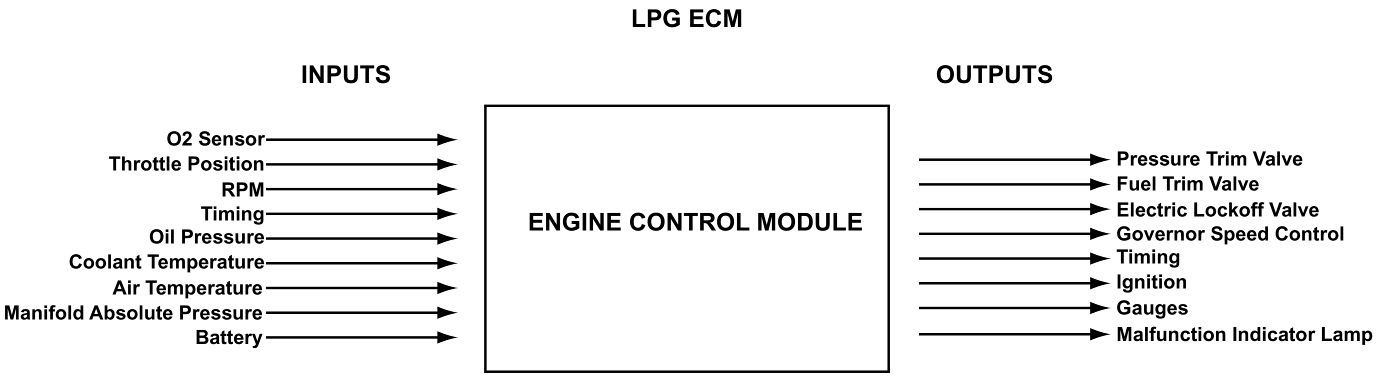


Figure 10 LPG Engine control module (ECM)

The controller also performs diagnostic functions on the fuel system and notifies the operator of engine malfunctions by turning on a Malfunction Indicator Light (MIL) mounted in the dash. Malfunctions in the system are identified by a Diagnostic Trouble Code number. In addition to notifying the operator of the malfunction in the system the controller also stores the information about the malfunction in its memory. A technician can than utilize a computerized diagnostic scan tool to retrieve the stored diagnostic code and by using the diagnostic charts in this manual determine the cause of the malfunction. In the event a technician does not have the computerized diagnostic tool, the MIL light can be used to identify the diagnostic code. By following specific steps the technician can activate the “blink” feature and count the number of blinks to determine the diagnostic code number to locate the fault in the system.

! CAUTION

The Heated Exhaust Gas Oxygen Sensor (HEGO) is an emissions control component. If the HEGO fails to operate, replace only with an OEM replacement part. The HEGO sensor is sensitive to silicone and silicone based products and can become contaminated. Avoid using silicone sealers or hoses treated with silicone lubricant in the air stream or fuel supply lines.

HEATED EXHAUST GAS OXYGEN SENSOR

The Heated Exhaust Gas Oxygen Sensor (HEGO) is mounted in the exhaust system downstream of the engine. The HEGO is used to measure the amount of oxygen present in the exhaust stream and communicate that to the ECM via an electrical signal. The amount of oxygen present in the exhaust stream indicates whether the fuel air ratio is to rich or to lean. If the HEGO sensor signal indicates that the exhaust stream is to rich the ECM will decrease or lean the fuel mixture during engine operation, if the mixture is to lean the ECM will richen the mixture. The ECM continuously monitors the HEGO sensor output if a rich or lean condition is present for an extended period of time and the ECM cannot correct the condition the ECM will set a diagnostic code and turn on the MIL light in the dash.

Figure 11 Heated Exhaust Gas Oxygen Sensor (HEGO)

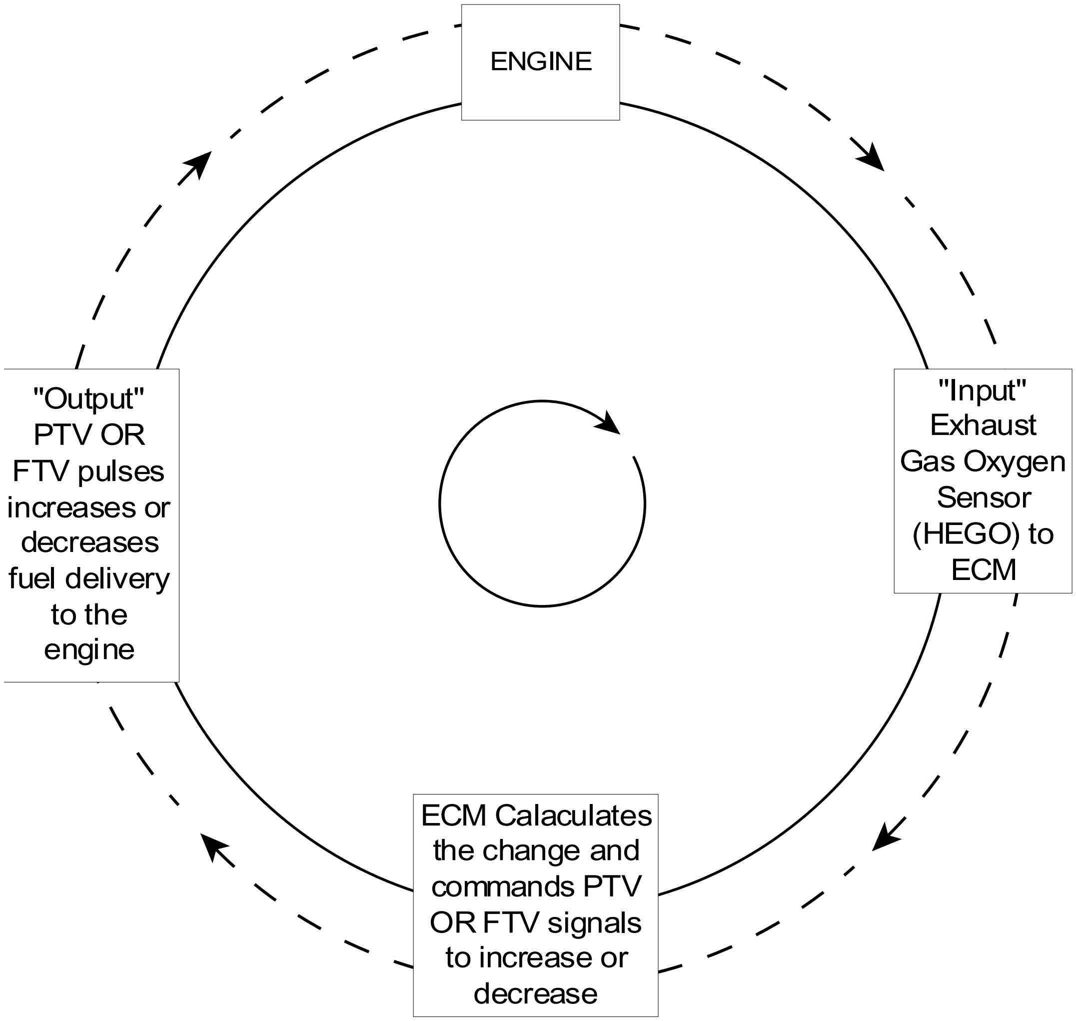


Figure 12 Propane Closed Loop Control Schematic

SECTION 1A2

GASOLINE FUEL SYSTEM OPERATION

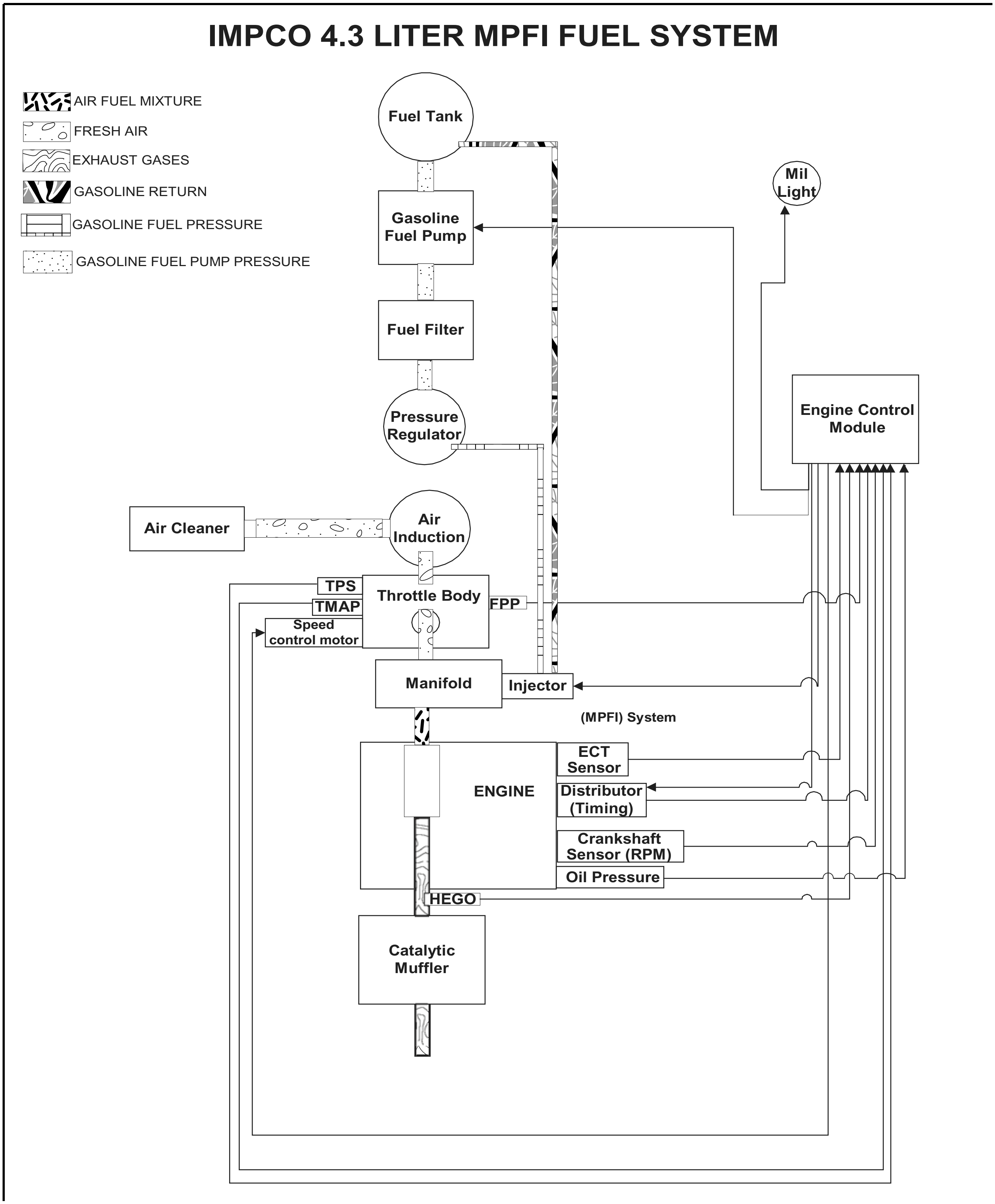


Figure 1 Gasoline Multi-Port Fuel Injection System

GASOLINE MULTI POINT FUEL INJECTION SYSTEM (MPFI)

The primary components of the Gasoline Multi Point Fuel Injection (MPFI) fuel system are the gasoline fuel tank, electric fuel pump, fuel filter, fuel rails, fuel pressure regulator, fuel injector, O2 sensor, engine control unit and three way catalytic muffler.

GASOLINE FUEL STORAGE TANK

The gasoline fuel storage tank location may very on equipment applications. The fuel tank may be integrated into the chassis frame or may be a stand alone vessel mounted on the equipment. For precise location for the equipment application refer to the OEMs vehicle manual.

GASOLINE FUEL PUMP

The Gasoline is stored as a liquid in the fuel tank and is drawn into the fuel system by a 12 volt electric fuel pump. Depending on the vehicle application the fuel pump may be mounted in the fuel tank or as a stand alone component. In either case the fuel pump will receive a signal from the ECM at Key On to prime the fuel system for approximately 2 seconds prior to start. Priming of the fuel system provides for a quicker start, when the engine begins to crank.

CAUTION

The fuel pump is an emissions control component. If the fuel pump fails to operate, replace only with an OEM replacement part. The fuel pump is calibrated to supply the correct amount of fuel to the injectors. Replacing the pump with anything other than the OEM replacement could cause damage to the fuel system and or damage to the fuel tank.

FUEL FILTER

After the fuel is drawn into the fuel pump the fuel then flows through the gasoline fuel filter. The fuel filter will trap small particles as the fuel passes through the filter to remove debris and prevent injectors from becoming damaged. Maintenance of the fuel filter is required as indicated in the *Recommended Maintenance Schedule*. A more frequent replacement of the filter may be required if the equipment operates in a dusty or dirty environment.

FUEL RAIL AND PRESSURE REGULATOR

The fuel flows from the fuel filter to the fuel rails where the fuel is regulated. During engine operation the regulator maintains the proper amount of fuel pressure to the top of the injector. During lower RPM operation excess fuel at the top of the injector is bypassed and returned to the fuel tank for recirculation.

The Fuel pressure regulator has no adjustments and is integrated into the fuel rail assembly. The fuel rail also contains a Schrader valve which is utilized to test the regulated pressure of the fuel system.

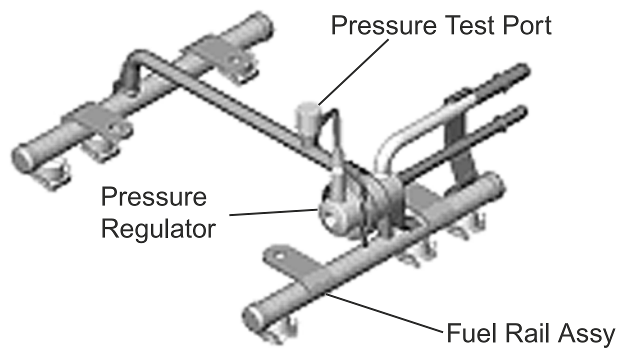


Figure 2 Gasoline Fuel Rail Assembly

FUEL INJECTOR

The fuel supply is maintained on the top of the injector by the fuel pressure regulator. The injector is fed a "pulse" signal through the wire harness which causes the injector to open. During regular operating conditions the ECM controls the opening and duration of opening of the injector. During lower RPM operation the injector signals or "pulses" are less frequent then when the engine is operating at higher RPMs. The certified engine has been calibrated to deliver the precise amount of fuel for optimum performance and emission control.

THROTTLE CONTROL DEVICE

Drive By Cable

Engine speed control is maintained by the amount of pressure applied to a foot pedal located in the operator's compartment. A cable is utilized to connect the foot pedal to the throttle shaft in the engine compartment. A coil spring mounted to the pedal and the throttle shaft will keep the throttle shaft in a "normally closed" position. When the foot pedal is depressed the throttle shaft is rotated opening the "butterfly" in the venturi of the throttle body allowing more air to enter the engine. When the ECM detects that the engine has reached maximum governed speed or requires adjustment for load, the ECM will correct the "blade position by overriding the throttle shaft with the electronic governor.

The Throttle Control device or "throttle body assembly" is connected to the intake manifold of the engine. The Throttle body maintains control of engine speed by increasing or decreasing the opening angle of the throttle blade in the throttle body bore thus increasing or decreasing the intake air to the engine. The throttle blade shaft is connected to a spring loaded cable connector which is connected to the foot pedal in the operator's compartment. The shaft incorporates a return spring to insure the blade position returns to idle when the operator removes his foot from the pedal. Also attached to the throttle shaft is a Throttle Position Sensor (TPS), which provides a signal to the ECM to indicate the throttle blade angle for speed control and load control as well as emission control. At the opposite end of the throttle shaft (cable end) is the Foot Pedal Position (FPP) sensor which indicates the position of the throttle pedal.

Also mounted to the throttle control device is an integrated electronic governor. The throttle control is maintained by a foot pedal located in the operator's compartment and connected to the throttle control device by a cable. The governor is controlled by the ECM and has no external adjustments. When the ECM determines load adjustment or maximum engine speed has been achieved the governor overrides the throttle shaft and corrects the throttle blade position.

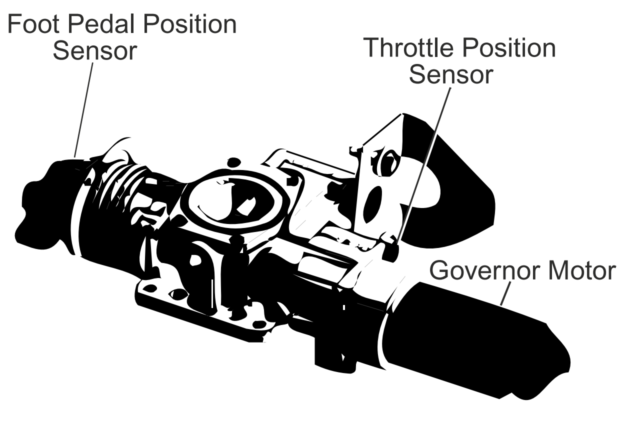


Figure 3 Throttle Control Device "Drive By Cable Throttle Body Assembly"

THREE WAY CATALYTIC MUFFLER

The emission certified engine has been designed and calibrated to meet the emission standards in effect for 2004. To help meet the emission requirements the vehicle has been equipped with a three way catalytic muffler. The catalyst muffler is a three way catalyst, sound damping and spark arresting unit. Besides controlling the noise created from the combustion process, and preventing sparks from escaping from the exhaust system the most important function is treating the exhaust gases which are created from the combustion process. The three-way catalyst consists of a honeycomb coated with a mixture of platinum, palladium, and rhodium. The hot gases flow through the catalyst sections where an oxidation and reduction reactions take place. These chemical reactions reduce the amount of CO, HC and NOX in the engines exhaust. The Exhaust gas then flows through the outlet.

Figure 4 Three Way Catalytic Converter

ENGINE CONTROL UNIT

To obtain maximum effect from the catalyst and accurate control of the air fuel ratio the emission certified engine is equipped with an onboard computer or Engine Control Unit (ECM). The ECM is a 32 bit controller which receives in-put data from sensors fitted to the engine and fuel system and then out-puts various signals to control engine operation.

One specific function of the controller is to maintain "closed loop fuel control". Closed loop fuel control is accomplished when the exhaust gas oxygen sensor (EGO) mounted in the exhaust system sends a voltage signal to the controller. The controller then calculates any correction that may need to be made to the air fuel ratio. The controller then changes the amount of fuel being delivered to the engine by changing the pulse frequency to the injector. The controller also performs diagnostic functions on the fuel system and notifies the operator of malfunctions by turning on a Malfunction Indicator Light (MIL) mounted in the dash. Malfunctions in the system are identified by a Diagnostic Code number. In addition to notifying the operator of the malfunction in the system the controller also stores the information about the malfunction in its memory. A technician can than utilize a computerized diagnostic tool to retrieve the stored diagnostic code and by using the diagnostic charts in this manual determine the cause of the malfunction. In the event a technician does not have the computerized diagnostic tool the MIL light can be used to identify the diagnostic code.

By following specific steps the technician can activate the

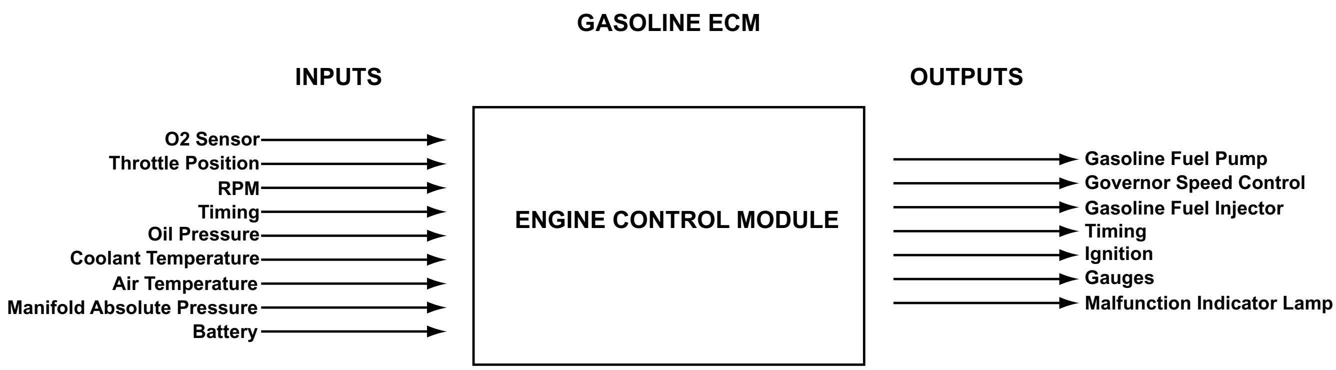


Figure 5 Gasoline Engine Control Module (ECM)

"blink" feature and count the number of blinks to determine the diagnostic code number to locate the fault in the system.

HEATED EXHAUST GAS OXYGEN SENSOR

The Heated Exhaust Gas Oxygen Sensor (HEGO) is mounted in the exhaust system downstream of the engine. The HEGO is used to measure the amount of oxygen present in the exhaust stream and communicate that to the ECM via an electrical signal. The amount of oxygen present in the exhaust stream indicates whether the fuel air ratio is to rich or to lean. If the HEGO sensor signal indicates that the exhaust stream is to rich the ECM will decrease or lean the fuel mixture by reducing the signals to the injectors during engine operation, if the mixture is to lean the ECM will richen the mixture or increase the pulse to the injectors. The ECM continuously monitors the HEGO sensor output if a rich or lean condition is present for an extended period of time and the ECM cannot correct the condition the ECM will set a diagnostic code and turn on the MIL light in the dash.

Figure 6 Heated Exhaust Gas Oxygen Sensor (Hego)

! CAUTION

The Heated Exhaust Gas Oxygen Sensor (HEGO) is an emissions control component. If the HEGO fails to operate, replace only with an OEM replacement part. The HEGO sensor is sensitive to silicone and silicone based products and can become contaminated. Avoid using silicone sealers or hoses treated with silicone lubricant in the air stream or fuel supply lines.

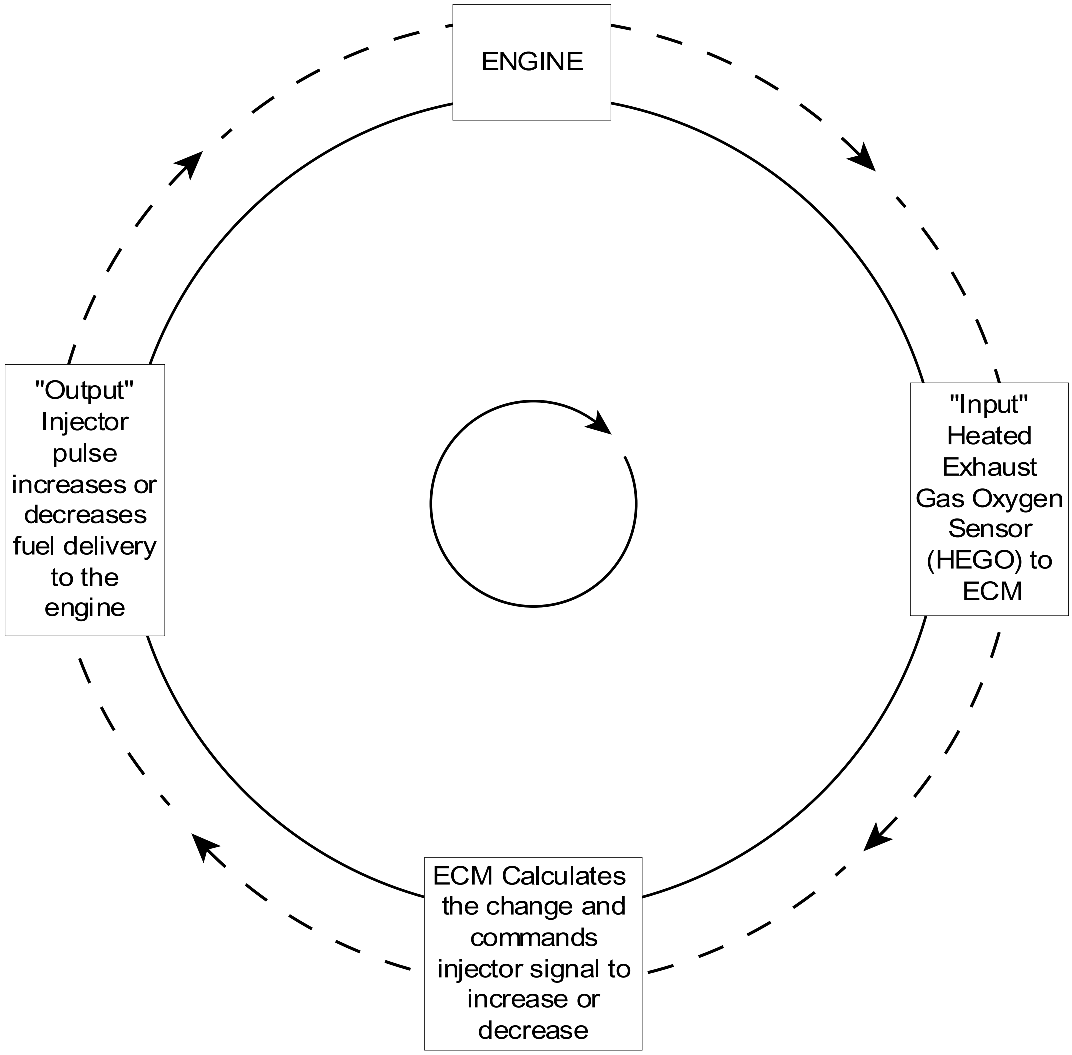


Figure 7 Gasoline Closed Loop Control Schematic

SECTION 1B1

LPG SYSTEM DIAGNOSIS

LPG Fuel System Diagnosis

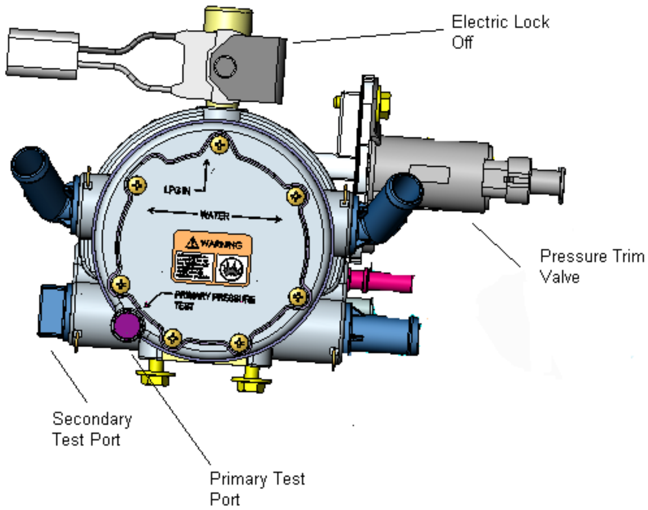


Figure 1 Low Pressure Regualtor Assembly

Fuel System Description

The Engine Control Module (ECM) receives information from various engine sensors in order to control the operation of the fuel control solenoid valves (FTV) and the low-pressure lock-off (LPL) solenoid. The LPL solenoids prevent fuel flow unless the engine is cranking or running. LPG is stored in the tank and delivered under pressure to the system as a liquid. During key on, the LPL receives a two (2) second prime pulse from the ECU which allows LPG to flow from the tank through fuel filter and fuel lines to the low pressure regulator (LPR) at pressures up to 21.5 BAR (312 psi).

In the (LPR) the fuel is vaporized and the pressure reduced in two stages. The first stage reduces the pressure to approximately 20.68 kilopascals (3.0 psi). The second stage reduces the pressure to approximately negative 38.1 mm (1.5”) of water column.

The fuel is then drawn from the secondary chamber of the LPR by the vacuum generated by air flowing through the mixer. This vacuum signal is also used to generate lift for the mixer air valve. This vacuum signal is most commonly referred to as air valve vacuum. In the mixer, the fuel mixes with the air entering the engine. This air/fuel mixture is then drawn into the engine for combustion.

Diagnostic Aids

This procedure is intended to diagnose a vehicle operating on LPG. If the vehicle will not continue to run on LPG, refer to Hard Start for preliminary checks. Before proceeding with this procedure, verify that the vehicle has a sufficient quantity of fuel and that liquid fuel is being delivered to the LPR. Also, ensure that the manual shut off valve on the LPG tank is fully opened and that the excess flow valve has not been activated.

Tools Required:

- 7/16 Open end wrench (for test port plugs)
- Straight Blade screw driver
- DVOM (GM J 39200, Fluke 88 or equivalent).

Duty Cycle Monitoring Tool

- IMPCO Fuel System Analyzer (FSA), or DVOM (GM J 39200, Fluke 88 or equivalent).

Diagnostic Scan Tool

- IMPCO hand held Diagnostic Scan Tool (DST).

Pressure Gauges

- Water Column Gauge / Manometer (GM 7333-6 or equivalent).
- 0-10 PSI Gauge

Test Description

The numbers below refer to step numbers on the diagnostic table.

5. This step will determine if the PTV and FTV and fuel supply system are functioning properly. The vacuum on the secondary test port will be approximately –1.0 “ to –2.0” w.c.
6. This step checks the base mechanical LPR output pressure by disabling all fuel control devices.
9. This step checks for proper air valve operation.
19. This determines if fuel is available from the fuel tank supply system.

LPG Fuel System Diagnosis

Step	Action	Value(s)	Yes	No
1	Were you referred to this procedure by a DTC diagnostic chart?	––	Go to *Step 3*	Go to *Step 2*
2	Perform the On Board Diagnostic (OBD) System Check. Are any DTCs present in the ECM?	––	Go to the applicable DTC Table	Go to *Step 3*
3	Verify that the LPG fuel tank has a minimum of 1/4 tank of fuel, that the manual valve is open and the tank quick connect is fully engaged Does the vehicle have fuel?	––	Go to *Step 4*	––
4	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Start the engine and allow it to reach operating temperature. Does the engine start and run?	––	Go to *Step 5*	Go to *Step 8*
5	With the engine idling, observe the pressure reading for the LPR secondary pressure. Does the fuel pressure fluctuate rhythmically **OUTSIDE** the specified range?	-1.0” to -2.0” w.c.	Go to *Step 25*	Go to *Step 6*
6	1. Disconnect the PTV & FTV electrical connectors. **Note:** This action may cause a DTC to be set by the ECU 2. With the engine idling observe the pressure reading on the secondary test port. Is the fuel pressure **WITHIN** the specified range?	-1.0” to -2.0” w.c.	Go to *Fuel Control System Diagnosis*	Go to *Step 7*
7	1. Inspect the air intake stream between the mixer assembly and the throttle body for leaks. 2. Inspect the fuel hose connection between the LPR and mixer assembly for damage or leakage. 3. Inspect the vacuum hoses to the FTV solenoid. Was a problem found and corrected?	––	Go to *Step 26*	Go to *Step 22*
8	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR secondary pressure. Does the fuel pressure indicate a vacuum is present?	––	Go to *Step 12*	Go to *Step 9*

9	1. Remove Air induction hose to the mixer 2. Observe the air valve for movement while the engine is cranking. **Note:** Movement of the air valve will be minimal at cranking speeds. Does the air valve move when the engine is cranked?	––	Go to *Step 11*	Go to *Step 10*
10	1. Inspect the air intake stream to the mixer assembly and the throttle body for vacuum leaks. 2. Inspect the vacuum hoses from the mixer to the PTV solenoids for proper connection and condition. Was a problem found and repaired?	––	Go to *Step 26*	Go to *Step 24*
11	Inspect the fuel hose connection between the LPR and the mixer assembly for damage or leakage. Was a problem found and repaired?	––	Go to *Step 26*	Go to *Step 12*
12	1. Connect a 0-10 psi gauge to the primary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR primary pressure. Is the fuel pressure **ABOVE** the specified value?	2.0 – 4.0 psi	Go to *Step 22*	Go to *Step 13*
13	1. Turn OFF the ignition. 2. Disconnect the LPL connector. 3. Install a test light between the pins of the LPL connector. 4. Crank the engine. The test light should illuminate. Does the test light illuminate?	––	Go to *Step 14*	Go to *Step 16*
14	Using a DVOM, check the resistance of the low pressure lock-off (LPL). Is the resistance within the specified range?	12 - 24 Ω	Go to *Step 15*	Go to *Step 23*
15	1. Turn the ignition OFF. 2. Close the manual shut-off valve on the LPG tank. **CAUTION: When disconnecting LPG fuel lines, liquid LPG may be present. Perform this step in a well ventilated area.** 3. Loosen the fuel inlet hose fitting at the inlet of the LPL. Was fuel present when the fitting was loosened?	––	Go to *Step 23*	Go to *Step 17*

16	1. Turn OFF the ignition. 2. Connect the test light to chassis ground and probe pin A of the LPL connector. 3. Crank the engine. The test light should illuminate. Does the test light illuminate?	––	Go to *Step 20*	Go to *Step 21*
17	1. Remove the LPG fuel filter / LPL. 2. Remove the filter from the LPL. 3. Empty the contents of the inlet side of the LPG fuel filter onto a clean surface. 4. Inspect the contents of the LPG fuel filter for an excessive amount of foreign material or water. If necessary, locate and repair the source of contamination. 5. Verify the LPG fuel filter is not restricted or plugged. Was a problem found?	––	Go to *Step 19*	Go to *Step 23*
18	The fuel supply system or hoses are plugged or restricted, locate and repair the problem. Is the action complete?	––	Go to *Step 26*	––
19	Replace the fuel filter. Refer to *Fuel Filter Replacement*. Is the action complete?	––	Go to *Step 26*	––
20	Repair the open in the lock-off ground circuit. Is the action complete?	––	Go to *Step 26*	––
21	Repair the open in the lock-off power (OEM fuel pump) circuit. Is the action complete?	––	Go to *Step 26*	––
22	Replace the low pressure regulator (LPR). Refer to *Low Pressure Regulator Replacement*. Is the action complete?	––	Go to *Step 26*	––
23	Replace the lock-off. Refer to *Low Pressure Lock-off (LPL) Replacement*. Is the action complete?	––	Go to *Step 26*	––
24	Replace the mixer assembly. Refer to *Fuel Mixer Replacement*. Is the action complete?	––	Go to *Step 26*	––

25	The fuel supply system is operating normally, if a failure of the control solenoids is suspected. Refer to *Fuel Control System Diagnosis.* 1. Install the test plug in the LPR secondary chamber. 2. If you were sent to this routine by another diagnostic chart, return to the previous diagnostic procedure. Is the action complete?	––	System OK	––
26	1. Disconnect all test equipment 2. Install the primary and secondary test port plugs. 3. Start the engine. 4. Using an approved liquid leak dtector, check the test port plugs. Is the action complete?	––	System OK	––

FUEL CONTROL DIAGNOSIS

STEP	ACTION	VALUE(S)	YES		NO	
1	Were you referred to this procedure by another diagnostic chart?					
			Go to Step	3	Go to Step	2
2	Perform the On-Board Diagnostic (OBD) System check		Go to Applicable DTC Table			
	Are any DTC's present in the ECM				Go to Step	3
3	Has the Fuel Ssytem diagnosis been performed?				Go to Fuel system Diagnosis	
			Go to Step	4		
4	1. Connect the Diagnostic Scan tool. 2. Start the engine and allow it to reach operating temperature 3. With the engine idling, observe the duty cycle reading of the PTV on the scan tool **OR** Back probe the PTV connector. Connect a duty cycle monitoring tool at the PTV connector as follows: **IMPCO FSA:** Yellow clip to pin B Green Clip (not used for this test) Red clip to 12V battery positive Black Clip to battery negative **DVOM:** Back probe the PTV connector. Set the DVOM for duty cycle percentage and connect between pin B and battery negative ground.	20% - 80%				
	Is the PTV duty cycle within the specified range?		Go to Step	6	Go to Step	5
5	Is the PTV duty cycle **ABOVE** the specified value ?	80%	Go to Step	7	Go to Step	6
6	1. Raise the engine speed to approximately 2500 RPM or greater 2.Observe the duty cycle reading of the PTV	20% - 80%				
	Is the PTV duty cycle withing the specifed range?		Go to Step	7	Go to Step	9

7	1. Connect the Diagnostic Scan tool. 2. Start the engine and allow it to reach operating temperature 3. With the engine idling, observe the duty cycle reading of the FTV on the scan tool **OR** Back probe the FTV connector. Contect a duty cycle monitoring tool at connector as follows: **IMPCO FSA:** Yellow clip ot pin B Green Clip (not used for this test) Red clip to 12V battery positive Black Clip battery negative **DVOM:** Back probe the FTV connector. Set the DVOM for duty cycle percentage and connect between pin B and battery negative.	20% - 80%				
	Is the FTV duty cycle within the specifed range?		Go to Step	24	Go to Step	8
8	Is the FTV duty cycle **ABOVE** the specified value ?	80%				
			Go to Step	12	Go to Step	9
9	1. Connect the negative lead of the DVOM to a know good engine ground 2. Using the positive lead of the DVOM Back-probe Pin B at the PTV connector	12.6 V to 15.1 V				
	Was the PTV voltage within the specified range?		Go to Step	12	Go to Step	10
10	1. Turn the engine OFF 2. Disconnect the ECU connector C001 3. Disconnect the PTV electrical connector 4. Check the PTV ground circuit terminal A for continuity to the ECU connector pin number 2. 5. Check the PTV ground circuit in Terminal A for short to ignition power or ground.					
	Was a problem found?		Go to Step	16	Go to Step	11
11	Using the DVOM measure the resistance at the PTV terminals					
	Was the resistance measured within specification?	16.0 –24.0	Go to Step	17	Go to Step	19
12	1. Connect the negative lead of the DVOM to battery negative 2. Using the positive lead of the DVOM Back-probe Pin B at the FTV connector	12.6 V to 15.1 V				
	Was the FTV voltage within the specified range?		Go to Step	14	Go to Step	13

13	1. Turn the engine OFF 2. Disconnect the ECU connector C001 3. Disconnect the FTV electrical connector 4. Check the FTV ground circuit terminal A for continuity to the ECU connector pin 2 5. Check the FTV ground circuit in Terminal A for short to ignition power or ground.					
	Was a problem found?		Go to Step	16	Go to Step	18
14	Using the DVOM measure the resistance at the FTV terminals	16.0 –24.0				
	Was the resistance measured within specification?		Go to Step	18	Go to Step	20
15	Replace the Engine Control Unit (ECU). *Refer to Engine Control Unit (ECU) replacement*					
	Is this action complete?		Go to Step	21	Go to Step	
16	Repair the open or damaged circuit?					
	Is this action complete?		Go to Step	21	Go to Step	
17	Check the vacuum hose to the PTV for kinks, obstruction or leakage					
	Was a problem found?		Go to Step	21	Go to Step	15
18	Check the fuel hose to the FTV for kinks, obstruction or leakage					
	Was a problem found?		Go to Step	21	Go to Step	15
19	Replace the pressure trim valve (PTV). Refer to *Pressure Trim Valve (PTV) Replacement.*					
	Is this action complete?		Go to Step	21	Go to Step	
20	Replace the fuel trim valve (FTV). Refer to *Fuel Trim Valve (FTV) Replacement.*					
	Is this action complete?		Go to Step	21	Go to Step	
21	1. Return the fuel system to normal operating condition. 2. Observe the duty cycle reading 3. Raise the engine speed to approximately 2500 RPM	20% - 80%				
	Is the duty cycle in the specified range?		Go to Step	25	Go to Step	22
22	Check all vacuum hoses and mixer connections for leakage.					
	Was a problem found?		Go to Step	21	Go to Step	23
23	Replace Mixer					
	Is this action complete		Go to Step	21	Go to Step	

24	The fuel control system is operating normally. Refer to Symptoms Diagnosis 1. Disconnect all test equipment 2. If you were sent to this routine by another dianostic chart, retune to the previous diagnostic procedure,		System OK			
	Is this action complete					
25	1. Disconnect all test equipment 2. Start the engine 3. Using a liquid leak detection solution leak check any fuel system repairs made.		System OK			
	Is this action complete					

SECTION 1B2

GASOLINE SYSTEM DIAGNOSIS

GASOLINE FUEL SYSTEM DIAGNOSIS

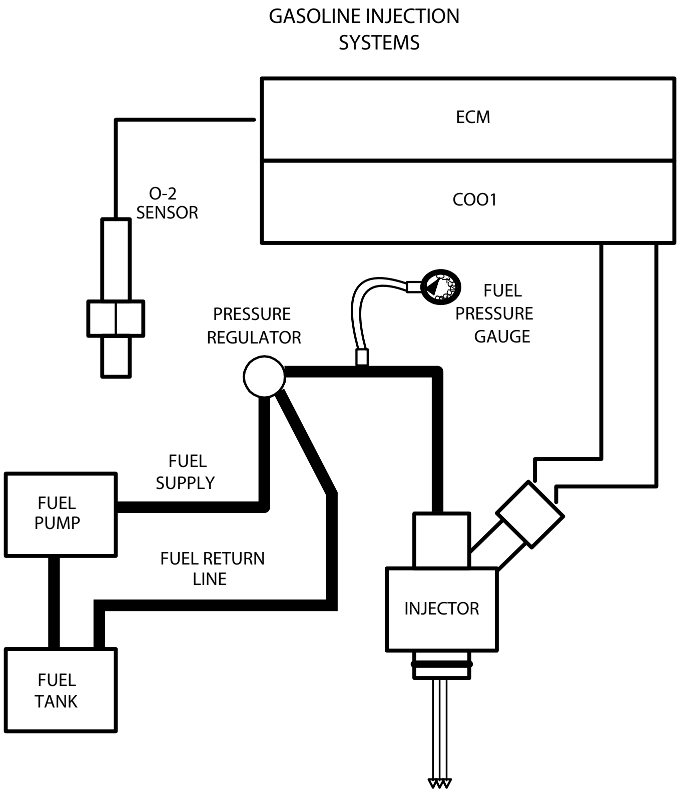


Figure 1 Gasoline Injection Systems

FUEL SYSTEM DESCRIPTION

The Engine Control Module (ECM) receives information from various engine sensors in order to control the operation of the fuel injectors. The electric fuel pump prevents fuel flow unless the engine is cranking or running. During key on, electric fuel pump receives a two (2) second prime pulse from the ECM which allows Gasoline to flow from the tank through fuel filter and fuel lines to the fuel rails where the pressure is regulated. With Ignition "ON" and fuel pump running pressure should be 284-325 kPa (41-47 psi).

When the engine is idling, manifold pressure is low (high vacuum) and is applied to the pressure regulator diaphragm. Vacuum will offset the spring pressure and result in very low fuel pressure. Fuel pressures at idle will vary somewhat depending on barometric pressure but, should be less then pump pressure.

Unused fuel is returned to the fuel tank by a separate return fuel line.

The fuel pump pressure test port is located on the fuel rail.

Diagnostic Aids

This procedure is intended to diagnose a vehicle operating on Gasoline. If the vehicle will not continue to run on Gasoline, refer to Hard Start for preliminary checks. Before proceeding with this procedure, verify that the vehicle has a sufficient quantity of fuel.

Tools Required:

- J 34730-1 or equivalent
- J 37287 or equivalent

Diagnostic Scan Tool

- IMPCO fuel system Diagnostic Scan Tool (DST).

Test Description

The numbers below refer to step numbers on the diagnostic table.

4. Connect fuel pressure gage as shown in illustration. Wrap a shop towel around the fuel connection to absorb any small amount of fuel leakage that may occur when installing the gage. With ignition "ON" and the fuel pump running pressure should be 284-325 kPa (41-47 psi). This pressure is controlled by spring pressure within the regulator assembly.
6. When the engine is idling, manifold pressure is low (High Vacuum) and is applied to the pressure regulator diaphragm. Vacuum will offset spring pressure and result in a lower pressure. Fuel pressure at idle will vary somewhat depending on barometric pressure but, should be less then the pressure noted in step 4.
11. Fuel pressure that drops off during acceleration or cruise may cause a lean condition and result in a loss of power, surging or misfire. This condition can be diagnosed using the Diagnostic Tool. If the fuel in the system is very lean the Heated Exhaust Gas Oxygen (HEGO) will stop toggling and output voltage will drop below 300 mV. Also injector pulse will increase.
14. Fuel pressure below 284 kPa (41 psi) may cause lean condition and may set a DTC. Driveablity conditions can include hard starting cold, hesitation, and lack of power or misfire.
15. Restricting the fuel return pipe cause the fuel pressure to build above the regulated pressure. With battery voltage applied to the pump, pressure should rise above 325 kPa (47 psi) as the valve in the return pipe is partially closed.

NOTICE: Do not allow the pressure to exceed 414 kPa (60 psi) as damage to the regulator may result.

17. Fuel pressure above 325 kPa (47 psi) may cause a rich

starting, followed by black smoke and a strong sulphur smell in the exhaust.

18. This test is to determine if the high fuel pressure is due to a restricted fuel return pipe or a faulty fuel pressure regulator.

21. The pressure regulator may be fitted with a screen which is designed to trap contaminants introduced during engine assembly. If dirty it can be removed with a small pick and discarded without potential harm to the regulator.

23. A system that does not hold pressure is caused by one of the following.
    - Leaking fuel pump check ball
    - Leaking fuel feed hose
    - Leaking valve/seat within the pressure regulator
    - Leaking injector

26. A leaking injector can best be determined by checking for a fouled or saturated spark plug(s). If a leaking injector can not be determined by a fouled or saturated plug the following procedure should be used.

- Remove the fuel rail but leave the lines connected

- Lift the fuel rail out just enough to leave injector nozzle's in the ports.

CAUTION

To reduce the risk of fire or personal injury that may result form fuel spray on the engine, make sure fuel rails is positioned over injector port and injector retaining clips are intact.

- **Pressurize the fuel system and observe injector nozzles.**

Gasoline Fuel System Diagnosis

Step	Action	Value(s)	Yes	No
1	Were you referred to this procedure by a DTC diagnostic chart?	––	Go to *Step 3*	Go to *Step 2*
2	Perform the On Board Diagnostic (OBD) System Check. Are any DTCs present in the ECM?	––	Go to the applicable DTC Table	Go to *Step 3*
3	Verify that the Gasoline fuel tank has a minimum of 1/4 tank of fuel, Does the vehicle have fuel?	––	Go to *Step 4*	––
4	1. Connect a fuel pressure gage at the Schrader Valve located on the fuel rail 2. Ignition "ON" fuel pump will run. 3. Note the pressure 4. Turn ignition off pressure may vary slightly then hold steady Is pressure within specified values	285-325 kPa (41-47 psi)	Go to *Step 5*	Go to *Step 10*
5	Did the fuel pressure hold study after the pump stopped?		Go to *Step 6*	Go to *Step 22*

6	1. Start engine allow it to warm to normal operating temperature at idle 2. Fuel pressure noted in step 4 should drop. Did pressure drop by the specified value?	21-69 kPa (3-10 psi)	Go to 27	Go to *Step 7*
7	1. Disconnect the vacuum hose from the pressure regulator 2. With the engine idling, apply 12-14 inches of vacuum to the pressure regulator, pressure should drop. Did the pressure drop by the specified value?	21-69 kPa (3-10 psi)	Go to *Step 8*	Go to *Step 9*
8	1. Locate and repair loss of vacuum to the pressure regulator. Is the action complete?	––	Go to *Step 27*	
9	Replace pressure regulator Is the action complete?	––	Go to *Step 27*	
10	Is pressure less then specified value?	285-325 kPa (41-47 psi)	Go to *Step 14*	Go to *Step 11*
11	1. With the fuel pressure gage installed 2. Start engine and accelerate with load Is pressure less then specified value?	285-325 kPa (41-47 psi)	Go to *Step 12*	Go to *Step 14*
12	1. Check for restricted fuel filter 2. Check for restricted fuel supply line from pump Was a problem found?		Go to *Step 27*	Go to *Step 13*
13	1. Replace fuel pump Is this action Complete?	––	Go to *Step 27*	
14	With the ignition “OFF” 1. Install a 10 amp fused jumper to the B+ 2. Slowly pinch the fuel return line 3. Pressure should rise NOTE: Do not exceed 414 kPa (60 psi) Did Pressure rise?	325 kPa (47 psi)	Go to *Step 9*	Go to *Step 15*

15	1. Check for restricted fuel pump strainer 2. Check for leaking fuel supply line from pump 3. Check to ensure fuel pump is correct Was a problem found?		Go to *Step 27*	Go to *Step 16*
16	1. Replace fuel pump Is this action Complete?	––	Go to *Step 27*	
17	Is pressure greater then specified value	285-325 kPa (41-47 psi)	Go to *Step 15*	
18	1. Disconnect the fuel return hose at the fuel rail 2. Attach a length of hose to the return pipe at the rail 3. Place the other end of the hose in an approved Gasoline container 4. Turn ignition “OFF” for 10 seconds 5. Turn ignition “ON” Is pressure within specified value?	285-325 kPa (41-47 psi)	Go to *Step 19*	Go to *Step 20*
19	The fuel return hoses are plugged or restricted, locate and repair the problem. Is the action complete?	––	Go to *Step 27*	––
20	Check for restricted engine return pipe Was a problem found?	––	Go to *Step 27*	*Go To Step 21*
21	Remove pressure regulator and check for restriction Was a problem found?	––	Go to *Step 27*	*Go to Step 9*
22	Fuel Pressure is within spec but does not hold pressure	––	Go to *Step 23*	––
23	1. Install J 37287 fuel line shut off adapter or suitable valve to close off fuel supply 2. Make sure valve is open 3. With the ignition “OFF” 4. Install a 10 amp fused jumper to the B+ 5. Pressure should rise 6. Disconnect the jumper and close valve Did pressure hold?	––	Go to *Step 24*	*Go to Step 25*
24	Check for leaking fuel pump supply line. Was there a problem found?	––	Go to *Step 27*	Go to *Step 13*

25	Open valve in fuel pressure pipe Reconnect test jumper and wait for pressure to build Disconnect jumper and close valve in fuel pressure pipe Does Pressure hold	__	Go to *Step 9*	*Go to Step 26*
26	1. Locate and correct leaking injectors Is the action complete?	__	*Go to Step 27*	__
27	1. Disconnect all test equipment 2. Install the test port cap. 3. Start the engine. 4. Verify engine is in closed loop and no MIL is on. Is the action complete?	__	System OK	__

SECTION 1B4

SYSTEM DIAGNOSIS

LPG SYMPTOM DIAGNOSIS

Symptom Diagnosis

Important Preliminary Checks

Checks	Action
Before Using This Section	Before using this section, you should have performed On Board Diagnostic Check and determined that: 1. The Control Module and MIL (Malfunction Indicator Lamp) 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. The visual and physical checks are very important. The checks can lead to correcting a problem without further checks that may save valuable time.
LPG 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 vehicle under the conditions the symptom occurs. Verify HEGO switching between lean and rich. **IMPORTANT!** **Normal HEGO switching indicates the LPG fuel system is in closed loop and operating correctly at that time.** 5. If a scan tool is available, **take a snapshot** under the condition that the symptom occurs. Go to *Engine Scan Tool Data* List to verify normal sensor values and parameters.
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 of the mixer module assembly. • Check for air leaks at the mixer assembly. • Check the ignition wires for the following conditions: – Cracking – Hardness – 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 scan tool readings do not indicate the problems, then proceed in a logical order, easiest to check or most likely to cause first.

Intermittent

Checks	Action
DEFINITION: The problem may or may not turn ON the Malfunction Indicator Lamp (MIL) or store a Diagnostic Trouble Code (DTC).	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Do not use the DTC tables. If a fault is an intermittent, the use of the DTC tables 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 – Terminal to wires poorly connected – Terminal tension 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. • 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, drive the vehicle with a scan tool. When the problem occurs, an abnormal voltage or scan reading indicates the problem may be in that circuit.
Intermittent Malfunction Indicator Lamp (MIL)	The following components can cause intermittent MIL and no DTC(s): • A defective relay, Control Module driven solenoid, or a switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating. • The improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc. • The ignition secondary voltage shorted to a ground. • The Malfunction Indicator Lamp (MIL) circuit or the Diagnostic Test Terminal intermittently shorted to ground. • The Control Module grounds.
Loss of DTC Memory	To check for the loss of the DTC Memory: 1. Disconnect the TMAP sensor. 2. Idle the engine until the Malfunction Indicator Lamp illuminates. The ECU should store a TMAP DTC. The TMAP DTC should remain in the memory when the ignition is turned OFF. If the TMAP DTC does not store and remain, the ECM is faulty.
Additional Checks	.

No Start

Checks	Action
DEFINITION: The engine cranks OK but does not start.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.
Control Module Checks	• If a scan tool is available: • Check for proper communication with both the ECM • Check the 3A inline fuse in the ECM battery power circuit. Refer to *Engine Controls Schematics.* • Check battery power, ignition power and ground circuits to the ECM. Refer to *Engine Control Schematics.* Verify voltage and/or continuity for each circuit.
Sensor Checks	• Check the TMAP sensor. • Check the Magnetic pickup sensor (RPM). .
Fuel System Checks	**Important**: A closed LPG manual fuel shut off valve will create a no start condition. • Check for air intake system leakage between the mixer and the throttle body. • Verify proper operation of the low pressure lock-off solenoids. • Verify proper operation of the fuel control solenoids. • Check the fuel system pressures. Refer to the *LPG Fuel System Diagnosis*. • Check for proper mixer air valve operation.

Ignition System Checks	Note: LPG being a gaseous fuel requires 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 correct for use with LPG (R42LTS)
	• Check the spark plugs for the following conditions:
	  – Wet plugs
	  – Cracks
	  – Wear
	  – Improper gap
	  – Burned electrodes
	  – Heavy deposits
	• Check for bare or shorted ignition wires.
	• Check for loose ignition coil connections at the coil.

Engine Mechanical Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for the following: – Vacuum leaks – Improper valve timing – Low compression – Bent pushrods – 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. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis*

Hard Start

<table>
<tr><th>Checks</th><th>Action</th></tr>
<tr><td colspan="2">DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.</td></tr>
<tr><td>Preliminary Checks</td><td>• Refer to Important Preliminary Checks.
• Make sure the vehicle’s operator is using the correct starting procedure.</td></tr>
<tr><td>Sensor Checks</td><td>• Check the Engine Coolant Temperature sensor with the scan tool. Compare the engine coolant temperature with the ambient air temperature on a cold engine. IF the coolant temperature reading is more than 5 degrees greater or less than the ambient air temperature on a cold engine, check for high resistance in the coolant sensor circuit. Refer to DTC 111
• Check the Crankshaft Position (CKP) sensor.
• Check the Throttle position (TPS) and Foot Pedal Position (FPP) sensor.</td></tr>
<tr><td>Fuel System Checks</td><td>Important: A closed LPG manual fuel shut off valve will create an extended crank OR no start condition.
• Verify the excess flow valve in the LPG manual shut-off valve is not tripped.
• Check mixer module assembly for proper installation and leakage.
• Verify proper operation of the low pressure lock-off solenoids.
• Verify proper operation of the PTV and FTV.
• Check for air intake system leakage between the mixer and the throttle body.
• Check the fuel system pressures. Refer to the Fuel System Diagnosis.</td></tr>
<tr><td>Ignition System Checks</td><td>Note: LPG being a gaseous fuel requires 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 correct for use with LPG (R42LTS)
• Check the spark plugs for the following conditions:
– Wet plugs
– Cracks
– Wear
– Improper gap
– Burned electrodes
– Heavy deposits
• Check for bare or shorted ignition wires.
• Check for moisture in the distributor cap if applicable.
• Check for loose ignition coil connections.
Important:
1. If the engine starts but then immediately stalls, check Crankshaft Position (CKP) sensor.
2. Check for improper gap, debris or faulty connections.</td></tr>
</table>

Engine Mechanical Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. • Check for the following: – Vacuum leaks – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes. Ref • Check the intake and exhaust manifolds for casting flash.
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. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis.*

Checks	Action
DEFINITION: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases which is not normally felt above 1500 RPM. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.

Ignition System Checks	• Start the engine.
	• Wet down the secondary ignition system with water from a spray bottle, and look/listen for arcing or misfiring as you apply water.
	• Check for proper ignition output voltage with spark tester J 26792.
	• Check for a cylinder misfire.
	• Verify that the spark plugs are correct for use with LPG (R42LTS)
	• Remove the spark plugs in these cylinders 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, cross-firing and proper routing
	  • Ignition coils for cracks or carbon tracking

Engine Mechanical Checks	• Perform a cylinder compression check.
	• Check the engine for the following:
	  – Improper valve timing
	  – Bent pushrods
	  – 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, low fuel pressure, etc. Refer to *LPG Fuel System Diagnosis*. • Check the condition of the wiring to the low pressure lock-off solenoid.

Additional Check	Check for Electromagnetic Interference (EMI).
	  • EMI on the reference circuit can cause a missing condition.
	  • Monitoring the engine RPM with a scan tool can detect an EMI.
	  • A sudden increase in the RPM with little change in the actual engine RPM, indicates EMI is present.
	  • If the problem exists, check the routing of the secondary wires and the ground circuit.

Hesitation, Sag, Stumble

Checks	Action
DEFINITION: The vehicle has a momentary lack of response when depressing the accelerator. The condition can occur at any vehicle speed. The condition may cause the engine to stall if it's severe enough.	
Preliminary Checks	Refer to *Important Preliminary Checks*.
Fuel System Checks	• Check the fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check for low fuel pressure during a moderate or full throttle acceleration. If the fuel pressure drops below specification, there is possibly a faulty low pressure regulator or a restriction in the fuel system. • Check the Manifold Absolute Pressure (MAP) sensor response and accuracy. • Check LPL electrical connection • Check the mixer air valve for sticking or binding. • Check the mixer module assembly for proper installation and leakage. • Check the PTV and FTV.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. If a problem is reported on LPG and not gasoline, do not discount the possibility of a LPG only ignition system failure and test the system accordingly. • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG (R42LTS) • Check for faulty spark plug wires • Check for fouled spark plugs. •
Additional Check	• Check for manifold vacuum or air induction system leaks • Check the generator 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	• Refer to *Important Preliminary Checks*.
Ignition System Checks	**Important!** **LPG, being a gaseous fuel, requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. The ignition system must be maintained in peak condition to prevent backfire.** • 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. • Check the spark plugs. The correct spark plugs for LPG are (R42LTS) • Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits
Engine Mechanical Check	**Important!** **The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than a gasoline fuel supply system.** • Check the engine for the following: – Improper valve timing – Engine compression – Manifold vacuum leaks – Intake manifold gaskets – Sticking or leaking valves – Exhaust system leakage • Check the intake and exhaust system for casting flash or other restrictions.
Fuel System Checks	• Perform a fuel system diagnosis. Refer to *LPG Fuel System Diagnosis*.

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 partially applying the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Refer to the *LPG Fuel system OBD System Check* • Compare the customer's vehicle with a similar unit. Make sure the customer has an actual problem. *Do not compare the power output of the vehicle operating on LPG to a vehicle operating on gasoline as the fuels do have different drive feel characteristics* • Remove the air filter and check for dirt or restriction. • Check the vehicle transmission Refer to the OEM transmission diagnostics.
Fuel System Checks	• Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check for the proper ignition output voltage with the spark tester *J 26792* or the equivalent. • Check for proper installation of the mixer module assembly. • Check all air inlet ducts for condition and proper installation. • Check for fuel leaks between the LPR and the mixer. • Verify that the LPG tank manual shut-off valve is fully open. • Verify that liquid fuel (not vapor) is being delivered to the LPR.
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the MAP sensor. • Check for proper operation of the TPS and FPP sensors.
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. – Check for possible plugged catalytic converter.
Engine Mechanical Check	Check the engine for the following: • Engine compression • Valve timing • Improper or worn camshaft. Refer to *Engine Mechanical* in the Service Manual.
Additional Check	• Check the ECM grounds for being clean, tight, and in their proper locations. • Check the generator 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 scan tool 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 vehicle at one time, as previously shown by an by refueling records.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Check the air cleaner element (filter) for dirt or being plugged. • Visually (Physically) check the vacuum hoses for splits, kinks, and proper connections. • Check the operators driving habits for the following items: – Is there excessive idling or stop and go driving? – Are the tires at the correct air pressure? – Are excessively heavy loads being carried? – Is their often rapid acceleration? • Suggest to the owner to fill the fuel tank and to recheck the fuel economy. • Suggest that a different operator use the equipment and record the results.
Fuel System Checks	• Check the LPR fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check the fuel system for leakage.
Sensor Checks	• Check the Temperature Manifold Absolute Pressure (TMAP) sensor.
Ignition System Checks	• Verify that the spark plugs are correct for use with LPG (R42LTS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – 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 for always being open or for the wrong heat range
Additional Check	• Check the transmission shift pattern. Refer to the OEM Transmission Controls section the Service Manual. • Check for dragging brakes.

Rough, Unstable, or Incorrect Idle, Stalling

<table>
<tr><th>Checks</th><th>Action</th></tr>
<tr><td colspan="2">DEFINITION: The engine runs unevenly at idle. If severe enough, the engine or vehicle may shake. The engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.</td></tr>
<tr><td>Preliminary Check</td><td>• Refer to Important Preliminary Checks.</td></tr>
<tr><td>Sensor Checks</td><td>• Check for silicon contamination from fuel or improperly used sealant. The sensor will have a white powdery coating. The sensor will 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 driveability problem.
• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance:
• Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.</td></tr>
<tr><td>Fuel System Checks</td><td>• Check for rich or lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem.
• Check for a sticking mixer air valve.
• Verify proper operation of the PTV and FTV.
• Perform a cylinder compression test. Refer to Engine Mechanical in the Service Manual.
• Check the LPR fuel pressure. Refer to the LPG Fuel System Diagnosis.
• Check mixer module assembly for proper installation and connection.</td></tr>
<tr><td>Ignition System Checks</td><td>• Check for the proper ignition output voltage using the spark tester J26792 or the equivalent.
• Verify that the spark plugs are correct for use with LPG (R42LTS)
• Check the spark plugs. Remove the plugs and inspect them for the following conditions:
– Wet plugs
– Cracks
– Wear
– Improper gap
– Burned electrodes
– Blistered insulators
– Heavy deposits
• Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires.</td></tr>
<tr><td>Additional Checks</td><td>Important: The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system.
• Check for vacuum leaks. Vacuum leaks can cause a higher than normal idle and low throttle angle control command.
• Check the ECU 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 idle quality..</td></tr>
</table>

Engine Mechanical Check	• Check the engine for the following: – Broken motor mounts – Improper valve timing – Low compression – Bent pushrods – 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 or cruise. The vehicle feels as if it speeds up and slows down with no change in the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Be sure the driver understands the Torque Converter Clutch operation.
Sensor Checks	Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance.
Fuel System Checks	• Check for Rich or Lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check the fuel pressure while the condition exists. Refer to *LPG Fuel System Diagnosis.* • Verify proper fuel control solenoid operation. • Verify that the LPG manual shut-off valve is fully open. • Check the in-line fuel filter for restrictions.
Ignition System Checks	• Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. • Verify that the spark plugs are correct for use with LPG (R42LTS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits – Check the Crankshaft Position (CKP) sensor.
Additional Check	• Check the ECU grounds for being clean, tight, and in their proper locations. • Check the generator output voltage. • Check the vacuum hoses for kinks or leaks. • Check Transmission

GASOLINE SYMPTOM DIAGNOSIS

Symptom Diagnosis

Important Preliminary Checks

Checks	Action
Before Using This Section	Before using this section, you should have performed On Board Diagnostic Check and determined that: 1. The Control Module and MIL (Malfunction Indicator Lamp) 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. The visual and physical checks are very important. The checks can lead to correcting a problem without further checks that may save valuable time.
LPG 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 vehicle under the conditions the symptom occurs. Verify HEGO switching between lean and rich. **IMPORTANT!** **Normal HEGO switching indicates the Gasoline fuel system is in closed loop and operating correctly at that time.** 5. If a scan tool is available, **take a snapshot** under the condition that the symptom occurs. Go to *Engine Scan Tool Data* List to verify normal sensor values and parameters.
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 of the Throttle Body assembly. • Check for fuel leaks at the fuel rail and injectors. • Check the ignition wires for the following conditions: – Cracking – Hardness – 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 scan tool readings do not indicate the problems, then proceed in a logical order, easiest to check or most likely to cause first.

Intermittent

Checks	Action
DEFINITION: The problem may or may not turn ON the Malfunction Indicator Lamp (MIL) or store a Diagnostic Trouble Code (DTC).	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Do not use the DTC tables. If a fault is an intermittent, the use of the DTC tables 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 – Terminal to wires poorly connected – Terminal tension 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. • 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, drive the vehicle with a scan tool. When the problem occurs, an abnormal voltage or scan reading indicates the problem may be in that circuit.
Intermittent Malfunction Indicator Lamp (MIL)	The following components can cause intermittent MIL and no DTC(s): • A defective relay, Control Module driven solenoid, or a switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating. • The improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc. • The ignition secondary voltage shorted to a ground. • The Malfunction Indicator Lamp (MIL) circuit or the Diagnostic Test Terminal intermittently shorted to ground. • The Control Module grounds.
Loss of DTC Memory	To check for the loss of the DTC Memory: 1. Disconnect the TMAP sensor. 2. Idle the engine until the Malfunction Indicator Lamp illuminates. The ECU should store a TMAP DTC. The TMAP DTC should remain in the memory when the ignition is turned OFF. If the TMAP DTC does not store and remain, the ECM is faulty.
Additional Checks	.

No Start

Checks	Action
DEFINITION: The engine cranks OK but does not start.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.
Control Module Checks	• If a scan tool is available: • Check for proper communication with both the ECM • Check the 3A inline fuse in the ECM battery power circuit. Refer to *Engine Controls Schematics.* • Check battery power, ignition power and ground circuits to the ECM. Refer to *Engine Control Schematics.* Verify voltage and/or continuity for each circuit.
Sensor Checks	• Check the TMAP sensor. • Check the Crankshaft Position (CKP) sensor. .
Fuel System Checks	• Check for fuel pump electrical circuit • Verify proper fuel pump pressure. • Verify proper Fuel rail pressure. • Refer to the *Gasoline Fuel System Diagnosis*. • Check Electrical connections at the injectors.
Ignition System Checks	• Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct use (R42LTS) • Check the spark plugs for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Check for bare or shorted ignition wires. • Check for loose ignition coil connections at the coil.
Engine Mechanical Checks	• Check for the following: – Vacuum leaks – Improper valve timing – Low compression – Bent pushrods – 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. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis*

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	• Refer to *Important Preliminary Checks*. • Make sure the vehicle's operator is using the correct starting procedure.
Sensor Checks	• Check the Engine Coolant Temperature sensor with the scan tool. Compare the engine coolant temperature with the ambient air temperature on a cold engine. IF the coolant temperature reading is more than 5 degrees greater or less than the ambient air temperature on a cold engine, check for high resistance in the coolant sensor circuit. Refer to *DTC 111* • Check the Crankshaft Position (CKP) sensor. • Check the Throttle position (TPS) sensor.
Fuel System Checks	• Check for fuel pump electrical circuit • Verify proper fuel pump pressure. • Verify proper Fuel rail pressure. • Refer to the *Gasoline Fuel System Diagnosis*. Check Electrical connections at the injectors
Ignition System Checks	• Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct use (R42LTS) • Check the spark plugs for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Check for bare or shorted ignition wires. • Check for moisture in the distributor cap if applicable. • Check for loose ignition coil connections. **Important**: 1. If the engine starts but then immediately stalls, Crankshaft Position (CKP). 2. Check for improper gap, debris or faulty connections.
Engine Mechanical Checks	• Check for the following: – Vacuum leaks – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes. Ref • Check the intake and exhaust manifolds for casting flash.

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. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis.*

Cuts Out, Misses

Checks	Action
DEFINITION: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases which is not normally felt above 1500 RPM. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.

Ignition System Checks	• Start the engine.
	• Wet down the secondary ignition system with water from a spray bottle, and look/listen for arcing or misfiring as you apply water.
	• Check for proper ignition output voltage with spark tester J 26792.
	• Check for a cylinder misfire.
	• Verify that the spark plugs are correct use (R42LTS)
	• Remove the spark plugs in these cylinders 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, cross-firing and proper routing
	  • Ignition coils for cracks or carbon tracking

Engine Mechanical Checks	• Perform a cylinder compression check.
	• Check the engine for the following:
	  – Improper valve timing
	  – Bent pushrods
	  – 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, low fuel pressure, etc. Refer to *Gasoline Fuel System Diagnosis*. • Check the condition of the wiring to the fuel pump and injectors.

Additional Check	Check for Electromagnetic Interference (EMI).
	  • EMI on the reference circuit can cause a missing condition.
	  • Monitoring the engine RPM with a scan tool can detect an EMI.
	  • A sudden increase in the RPM with little change in the actual engine RPM, indicates EMI is present.
	  • If the problem exists, check the routing of the secondary wires and the ground circuit.

Hesitation, Sag, Stumble

Checks	Action
DEFINITION: The vehicle has a momentary lack of response when depressing the accelerator. The condition can occur at any vehicle speed. The condition may cause the engine to stall if it's severe enough.	
Preliminary Checks	Refer to *Important Preliminary Checks*.
Fuel System Checks	• Check for fuel pump electrical circuit • Verify proper fuel pump pressure. • Verify proper Fuel rail pressure. • Refer to the *Gasoline Fuel System Diagnosis*. • Check Electrical connections at the injectors
Ignition System Checks	• Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct use (R42LTS) • Check for faulty spark plug wires • Check for fouled spark plugs. •
Additional Check	• Check for manifold vacuum or air induction system leaks • Check the generator 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	• Refer to *Important Preliminary Checks*.
Ignition System Checks	• 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 each ignition coil. • Check for deteriorated spark plug wire insulation. • Check the spark plugs. The correct spark plugs are (R42LTS) • Remove the plugs and inspect them for the following conditions: – Wet plugs – 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 • Check the intake and exhaust system for casting flash or other restrictions.
Fuel System Checks	• Perform a fuel system diagnosis. Refer to *Gasoline Fuel System Diagnosis*.

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 partially applying the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Refer to the *Gasoline Fuel system Diagnostics.* • Compare the customer's vehicle with a similar unit. Make sure the customer has an actual problem. • Remove the air filter and check for dirt or restriction. • Check the vehicle transmission Refer to the OEM transmission diagnostics.
Fuel System Checks	• Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to *Gasoline Fuel System Diagnosis*. • Check for the proper ignition output voltage with the spark tester *J 26792* or the equivalent. • Check for fuel pump electrical circuit. • Verify proper fuel pump pressure. • Verify proper Fuel rail pressure. • Refer to the *Gasoline Fuel System Diagnosis*. Check Electrical connections at the injectors
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the MAP sensor. • Check for proper operation of the TPS and FPP sensors.
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. – Check for possible plugged catalytic converter.
Engine Mechanical Check	Check the engine for the following: • Engine compression. • Valve timing. • Improper or worn camshaft. Refer to *Engine Mechanical* in the Service Manual.
Additional Check	• Check the ECU grounds for being clean, tight, and in their proper locations. • Check the generator 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 scan tool 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 vehicle at one time, as previously shown by an by refueling records.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Check the air cleaner element (filter) for dirt or being plugged. • Visually (Physically) check the vacuum hoses for splits, kinks, and proper connections. • Check the operators driving habits for the following items: – Is there excessive idling or stop and go driving? – Are the tires at the correct air pressure? – Are excessively heavy loads being carried? – Is their often rapid acceleration? • Suggest to the owner to fill the fuel tank and to recheck the fuel economy. • Suggest that a different operator use the equipment and record the results.
Fuel System Checks	• Check the fuel Rail pressure. Refer to Gasoline *Fuel System Diagnosis*. • Check the fuel system for leakage.
Sensor Checks	• Check the Temperature Manifold Absolute Pressure (TMAP) sensor.
Ignition System Checks	• Verify that the spark plugs are correct use (R42LTS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – 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 for always being open or for the wrong heat range
Additional Check	• Check the transmission shift pattern. Refer to the OEM Transmission Controls section the Service Manual. • Check for dragging brakes.

Rough, Unstable, or Incorrect Idle, Stalling

Checks	Action
DEFINITION: The engine runs unevenly at idle. If severe enough, the engine or vehicle may shake. The engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Sensor Checks	• Check for silicon contamination from fuel or improperly used sealant. The sensor will have a white powdery coating. The sensor will 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 driveability problem. • Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance: • Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.
Fuel System Checks	• Check for rich or lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check for a sticking mixer air valve. • Verify proper operation of the Injectors. • Perform a cylinder compression test. Refer to *Engine Mechanical* in the Service Manual. • Check the fuel Rail pressure. Refer to the Gasoline *Fuel System Diagnosis*. • Check injector electrical connections.
Ignition System Checks	• Check for the proper ignition output voltage using the spark tester *J26792* or the equivalent. • Verify that the spark plugs are correct use (R42LTS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – 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 the ECU 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 idle quality..
Engine Mechanical Check	• Check the engine for the following: – Broken motor mounts – Improper valve timing – Low compression – Bent pushrods – 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 or cruise. The vehicle feels as if it speeds up and slows down with no change in the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Be sure the driver understands the Torque Converter Clutch operation.
Sensor Checks	Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance.
Fuel System Checks	• Check for Rich or Lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check the fuel rail pressure while the condition exists. Refer to *Gasoline Fuel System Diagnosis.* • Verify check injector electrical connections • Check the in-line fuel filter for restrictions.
Ignition System Checks	• Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. • Verify that the spark plugs are correct use (R42LTS) • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits – Check the Crankshaft Position (CKP) sensor.
Additional Check	• Check the ECU grounds for being clean, tight, and in their proper locations. • Check the generator output voltage. • Check the vacuum hoses for kinks or leaks. • Check Transmission

Restricted Exhaust System Diagnosis

Exhaust System Description

The emission certified engine has been designed and calibrated to meet the emission standards in effect for 2004. To help meet the emission requirements the vehicle has been equipped with a Three Way Catalytic (TWC) muffler. The catalyst muffler is a three way catalyst, sound damping and spark arresting unit. Besides controlling the noise created from the combustion process, and preventing sparks from escaping from the exhaust system the most important function is treating the exhaust gases which are created from the combustion process.

The three-way catalyst consists of a honeycomb coated with a mixture of platinum, palladium, and rhodium. The hot gases flow through the catalyst sections where an oxidation and reduction reactions take place. These chemical reactions reduce the amount of CO, HC and NOX in the engines exhaust. The Exhaust gas then flows through the outlet.

During normal operation the exhaust system could become damaged. Damage which reduces the flow of the exhaust gas will create increased back pressure in the engine. Reduction in exhaust flow can result from crushed muffler outlets or melted catalyst brick inside the converter.

It may be necessary to measure the back pressure in the exhaust system. To determine if the back pressure in the engine is correct use the following procedure.

Diagnostic Aids

Tools Required:

- J 35314-A Exhaust Back Pressure Gage

Diagnostic Scan Tool

- IMPCO Fuel System diagnostic tool.

Check at Heated Exhaust Gas Oxygen Sensor (HEGO)

1. Carefully remove the HEGO.
2. Install exhaust backpressure test (J35314-a) in place of the HEGO.
3. With the engine idling at normal operating temperature, observe the exhaust system back pressure reading on te gage. Reading should not exceed 8.6 kPa (1.25 psi).
4. Increase engine speed to 2000 RPM and observe gage. Reading should not exceed 20.7 kPa (3 psi).
5. If the back pressure at either speed exceeds specification, a restricted exhaust system is indicated.
6. Inspect the entire exhaust system for a collapsed pipe, heat distress or possible internal muffler failure.
7. If there are no obvious reasons for the excessive back pressure, the catalytic converter is suspected to be restricted and should be replaced using current recommended procedures.

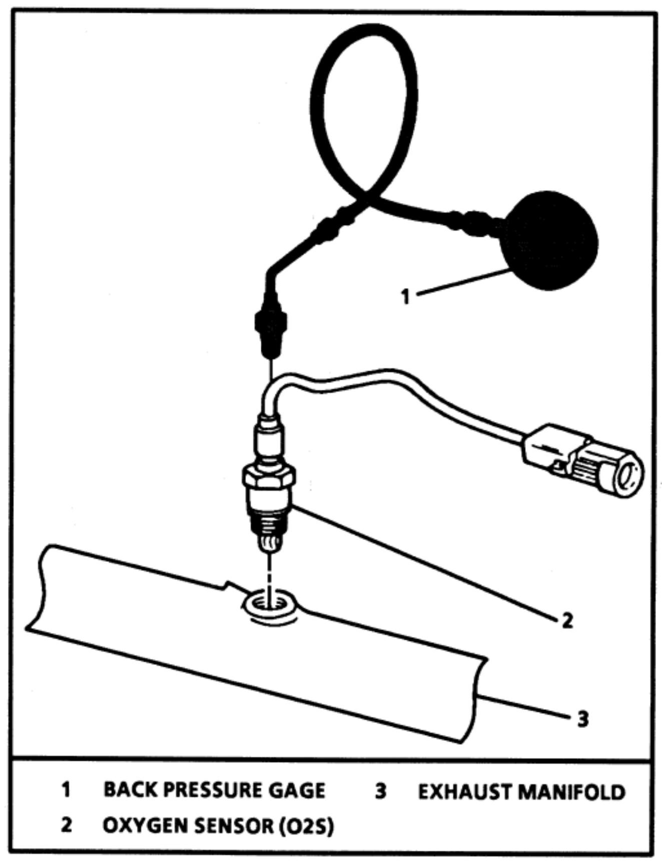


Figure 1 Exhaust Back Pressure Test

SECTION 1C2

WIRING SCHEMATICS

ON-VEHICLE SERVICE WIRE HARNESS REPAIR

The ECM/PCM harness electrically connects the ECM/PCM to the various solenoids, electrically and sensors in vehicle engine and passenger compartment.

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

With the low current and voltage levels found in the system, it is important that the best possible bond at all wire splices be made by soldering the splices, as shown in Figure 3-20.

Molded on connectors require complete replacement of the connector. This means splicing a new connector assembly into the harness.

Refer to Figure 1 for wiring diagrams.

CONNECTORS AND TERMINALS

Use care when probing a connector or replacing terminals in them. It is possible to short between opposite terminals. If this happens to the wrong terminal pair, it is possible to damage certain components. Always use jumper wires between connectors, for circuit checking. NEVER probe through the Weather-Pack seals. 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.

When diagnosing, open circuits are often difficult to locate by sight, because oxidation, or terminal misalignment are hidden by the connectors. 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.

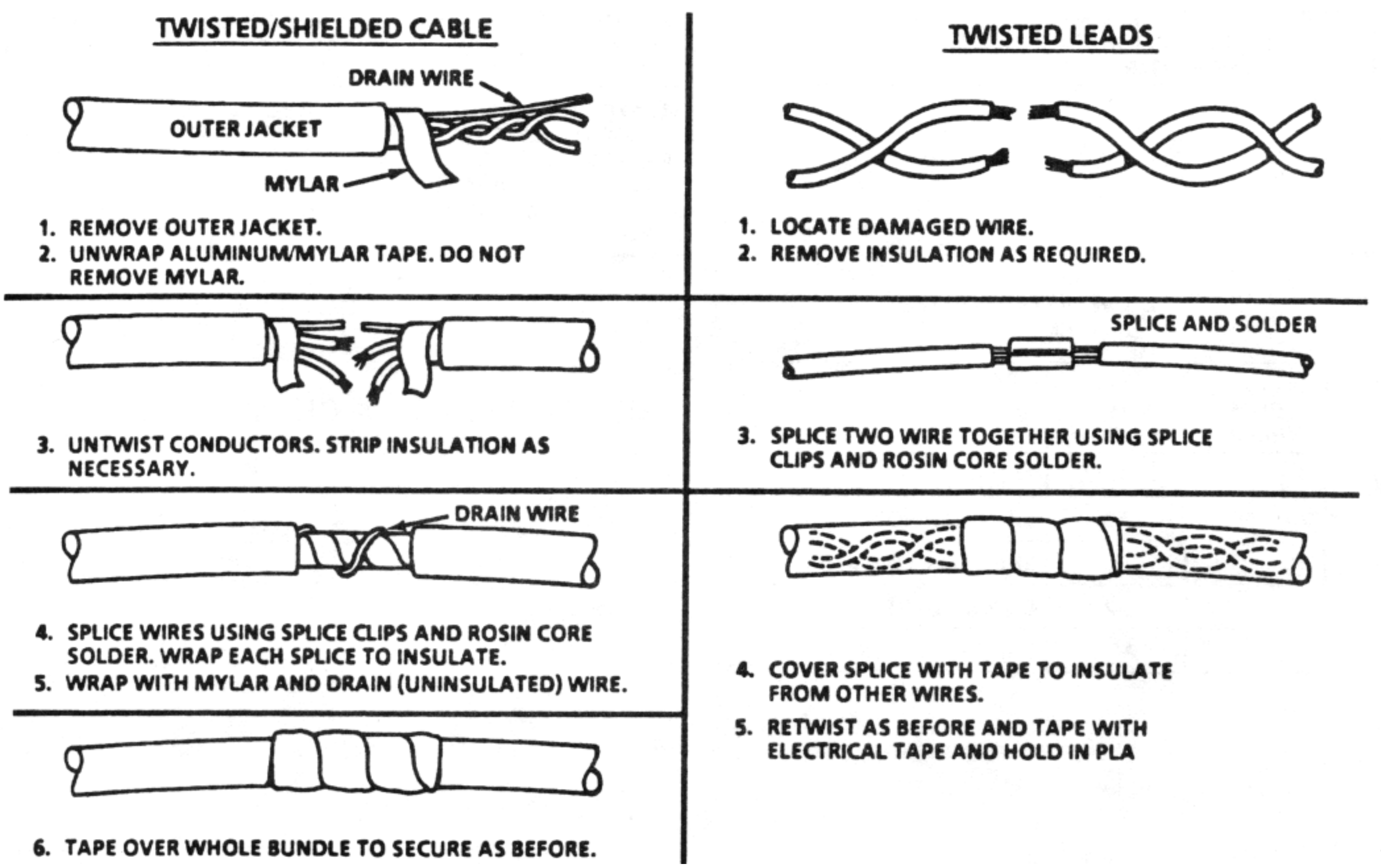


FIGURE 1 WIRE HARNESS REPAIR

Micro-Pack

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

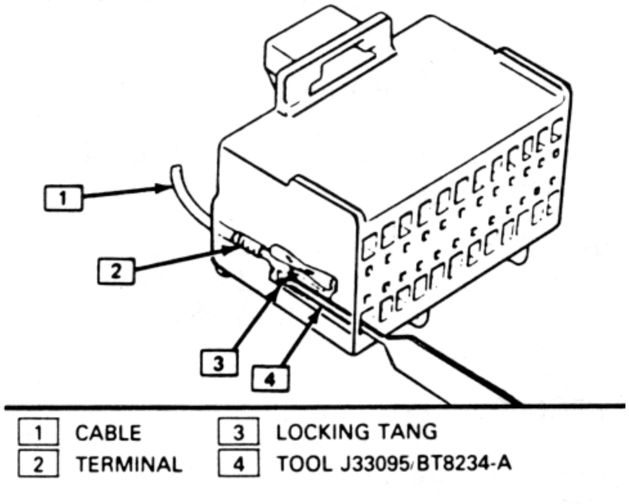


FIGURE 2 MICRO-PACK CONNECTOR

Metri-Pack

Some connectors use terminals called Metri-Pack Series 150. (Figure 3). ‘These may be used at the coolant sensor, as well as TBI units.

They are also called “Pull-To-Seat” terminals, because, to install a terminal on a wire, the wire is first inserted through the seal (5) and connector (4). The terminal is then crimped on the wire and the terminal pulled back into the connector to seat it in place.

To remove a terminal:

1. Slide the seal back on the wire.
2. Insert tool (3) 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 tang (2).

Weather-Pack

A Weather-Pack connector can be identified by a rubber seal, at the rear of the connector. This connector, which is used in the engine compartment, protects against moisture and dirt, which could create oxidation and deposits on the terminals. This protection is important, because of the very low voltage and current levels found in the electronic system.

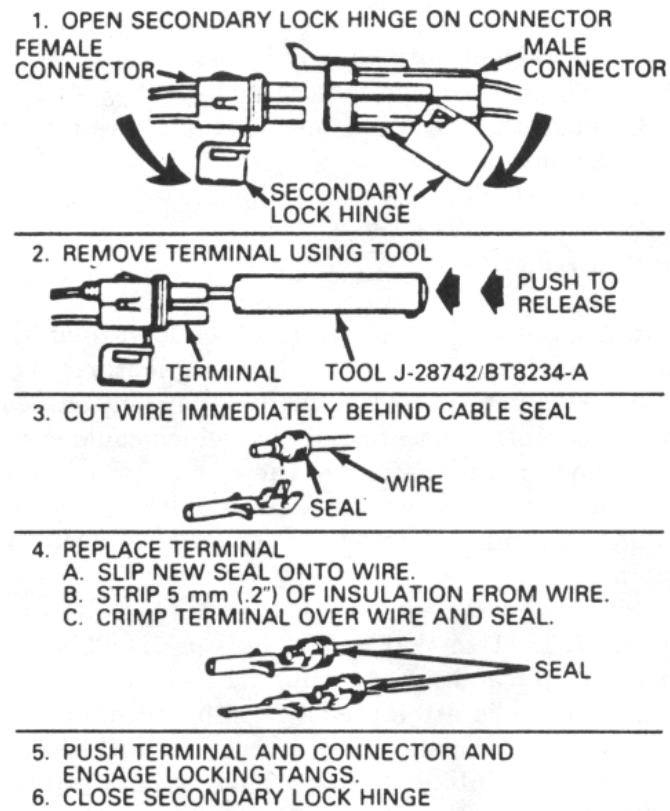
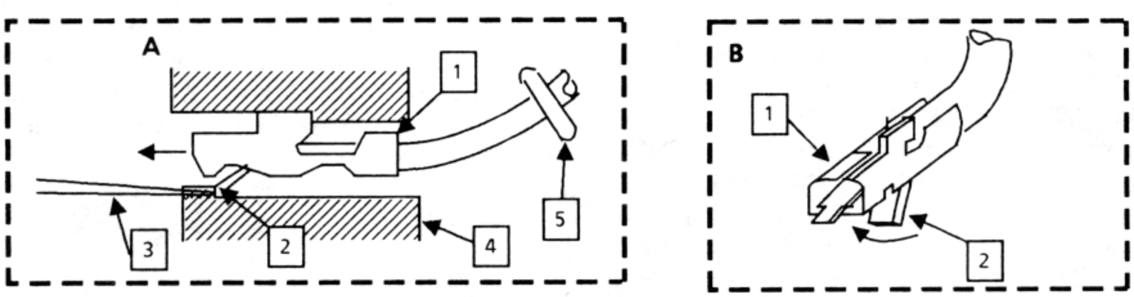


FIGURE 3 WEATHER PACK TERMINAL REPAIR



1. METRI-PACK SERIES 150 FEMALE TERMINAL
2. LOCKING TANG
3. TOOL J35689 OR BT-8446
4. CONNECTOR BODY
5. SEAL

FIGURE 2 METR-PACK SERIES 150 TERMINAL REMOVAL

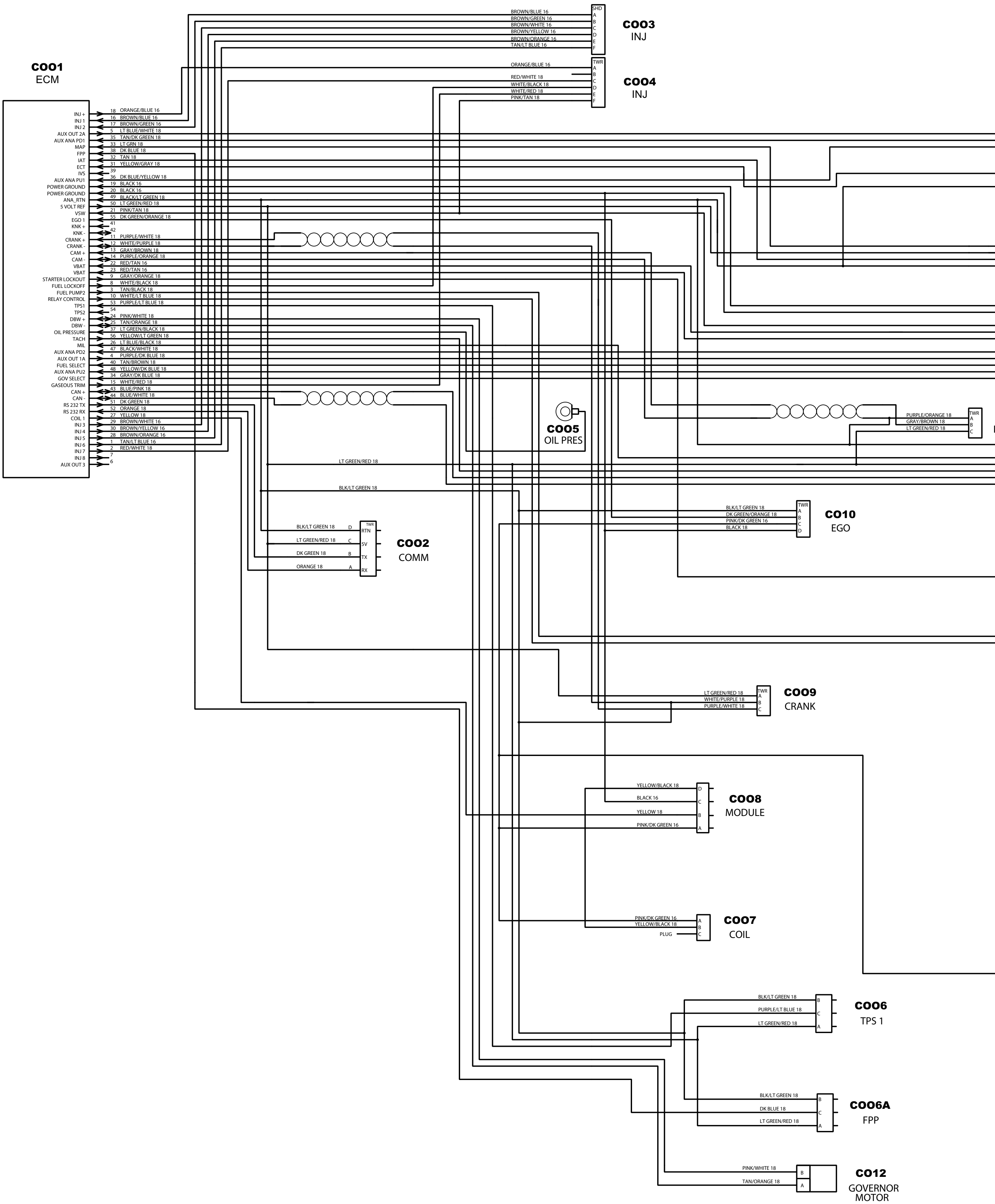
Repair of a Weather-Pack terminal is shown in Figure 3-23. Use tool J M28742, or BT8234-A to remove the pin and sleeve terminals.

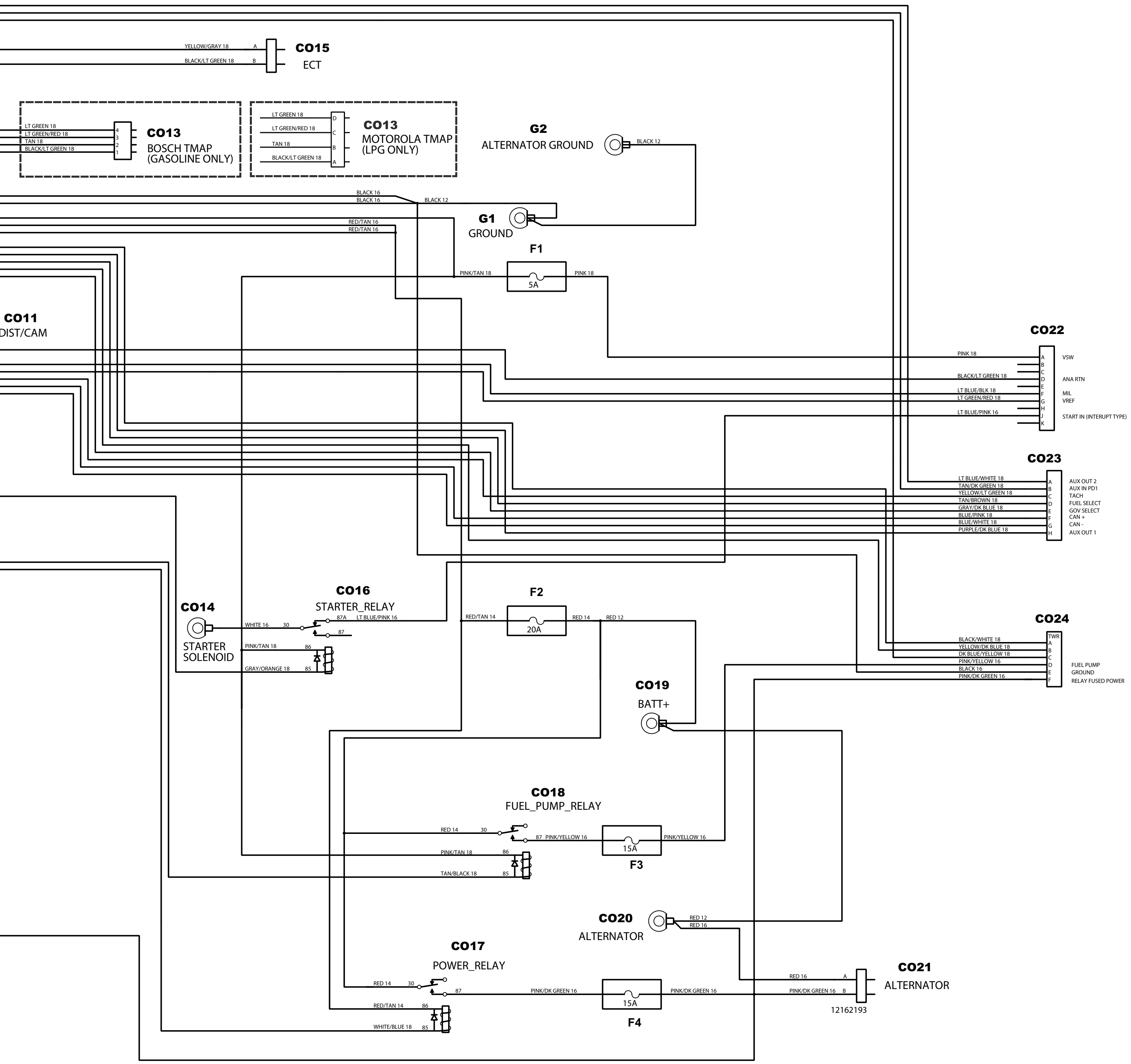
If removal is attempted with an ordinary pick, there is a good chance that the terminal will be bent, or deformed. Unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

Make certain 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 tangs are not positioned properly.

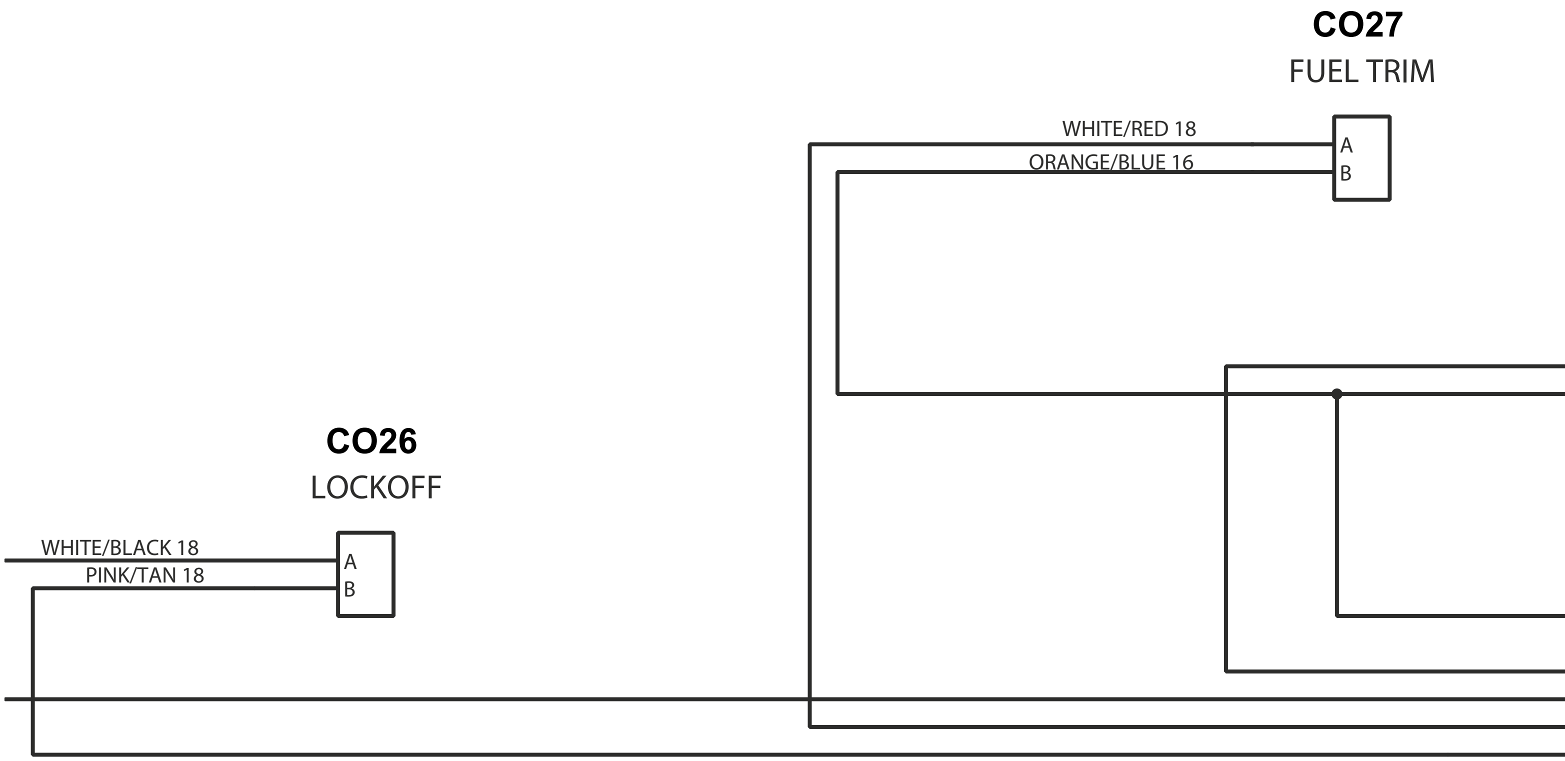
Weather-Pack connections cannot be replaced with standard connections. Instructions are provided with Weather-Pack connector and terminal packages.

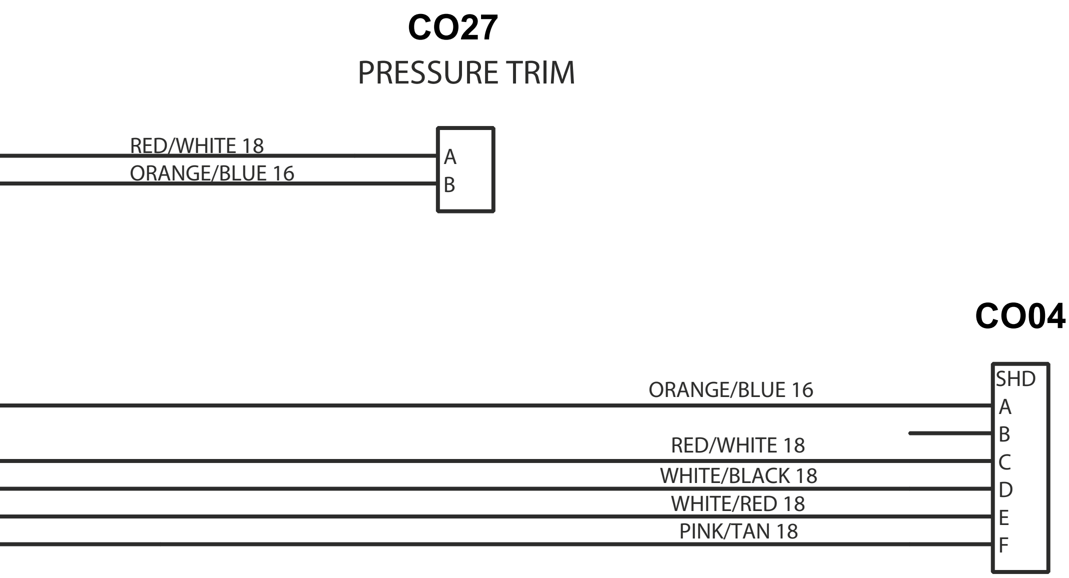
4.3L MAIN HARNESS



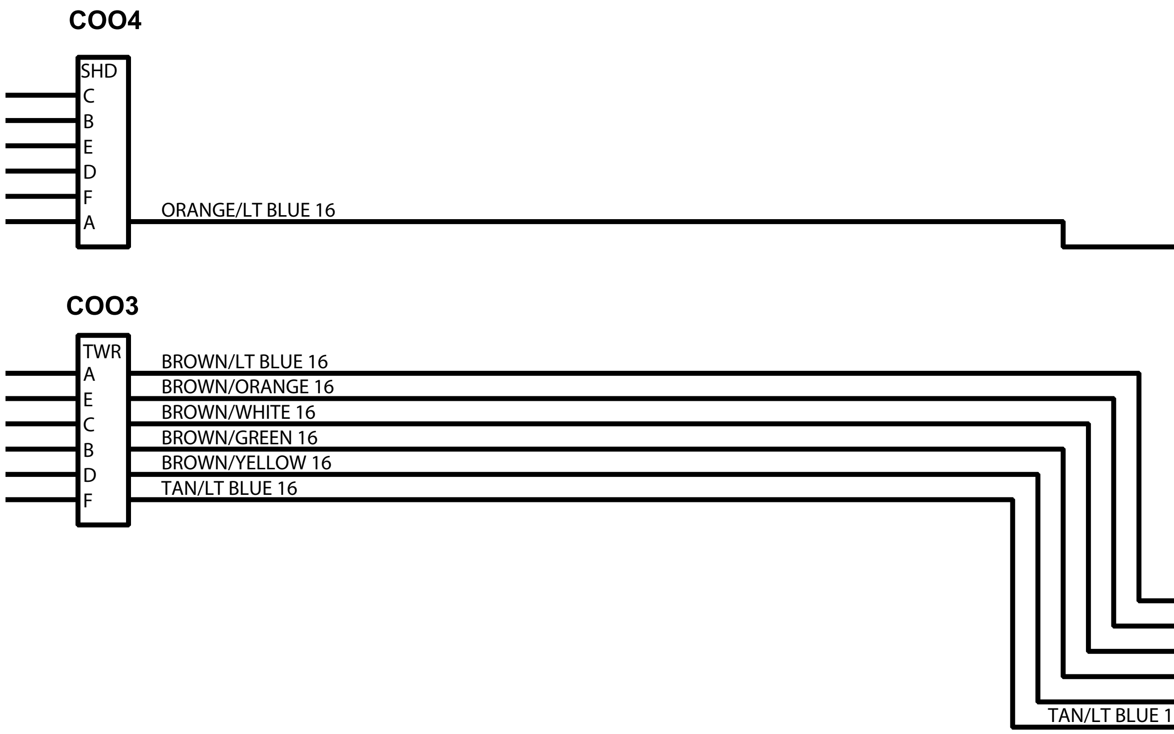

CO15
ECT
YELLOW/GRAY 18
BLACK/LT GREEN 18
CO13
BOSCH TMAP
(GASOLINE ONLY)
CO13
MOTOROLA TMAP
(LPG ONLY)
G2
ALTERNATOR GROUND
BLACK 12
G1
GROUND
F1
5A
PINK/TAN 18
PINK 18
CO11
DIST/CAM
CO22
VSW
ANA RTN
MIL
VREF
START IN (INTERUPT TYPE)
CO23
AUX OUT 2
AUX IN PD1
TACH
FUEL SELECT
GOV SELECT
CAN +
CAN -
AUX OUT 1
CO24
FUEL PUMP
GROUND
RELAY FUSED POWER
CO14
STARTER
SOLENOID
CO16
STARTER_RELAY
F2
20A
CO19
BATT+
CO18
FUEL_PUMP_RELAY
15A
F3
CO20
ALTERNATOR
CO17
POWER_RELAY
15A
F4
CO21
ALTERNATOR
12162193

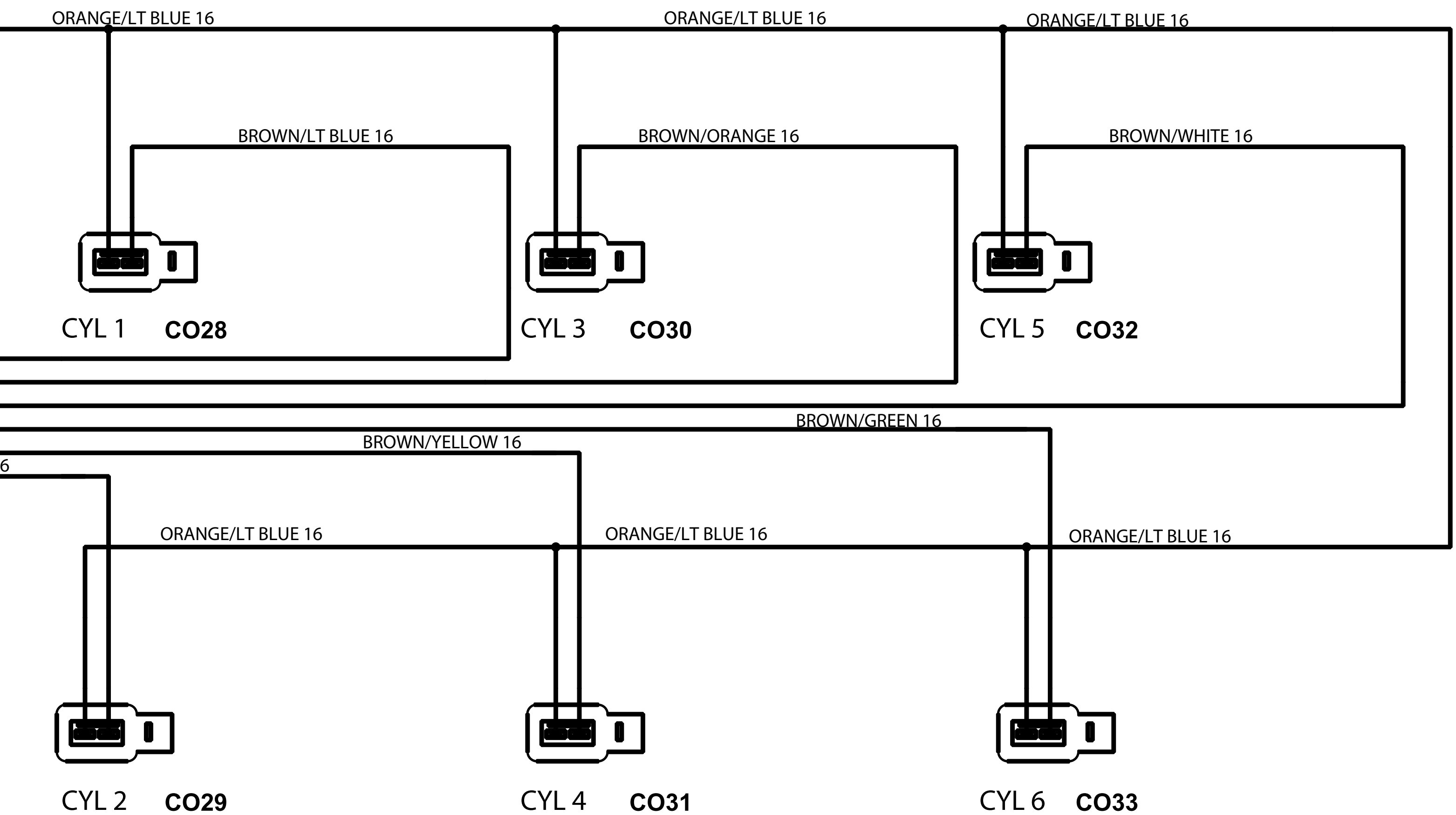
4.3L LPG JUMP HARNESS



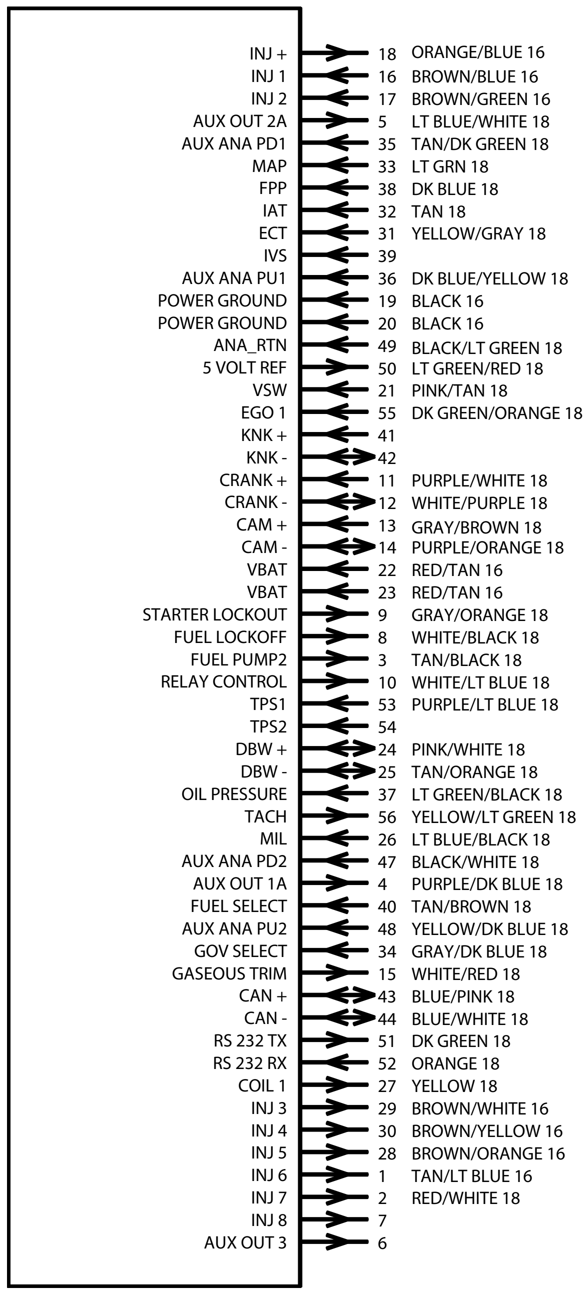

CO27
PRESSURE TRIM
RED/WHITE 18
ORANGE/BLUE 16
A
B
CO04
SHD
A
B
C
D
E
F
ORANGE/BLUE 16
RED/WHITE 18
WHITE/BLACK 18
WHITE/RED 18
PINK/TAN 18

4.3L GASOLINE JUMP HARNESS

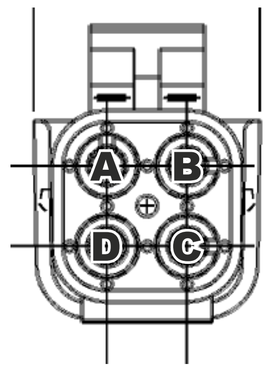



ORANGE/LT BLUE 16
ORANGE/LT BLUE 16
ORANGE/LT BLUE 16
BROWN/LT BLUE 16
BROWN/ORANGE 16
BROWN/WHITE 16
CYL 1
CO28
CYL 3
CO30
CYL 5
CO32
BROWN/GREEN 16
BROWN/YELLOW 16
6
ORANGE/LT BLUE 16
ORANGE/LT BLUE 16
ORANGE/LT BLUE 16
CYL 2
CO29
CYL 4
CO31
CYL 6
CO33

ECM CONNECTOR C001

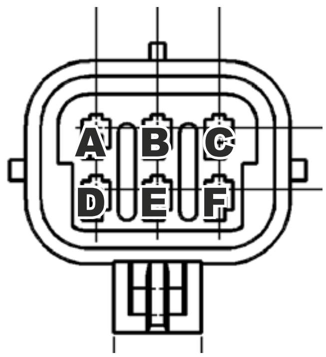


COMMUNICATION PORT C002



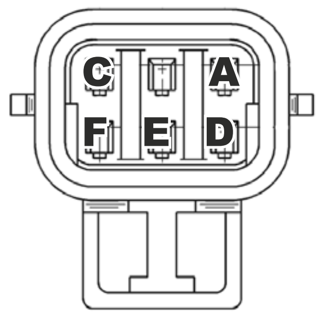
Pin	Wire Color	Function
A	Orange	RS232 RX
B	Dark Green	RS232 TX
C	Lt Green/Red	5 Volt Ref
D	Black/Lt Green	Ana Rtn

INJECTOR CONNECTOR C003



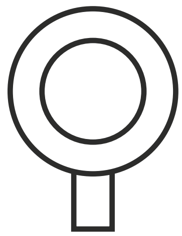
Pin	Wire Color	Function
A	Brown/Blue	Injector 1
B	Brown/Green	Injector 2
C	Brown/White	Injector 3
D	Brown/Yellow	Injector 4
E	Brown/Orange	Injector 5
F	Tan/Light Blue	Injector 6

INJECTOR CONNECTOR C004



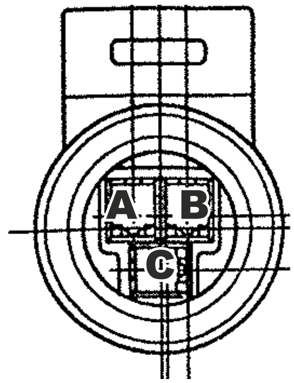
Pin	Wire Color	Function
A	Orange/Blue	Injector +
Not Used		
C	Red/White	Injector 7
D	White/Black	Fuel Lockoff
E	White/Red	Gaseous Trim
F	Pink/Tan	VSW

OIL PRESSURE CONNECTOR C005



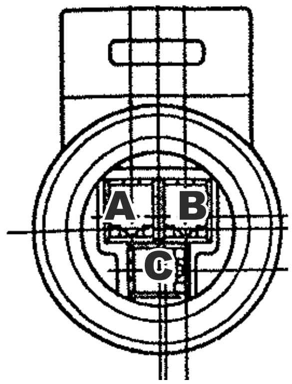
Pin	Wire Color	Function
A	Lt Green/Black	Oil Pressure

TPS 1 CONNECTOR C006



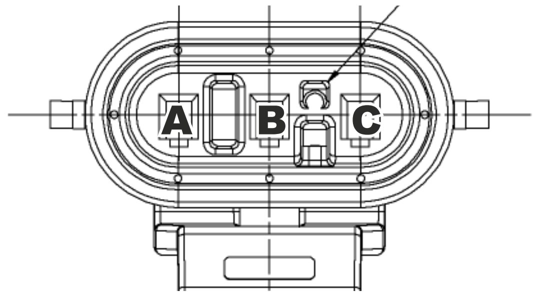
Pin	Wire Color	Function
A	Lt Green/Red	5 Volt Ref
B	Black/Lt Green	Ana Return
C	Purple/Lt Blue	Throttle Position Sensor 1

FPP CONNECTOR C006A



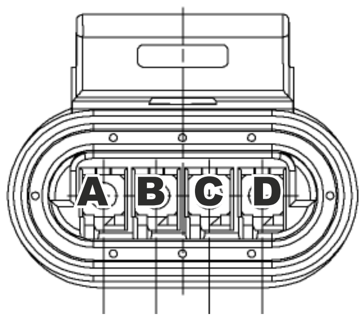
Pin	Wire Color	Function
A	Lt Green/Red	5 Volt Ref
B	Black/Lt Green	Ana Return
C	Dk Blue	FPP

COIL CONNECTOR C007



Pin	Wire Color	Function
A	Pink/Dk Green	EGO
B	Yellow/Black	Module
C	Not Used	

MODULE CONNECTOR C008



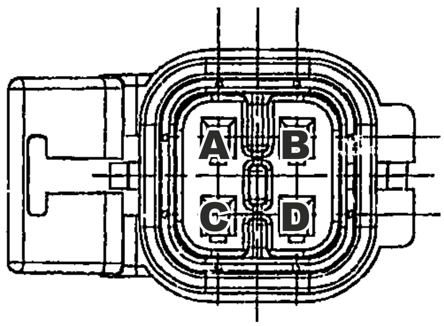
Pin	Wire Color	Function
A	Pink/Dk Green	Coil
B	Yellow	Coil
C	Black	Power Ground
D	Yellow/Black	Coil

CRANK SENSOR CONNECTOR C009

A B C

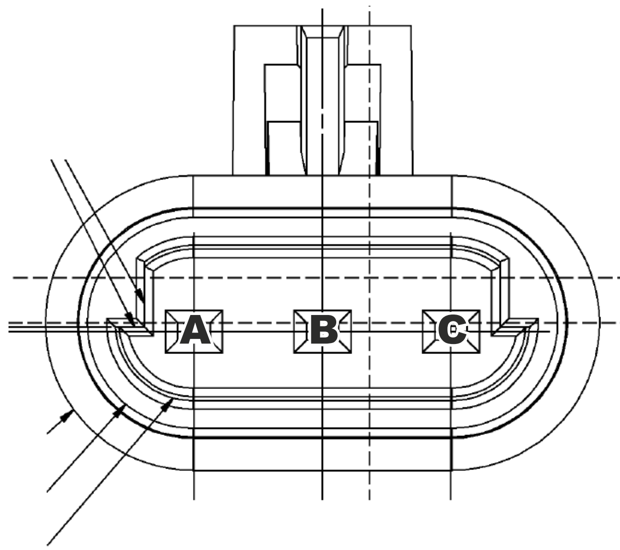
Pin	Wire Color	Function
A	Lt Green/Red	5 Volt Reference
B	White/Purple	Crank +
C	Black	Power Ground

EGO SENSOR CONNECTOR C010



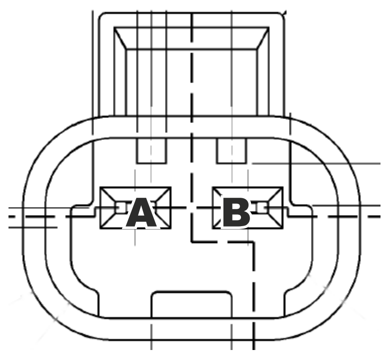
Pin	Wire Color	Function
A	Blk/Lt Green	Power Ground
B	Dk Green/Orange	EGO
C	Pink/Dk Green	Coil
D	Black	Power Ground

CAM CONNECTOR C011



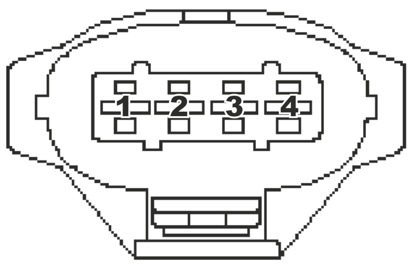
Pin	Wire Color	Function
A	Purple/Orange	Cam –
B	Grey/Brown	Cam +
C	Lt Green/Red	5 Volt Ref

THROTTLE CONNECTOR C012

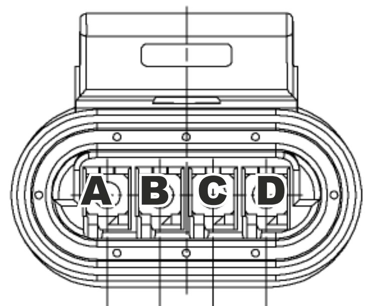


Pin	Wire Color	Function
1	Tan/Orange	DBW -
2	Pink/White	DBW +

TMAP CONNECTOR C013



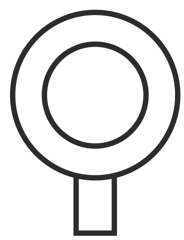
Bosch TMAP used with gasoline fuel system only



Motorola TMAP used with LPG fuel system only

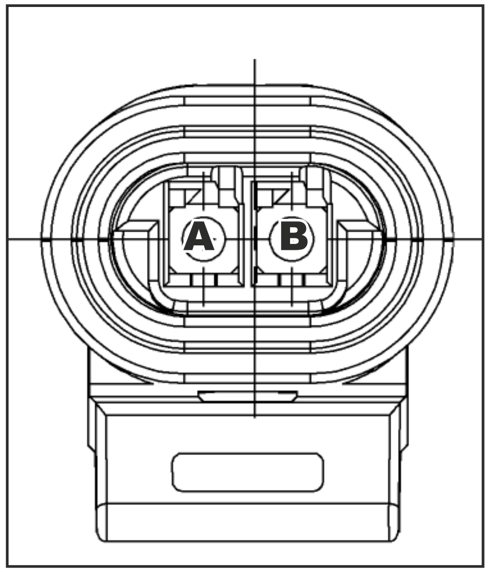
Pin	Wire Color	Function
1 (A)	Black/Lt Green	Analog Return
2 (B)	Tan	IAT
3 (C)	Lt Green/Red	5 Volt Reference
4 (D)	Lt Green	MAP

STARTER SOLENOID CONNECTOR C014



Pin	Wire Color	Function
A	White	Starter Relay

ECT CONNECTOR C015



Pin	Wire Color	Function
A	Yellow/Gray	ECT
B	Black/Lt Green	Analog Return

STARTER RELAY C016

Pin	Wire Color	Function
87A	Lt Blue/Pink	Start In (Interrupt Type)
87	Pink/Black	Start In (Autocrank)
86	Pink/Tan	VSW Fuse, F1
85	Grey/Orange	Starter Lockout
30	White	Starter Solenoid

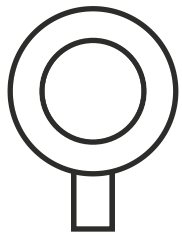
POWER RELAY C017

Pin	Wire Color	Function
87	Pink/Dk Green	Alternator Fuse, F3
86	Red/Tan	ECM VBAT
85	White/Blue	Relay Control
30	Red	Battery +

FUEL PUMP RELAY C018

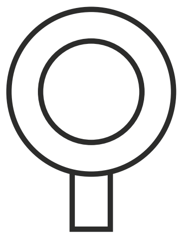
Pin	Wire Color	Function
87	Pink/Yellow	Fuel Pump
86	Pink/Tan	VSW Fuse, F1
85	Tan/Black	ECM, Fuel Pump
30	Red	Battery +

BATTERY CONNECTOR C019



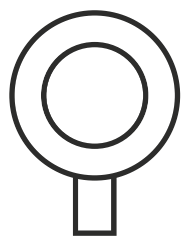
Pin	Wire Color	Function
A	Red	Battery +

ALTERNATOR CONNECTOR C020



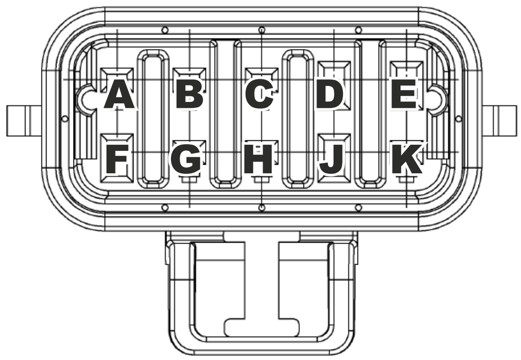
Pin	Wire Color	Function
A	Red	Battery +

ALTERNATOR CONNECTOR C021



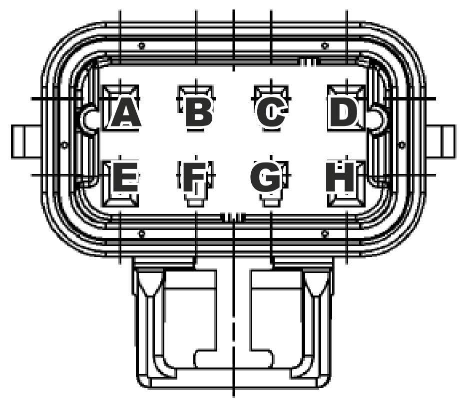
Pin	Wire Color	Function
A	Red	Battery +

INSTRUMENT PANEL CONNECTOR C022



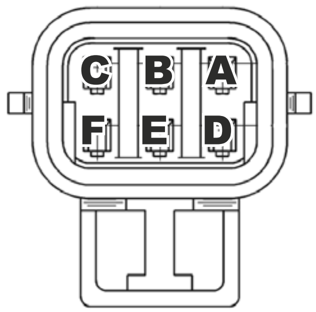
Pin	Wire Color	Function
A	Pink	VSW
B	Dk Blue	FPP
C	Purple/Yellow	IVS
D	Black/Lt Green	Ana Return
E	Not Used	
F	Lt Blue/Black	MIL
G	Lt Green/Red	VREF
H	Not Used	
J	Lt Blue/Pink	Start In (Interrupt Type)
K	Pink/Black	Start In (Autocranking)

INSTRUMENT PANEL CONNECTOR C023



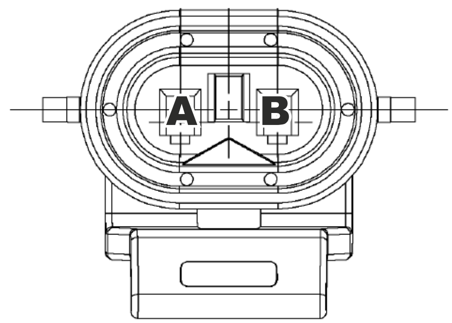
Pin	Wire Color	Function
A	Lt Blue/White	Aux Out 2A
B	Tan/Dk Green	Aux In PD1
C	Yellow/Lt Green	Tach
D	Tan/Brown	Fuel Select
E	Grey/Dk Blue	Gov Select
F	Blue/Pink	Can +
G	Blue/White	Can -
H	Purple/Dk Blue	Aux Out 1

INSTRUMENT PANEL CONNECTOR C024



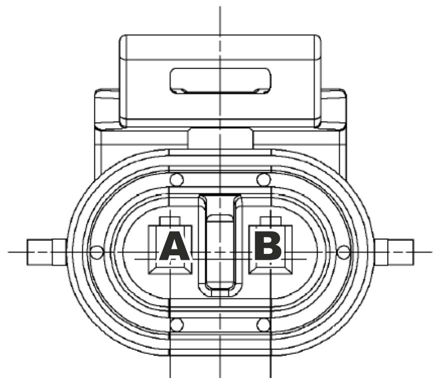
Pin	Wire Color	Function
A	Black/White	Aux In PD2
B	Yellow/Dk Blue	Aux In PU2
C	Dk Blue/Yellow	Aux In PU1
D	Pink/Yellow	Fuel Pump
E	Black	Ground
F	Pink/Dk Green	Relay Fused Power

FUEL TRIM VALVE CONNECTOR C025



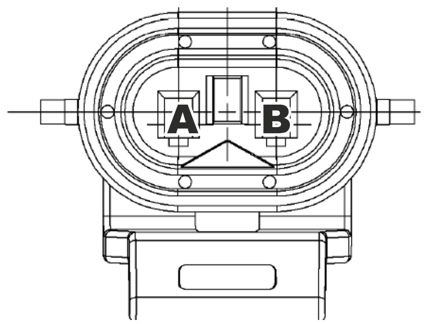
Pin	Wire Color	Function
A	Red/White	Injector 7
B	Orange/Lt Blue	Injector +

FUEL LOCKOFF CONNECTOR C026



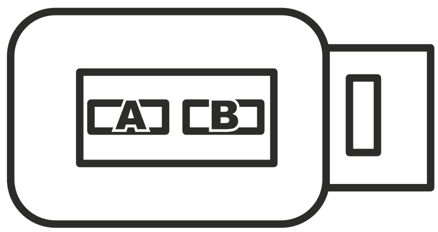
Pin	Wire Color	Function
A	White/Black	Fuel Lockoff
B	Pink/Tan	VSW

PRESSURE TRIM VALVE CONNECTOR C027



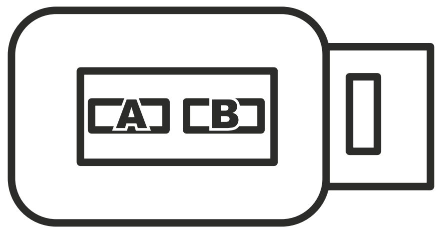
Pin	Wire Color	Function
A	White/Red	Fuel Trim
B	Orange/Lt Blue	INJ +

INJECTOR 1 CONNECTOR C028



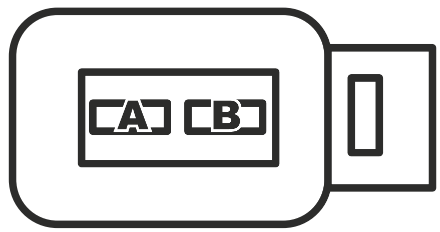
Pin	Wire Color	Function
A	Orange/Lt Blue	Fuel Trim Valve
B	Brown/Lt Blue	Injector 1

INJECTOR 2 CONNECTOR C029



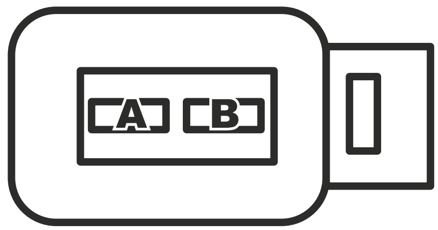
Pin	Wire Color	Function
A	Orange/Lt Blue	Fuel Trim Valve
B	Tan/Lt Blue	Injector 2

INJECTOR 3 CONNECTOR C030



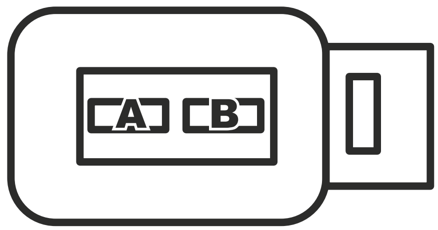
Pin	Wire Color	Function
A	Orange/Lt Blue	Fuel Trim Valve
B	Brown/Orange	Injector 3

INJECTOR 4 CONNECTOR C031



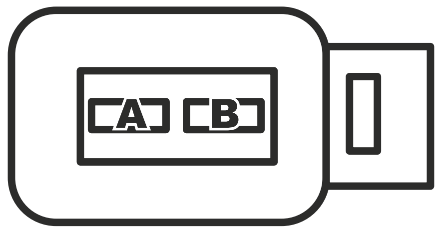
Pin	Wire Color	Function
A	Orange/Lt Blue	Fuel Trim Valve
B	Brown/Yellow	Injector 4

INJECTOR 5 CONNECTOR C032



Pin	Wire Color	Function
A	Orange/Lt Blue	Fuel Trim Valve
B	Brown/White	Injector 5

INJECTOR 6 CONNECTOR C033



Pin	Wire Color	Function
A	Orange/Lt Blue	Fuel Trim Valve
B	Brown/Green	Injector 6

SECTION 1C4

DIAGNOSTIC TROUBLE CODES

DESCRIPTION OF ECM BASED DIAGNOSTICS

DEFINITION OF TERMS

Active Gov Mode	Speed is governed by one of two modes. Isochronous, which maintains an exact speed, or Droop, which allows speed to drop a predetermined amount based on current engine load.
AL	Adaptive Learn
AL Mult	Adaptive Learn Multiplier. The adaptive learn multiplier is a correction to the fuel delivery which is expressed as a percentage (%) and stored in the ECM's RAM.
Analog	0 to 5 volt or 0 to 12 volt signals
Batt	Battery Voltage
BP	Barometric Pressure. The pressure of the outside air.
CHT	Cylinder Head Temperature
CL	Closed Loop
CL Mult	Closed Loop Multiplier. The closed loop multiplier is a fast acting adjustment to the fuel delivery based on feedback from the HEGO. The closed loop multiplier is expressed as a percentage (%) and is not stored in the ECM's memory.
Closed Loop	Fuel and timing modified based on feedback from the O2 sensor.
DBW	Drive by wire.
DTC	Diagnostic Trouble Code. A code which is stored in the ECM when an ECM initiated test fails.
ECT	Engine Coolant Temperature.
ECM	Engine Control Module. The computer, which controls the fuel and ignition system on the engine.
EGO	See HO2S
FPP	Foot Pedal Position.
HO2S	Heated Oxygen Sensor
IAT	Intake Air Temperature
IVS	Idle Validation Switch
MAP	Manifold Absolute Pressure. The pressure of the air in the intake manifold.
MAT	Manifold Air Temperature. The temperature of the air in the intake manifold
MIL	Malfunction Indicator Light. A dash mounted light that illuminates when the ECM senses a system fault.
ms	Milli-seconds. 1/1000 of a second.
Open Loop	Fuel and timing based strictly on tables stored in the ECM.
PSIA	Pounds per square inch absolute. 14.7 psia = 0 psig
RAM	Random Access Memory. The portion of computer memory within the ECM, which changes as the engine is running and is stored while the engine is off.
TPS	Throttle Position Sensor. The throttle position sensor measures the opening of the throttle.

DIAGNOSTICS OVERVIEW OF THE SPECTRUM FUEL SYSTEM

The Spectrum Fuel system has built-in diagnostics for trouble shooting. The system has a dash mounted Malfunction Indicator Lamp (MIL) for indication of system problems.

MALFUNCTION INDICATOR LAMP (MIL)

Most engine control system related problems that affect emissions or driveability of the vehicle will set a (DTC) Diagnostic Trouble Code and illuminate the Malfunction Indicator Lamp.

The MIL has the following functions:

1. It notifies the driver of a problem with the fuel system, ignition system, or emission control system so the driver can arrange for service as soon as possible.
2. It will display DTC's that have been stored due to a system malfunction.

The lamp should come on when the key is in the ON position and the engine is not running. This feature verifies that the lamp is in proper working order. If the lamp does not come on with the vehicle key on/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 illuminates while the engine is in the start or run mode, there is a current Diagnostic Trouble Code.

Spectrum Diagnostic Trouble Codes (DTC)

Diagnostic Trouble Codes are set when the Spectrum ECM (Electronic Control Module) runs a diagnostic self-test and the test fails. When a DTC is set, the ECM will illuminate the Malfunction Indicator Lamp on the instrument panel and save the code in memory. The ECM will continue to run the self-test unless the DTC is an oxygen sensor lean, oxygen sensor rich, or an internal ECM related DTC. If the system continues to fail the test, the lamp will stay illuminated and the DTC is current (ACTIVE). All DTC's are stored as historical faults until they are cleared. All DTC's except the ECM related DTC's will automatically clear from memory if the DTC does not reset within 50 consecutive engine run cycles.

While a Diagnostic Trouble Code is current for a sensor, the ECM may assign a default "limp home" value and use that value in its control algorithms. All of the system diagnostic self-tests run continuously during normal vehicle operation.

The Diagnostic Trouble Codes can be read by using either the MIL lamp or a laptop computer. Refer to *Using a Laptop Computer to Diagnose the Spectrum System* and *Using a Diagnostic Jumper to Diagnose the* ECI *System*, located in this section. Diagnostic Trouble Codes can be cleared from memory with a laptop computer or by turning the ignition key to the OFF position and removing the system main power fuse (F3) for 15 seconds.

If more than one DTC is detected, always begin with the **lowest number DTC** and diagnose each problem to correction unless directed to do otherwise by the fault tree. The DTC's are numbered in order of importance. Having DTC 112 and DTC 122, both concerning the oxygen sensor, is possible. By repairing DTC 112 first, the problem causing the DTC 122 may also be corrected.

USING A LAPTOP COMPUTER TO DIAGNOSE THE SPECTRUM SYSTEM

A laptop computer is the preferred tool for performing diagnostic testing of the Spectrum system. A laptop computer, with the system diagnostic cable and diagnostic software, is used to read and clear Diagnostic Trouble codes. It is also used to monitor sensor and actuator values. The diagnostic software also performs several special tests.

The following procedures will assist you in using a laptop computer to diagnose the Spectrum system:

INSTALLING THE SPECTRUM DIAGNOSTIC SOFTWARE

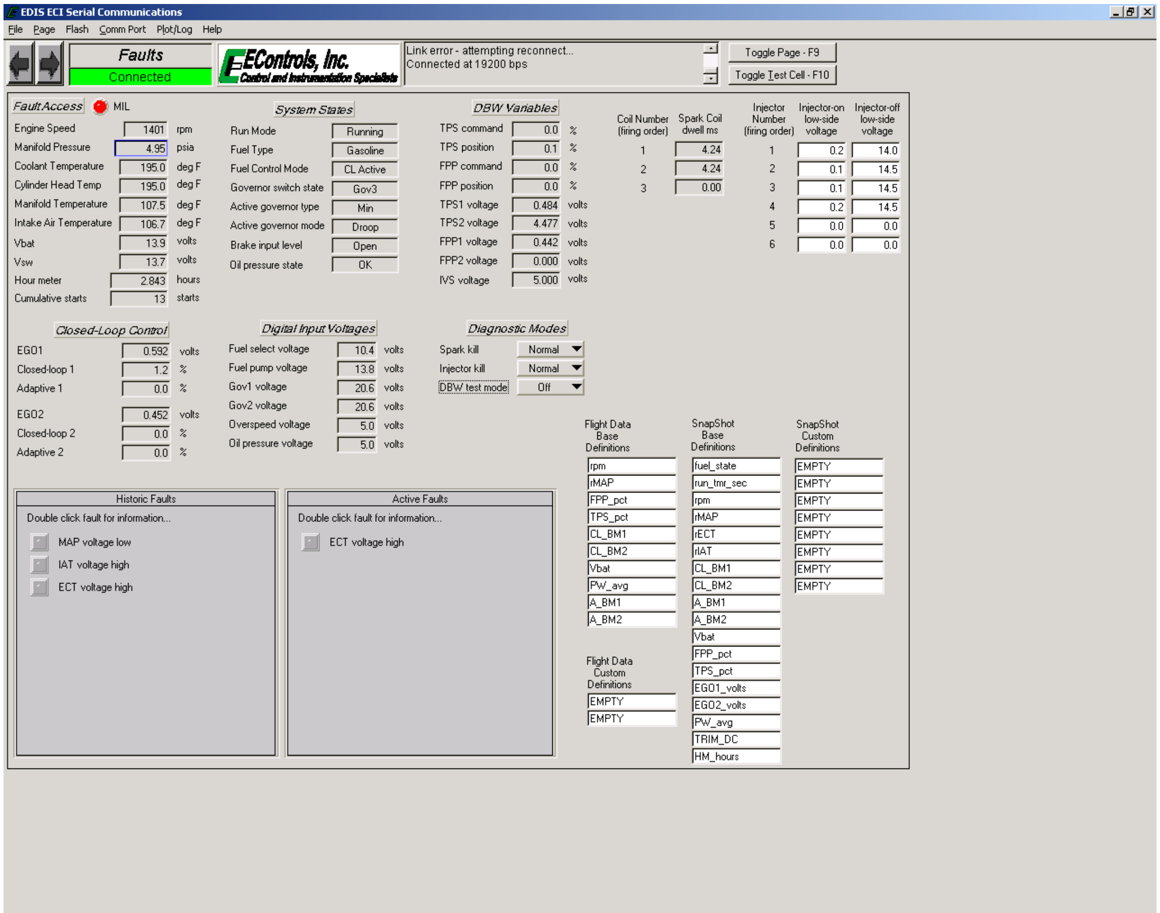
Loading Software and Connecting the Computer

- Start Windows
- Insert the Diagnostic Interface software CD.
- Click on the ***START*** button.
- From the Start menu, select ***RUN***.
- In the command-line text box, type the letter of your CD-ROM drive, followed by: ***setup*** (for example, ***e:\setup***), then click ***OK***.
- Follow the on screen instructions.

Connecting a Laptop Computer to the Spectrum System

- Connect the system diagnostic cable to the RS232 port on the back of the computer. If you do not have a RS-232 port use the USB to RS232 adapter cable.
- Connect the diagnostic cable to the diagnostic connector on the engine harness. The diagnostic connector is a square 4-pin connector located near the Spectrum system ECM.
- Turn the computer ON.
- Start Windows.
- From the ***Start*** menu select ***Programs.***
- Select IMPCO ***Display***.
- Place the ignition key in the ON position.
- The system Gauge screen should now appear and a green banner in the upper left hand will read “Connected”.

DIAGNOSTIC TROUBLE CODES



The System Fault screen is used to view and clear DTC's, which have been set.

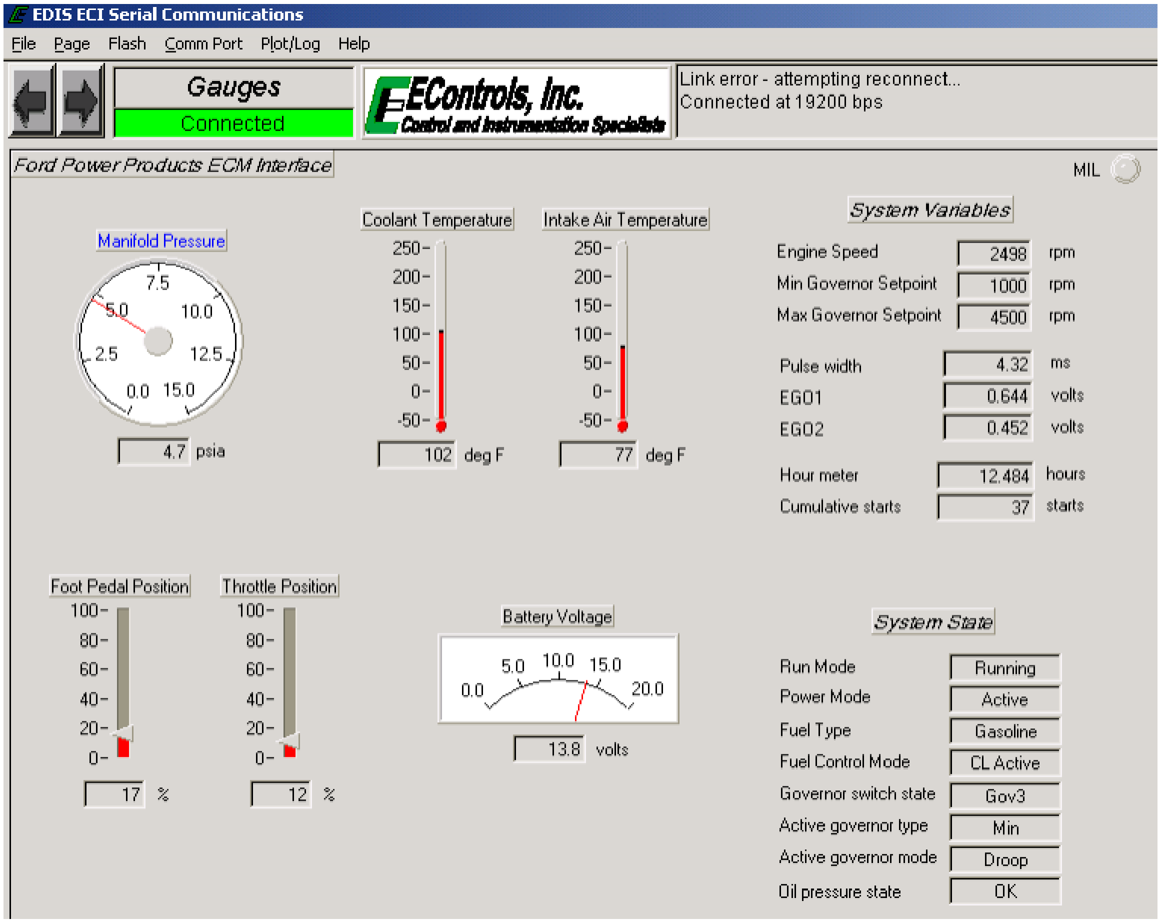
Checking Diagnostic Trouble Codes

The System Fault screen contains a listing of all of the Historic and Active DTC's set within the system. If a DTC is stored in memory, the screen will display that fault in the History column. If the fault is active it will also show up in that column.

Clearing Diagnostic Trouble Codes

To clear a DTC from memory use the arrow keys or mouse to move the Press the Enter key to clear the fault from memory. **NOTE:** Record faults before erasing them for reference during diagnostics.

DATA STREAM

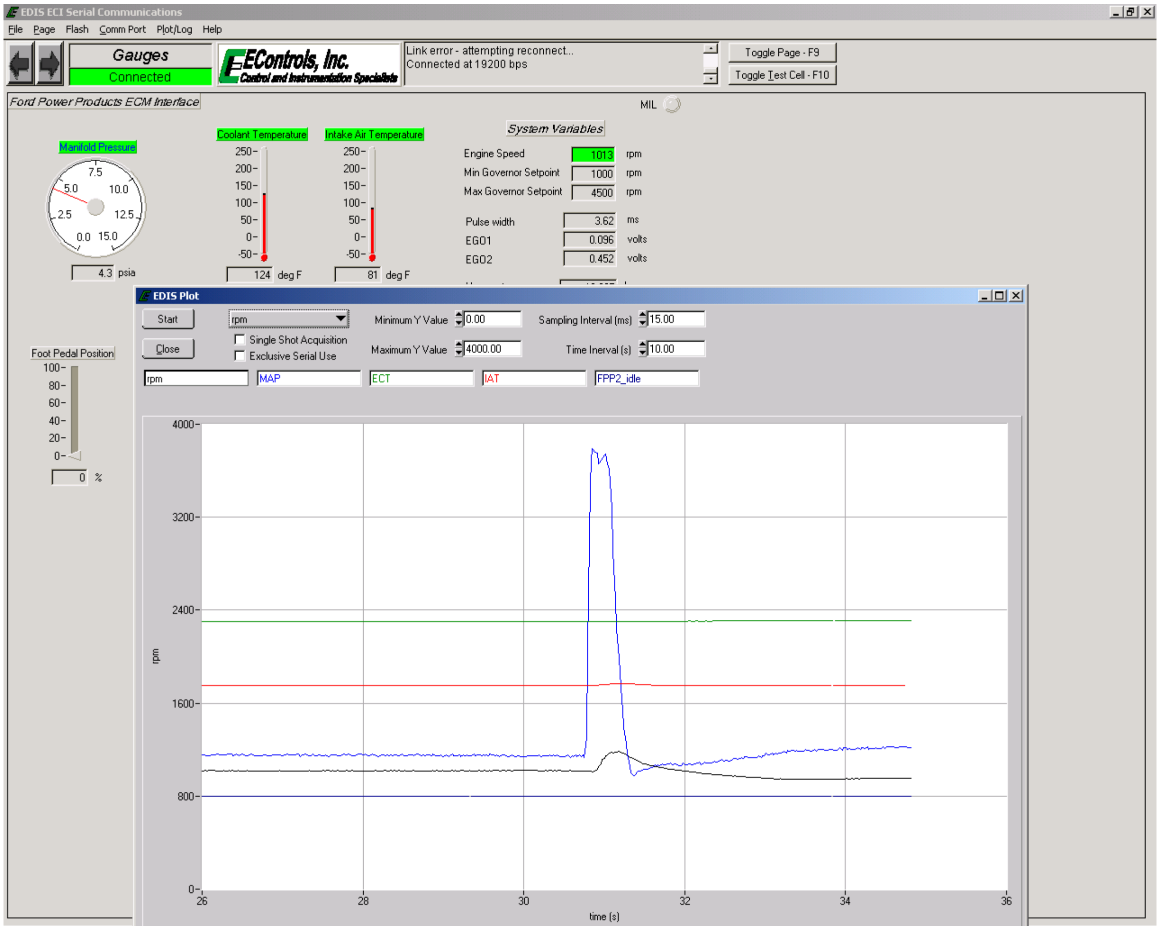


Reading Sensor and Actuator Values

Most applicable sensor and actuator values are displayed on the Gauges screen. The display shows the value for sensors, voltages and the sensor values in engineering units.

NOTE: If a DTC for a sensor is current, the engineering value for that sensor may be a default, limp home value and the voltage value will be the actual sensor voltage. Use the voltage value when performing diagnostics unless directed to do otherwise by the diagnostic trouble tree.

Graphing and Data Logging



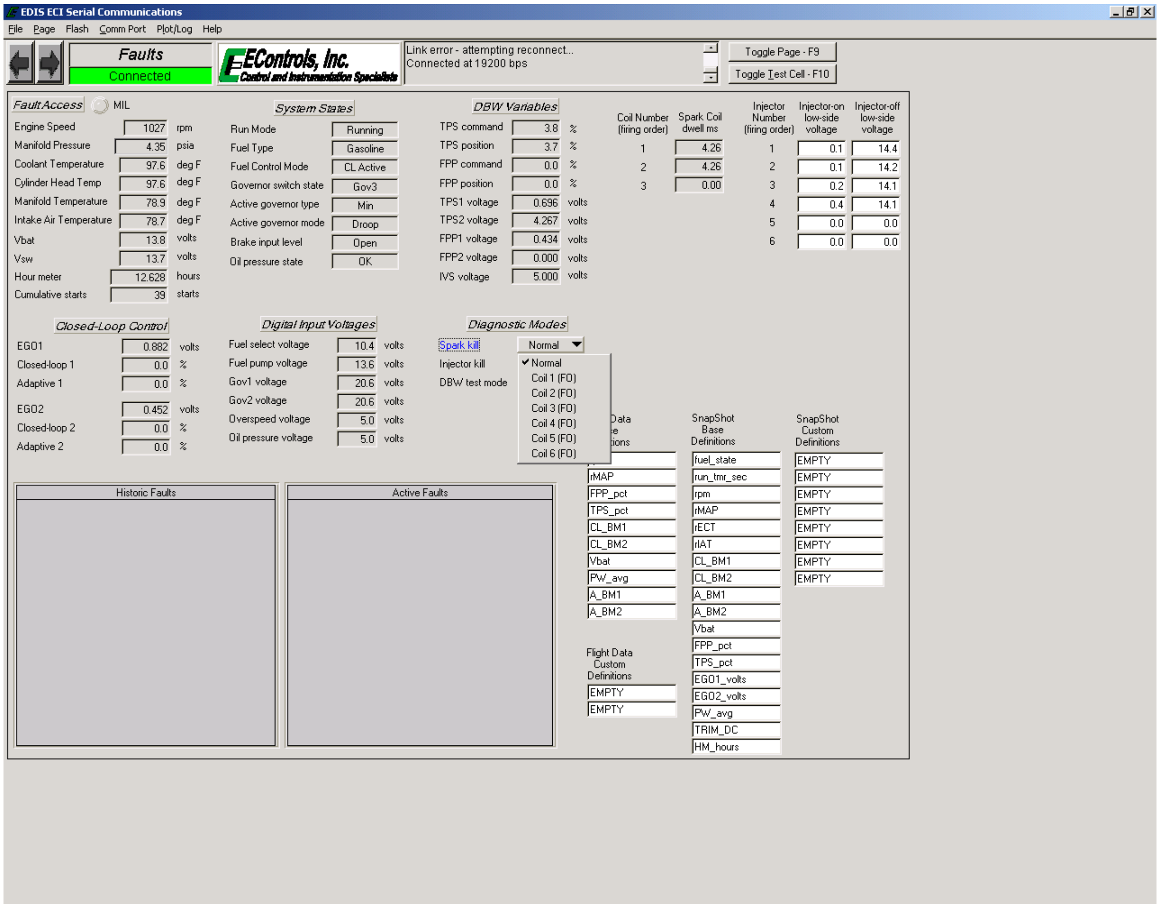
Graphing the values and voltages can be a very useful tool in doing intermittent diagnosis. The system diagnostic monitoring software includes graphing and data logging capability. These features enhance the ability to diagnose and repair possible problems with the system. The graphing feature allows sensor inputs and select control output variables to be plotted in real-time while the engine is running.

To plot a variable you must first "TAG" the variable you wish to plot. To do this, use the mouse to highlight the variable, and then right click.

Next press the "P" key or double click the Plot/Log button to invoke the plotting feature. You may change the desired time interval for each display screen. The default is 10 seconds. This can be increased or decreased as necessary to display the desired results. You can also change the sample rate.

You are now ready to plot. Simply click the "START" button to observe the plotted variables. The plot sweeps across the screen from left to right. To pause the display screen press the "SPACE BAR" at any time during plotting. To continue plotting simply press the "SPACE BAR" again. To stop the plotting feature simply click the "STOP" button. To exit the plotting screen click the "CLOSE" button. The range of each variable is listed along the left side of the display and the time is listed along the bottom of the screen.

IGNITION SYSTEM TEST



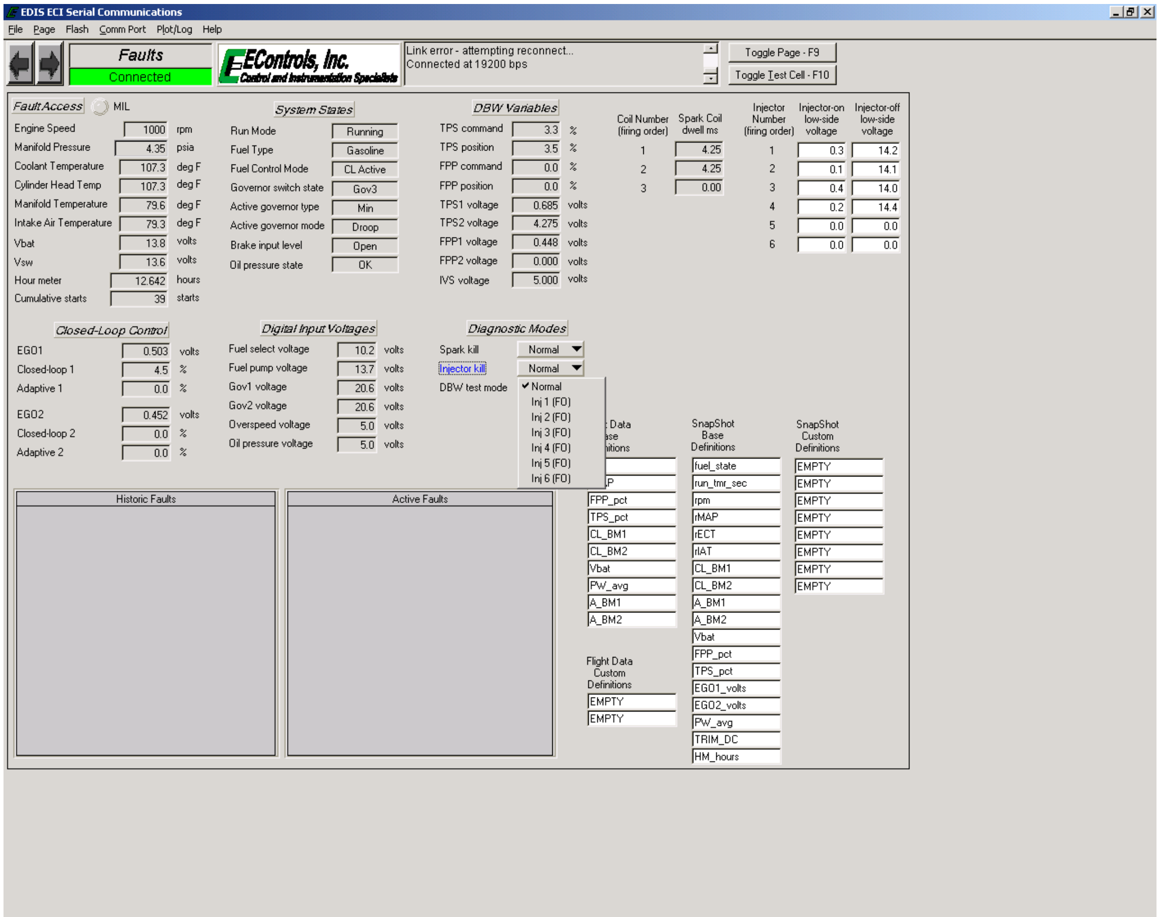
The Spark Kill diagnostic mode allows the technician to disable the ignition on individual cylinders. If the Spark Kill diagnostic mode is selected with the engine running below 1000 RPM, the minimum throttle command will lock into the position it was in when the test mode was entered. If the Spark System Test mode is selected with the engine running above 1000 RPM, the throttle will continue to operate normally.

Disabling Ignition Outputs

To disable the ignition system for an individual cylinder, use the mouse to highlight the "Spark Kill" button and select the desired coil. The spark output can be re-enabled by using the mouse to highlight the "Spark Kill" button and selecting "Normal". If the engine is running below 1000 RPM, the spark output will stay disabled for 15 seconds and then re-set. If the engine is running above 1000 RPM, the spark output will stay disabled for 5 seconds and then re-set. This test mode has a timeout of 10 minutes. Record the rpm drop related to each spark output disabled.

The Spark outputs are arranged in the order which the engine fires, not by cylinder number.

INJECTOR TEST

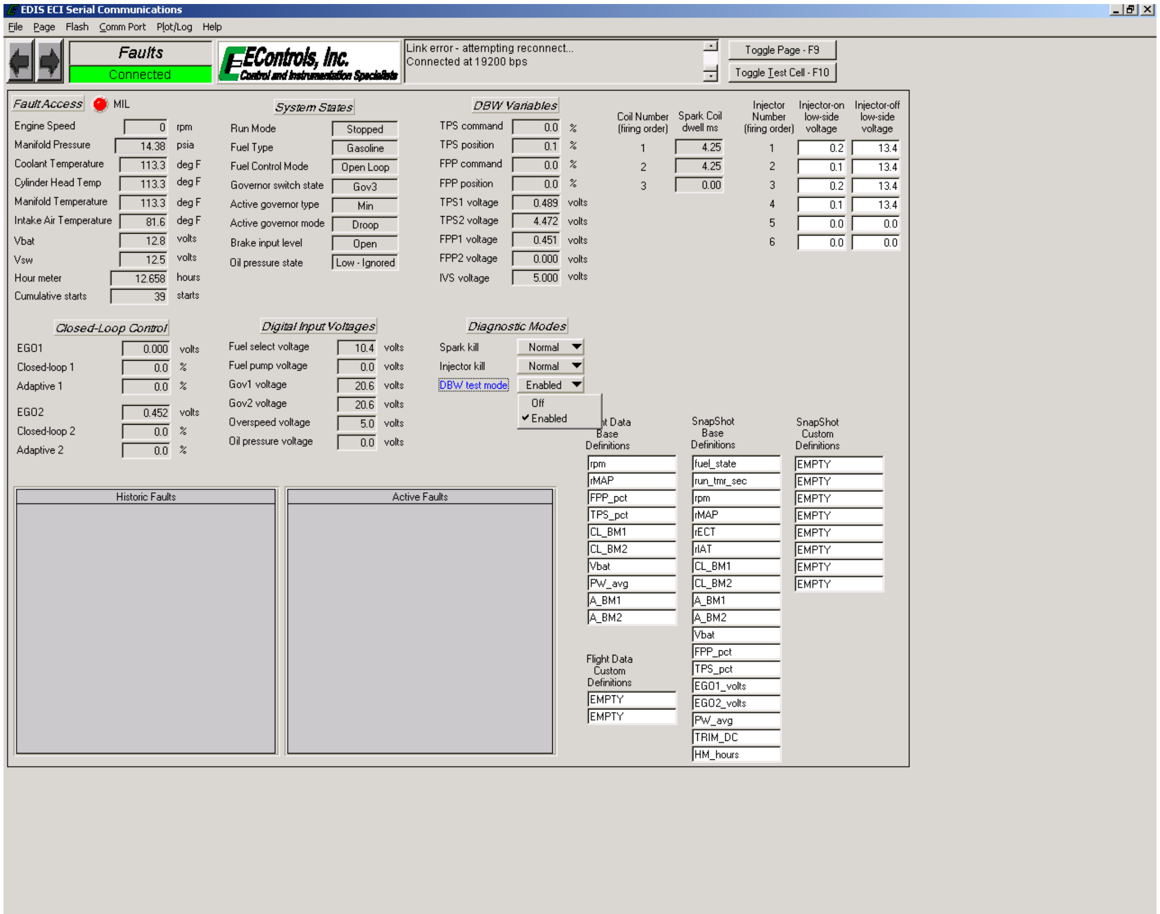


The Injector Kill mode is used to disable individual fuel injectors. If the Injector Kill mode is selected with the engine running below 1000 RPM, the minimum throttle command will lock into the position it was in when the test mode was entered. If the Injector Kill mode is selected with the engine running above 1000 RPM, the throttle will continue to operate normally.

Disabling Injectors

To disable an injector, use the mouse to select the desired. The word “Normal” will change to the Injector you have selected. The injector driver can be re-enabled by selecting again. If the engine is running below 1000 RPM, the injector driver will stay disabled for 15 seconds and then re-set. If the engine is running above 1000 RPM, the injector driver will stay disabled for 5 seconds and then re-set. Record the change in rpm or closed loop multiplier while each driver is disabled.

THROTTLE TEST



To select this test mode the engine must be off but the key must be in the ON position.

The DBW (Drive By Wire) test mode allows the technician to control the throttle directly with the foot pedal or throttle input and is used during the diagnostic routines specified for FPP and TPS for Spectrum systems that use DBW.

FPP position displays the current position of the foot pedal as a percentage. FPP volts display the voltage which the ECM is reading from the FPP sensor.

TPS Command displays the commanded throttle position expressed as a percentage, which is being sent to the throttle. TPS Position is the actual percent of throttle opening being sent to the ECM from the throttle. TPS volts display the actual TPS signal voltage the ECM is receiving from the throttle.

Using a Diagnostic Jumper to Diagnose the ECI System

If you do not have access to a laptop computer, it is still possible to access the Diagnostic Trouble Codes stored in the memory of the Spectrum system ECM using a diagnostic jumper and the Malfunction Indicator Lamp. With the key off connect the diagnostic jumper to the ECI system diagnostic connector located near the ECM. The jumper will connect diagnostic pins A and D. Turn the ignition on but do not start the vehicle. The Malfunction Indicator Lamp (MIL) will begin to flash.

The MIL displays three digit codes by flashing the first digit, pausing, then flashing the second digit, pausing, and then flashing the third digit. There will be a long pause between codes. For example, a code 143 would be one flash followed by four flashes followed by three flashes.

The MIL will first display a 123 three times. Code 123 indicates that the ECM based diagnostic routines are functioning. Then, any Diagnostic Trouble Codes stored in memory will display three times each. The MIL will then start over with the code 123. If the vehicle is started while the diagnostic jumper is in place, the MIL will flash rapidly.

Diagnostic Trouble Codes may be cleared from the system ECM memory by moving the ignition key to the OFF position and removing the (F1) system battery fuse for at least 15 seconds. **Note:** This will erase all of the memory in the computer including the adaptive learn.

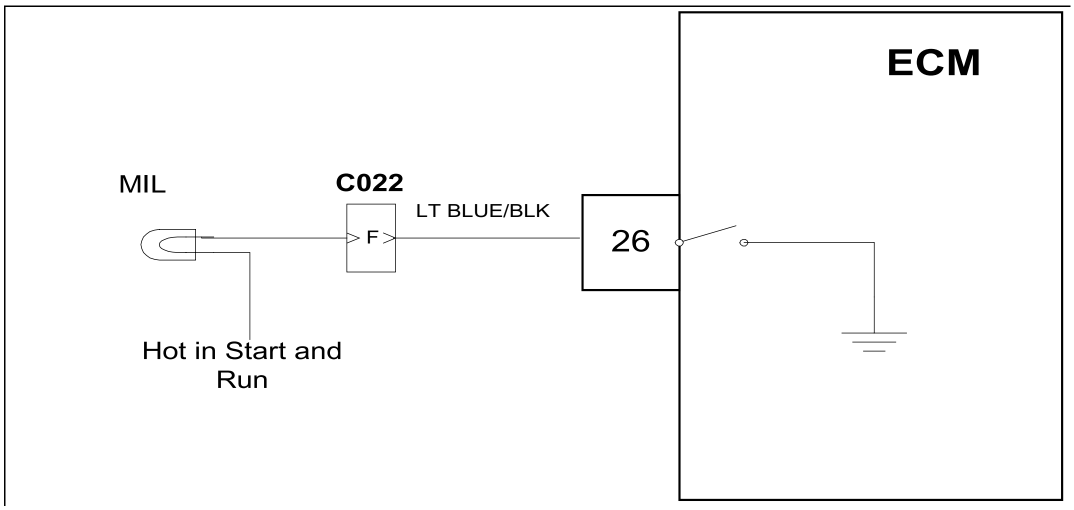
DIAGNOSTIC PROCEDURES FOR BI-FUEL APPLICATIONS

Diagnostic Trouble Codes (DTC) will set in both propane and gasoline fuel modes. Some DTC's are specific to either gasoline or propane, but are described in the DTC charts as such. When dealing with a fuel specific DTC, it is advised to run the diagnostic test in the fuel mode that the code was originally set. In the case of a fuel specific DTC, the diagnostic test procedures must be performed running in the fuel mode that is described for that particular DTC. An example of this would be DTC 243 Adaptive Learn High (LPG) The diagnostic test must be run in the LPG mode for a successful repair. In the presence of multiple DTC codes always begin with the lowest number DTC and diagnose each problem to correction, unless directed to do otherwise by the DTC chart. The DTC's are numbered in order of importance. Having DTC 112 and DTC 122, both concerning the oxygen sensor, is possible. By repairing DTC 112 first, the problem causing the DTC 122 may also be corrected.

When a DTC is set, the ECM will illuminate the Malfunction Indicator Lamp on the instrument panel and save the code in memory. The ECM will continue to run the self-test unless the DTC is an oxygen sensor lean, oxygen sensor rich, or an internal ECM related DTC. If the system continues to fail the test, the lamp will stay illuminated and the DTC is current (ACTIVE). All DTC's are stored as historical faults until they are cleared. All DTC's except the ECM related DTC's will automatically clear from memory if the DTC does not reset within 50 consecutive engine run cycles.

While a Diagnostic Trouble Code is current for a sensor, the ECM may assign a default "limp home" value and use that value in its control algorithms. All of the system diagnostic self-tests run continuously during normal vehicle operation.

OBD SYSTEM CHECK/MALFUNCTION INDICATOR LAMP



Circuit Description

The Spectrum Fuel system is equipped with OBD (On-Board Diagnostics). The system has a dash mounted MIL (Malfunction Indicator Lamp) for the indication of system problems. Engine control system problems that affect emissions or driveability of the vehicle will set a DTC (Diagnostic Trouble Code). The ECM will then provide a path to ground and illuminate the MIL (Malfunction Indicator Lamp)

The MIL has the following functions:

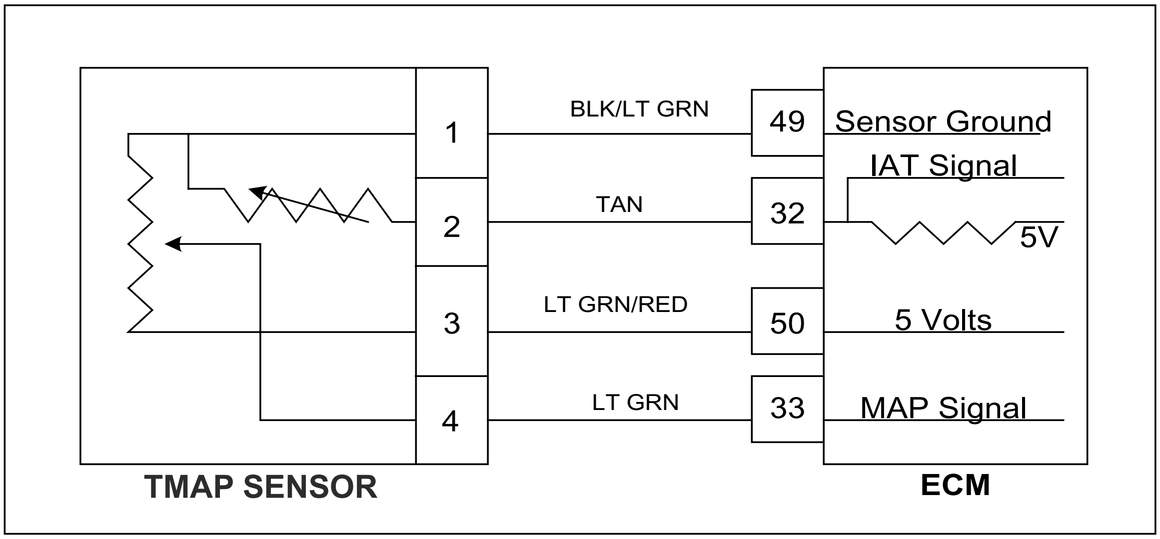
1. It notifies the driver of a problem with the fuel system, ignition system, or emission control system so the driver can arrange for service as soon as possible.
2. It will display DTC's that have been stored due to a system malfunction.

The lamp should illuminate when the key is in the ON position, and the engine is not running. This feature verifies that the lamp is in proper working order. If the lamp does not come on with the vehicle key on/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 illuminates while the engine is in the start or run mode, a current Diagnostic Trouble Code may be set. Always use the OBD System Check chart on the next page of this manual to verify proper MIL operation before proceeding with a DTC diagnostic code repair.

OBD System Check

Step	Action	Value(s)	Yes	No
1	• Key ON Engine OFF Does the MIL illuminate?		*Go to Step (2)*	*Go to Step (3)*
2	• Start the engine • Does the MIL lamp turn off?		*MIL is working properly. OBD System Check is complete*	Go to Step (10)
3	• Key ON engine OFF • Check for voltage between MIL power source and engine ground Do you have voltage?		*Go to Step (4)*	*Repair MIL voltage source. Refer to OEM body and chassis wiring diagrams*
4	Replace MIL lamp Did that solve the problem?		*Go to step (1)*	*Go to Step (5)*
5	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between MIL ground and ECM terminal 26 Do you have continuity?		*Go to Step (6)*	*Go to Step (8)*
6	• Inspect the MIL lamp socket, connector C022 and ECM terminal 26 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 ECM Is the replacement complete?		Go to Step (1)	-
8	• Back probe the MIL and ECM terminal F in connector C022 • Using a DVOM check for continuity through connector C022 Do you have continuity?		*Go to Step (9)*	*Go to Step (9)*
9	• Inspect the MIL lamp socket, connector C022 and ECM terminal 26 for damage, corrosion or contamination Did you find a problem?		Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Repair the open circuit as necessary. Refer to Section 1C2 for wiring repairs
10	Active DTC (Diagnostic trouble code) is stored in memory. Proceed with DTC diagnosis. If no active DTC is found in ECM memory return to this page Step (11)		-	-

DTC 111-IAT High Voltage Bosch® TMAP



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-IAT Sensor Voltage greater than 4.95
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm. The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

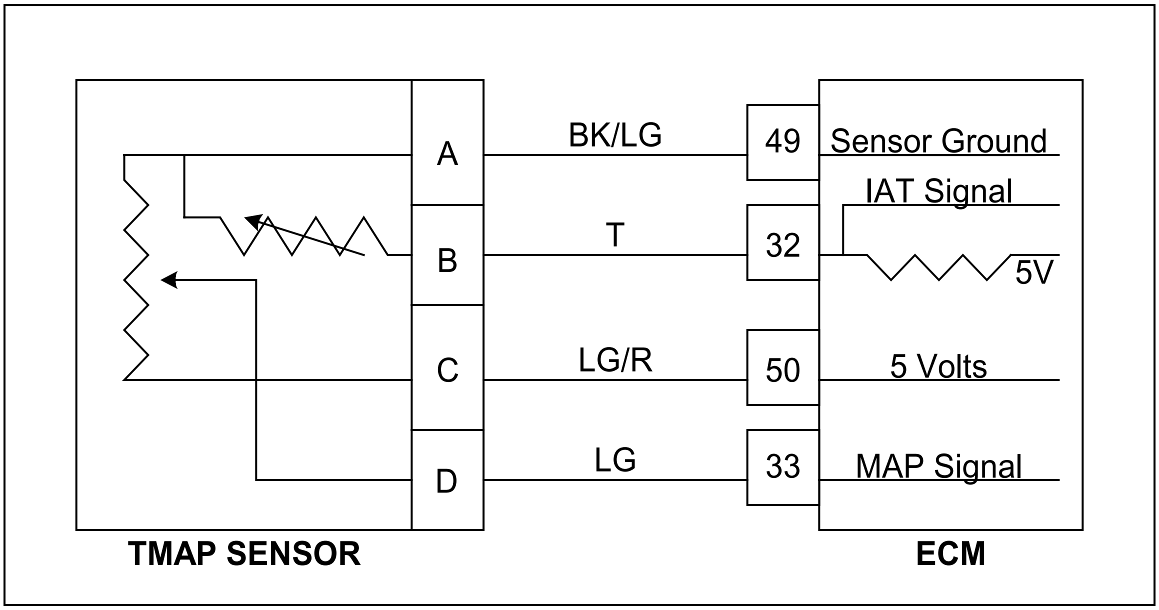
This fault will set if the signal voltage is more than 4.95 volts anytime the engine is running. The ECM will use the default value for the IAT sensor in the event of this fault.

DTC 111- IAT VOLTAGE HIGH (BOSCH®) TMAP

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 Does DST display IAT voltage of 4.95 or greater?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key Off* • *Disconnect the TMAP sensor connector from the wiring and harness and jumper pins 1 and 2 together* • *Key On* Does the DST display IAT voltage of 0.1 volts or less?		Go to step (9)	*Go to step (4)*
4	• Key OFF • Jumper TMAP sensor connector signal pin 2 to engine ground • Key ON • Does DST display IAT voltage of 0.1 volts or less?		*Go to Step (7)*	*Go to Step (6)*
5	Replace TMAP sensor. Is the replacement complete?		*Go to Step (11)*	_
6	• Key OFF • Disconnect the ECM wire harness connector. • Check for continuity between TMAP sensor connector signal pin 2 and ECM IAT signal pin 32. Do you have continuity between them?	__	Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	• Check for continuity between TMAP sensor connector ground circuit pin 1 and ECM sensor ground circuit pin 49. Do you have continuity between them?	__	Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	*Go to step (11)*	_
9	• Re-check wire harness and TMAP sensor connectors for damage corrosion or contamination Were any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (5)
10	• Re-check wire harness and TMAP sensor connectors for damage corrosion or contamination Were any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (8)

11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-111 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 111-IAT High Voltage Motorola TMAP



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-IAT Sensor Voltage greater than 4.95
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm. The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

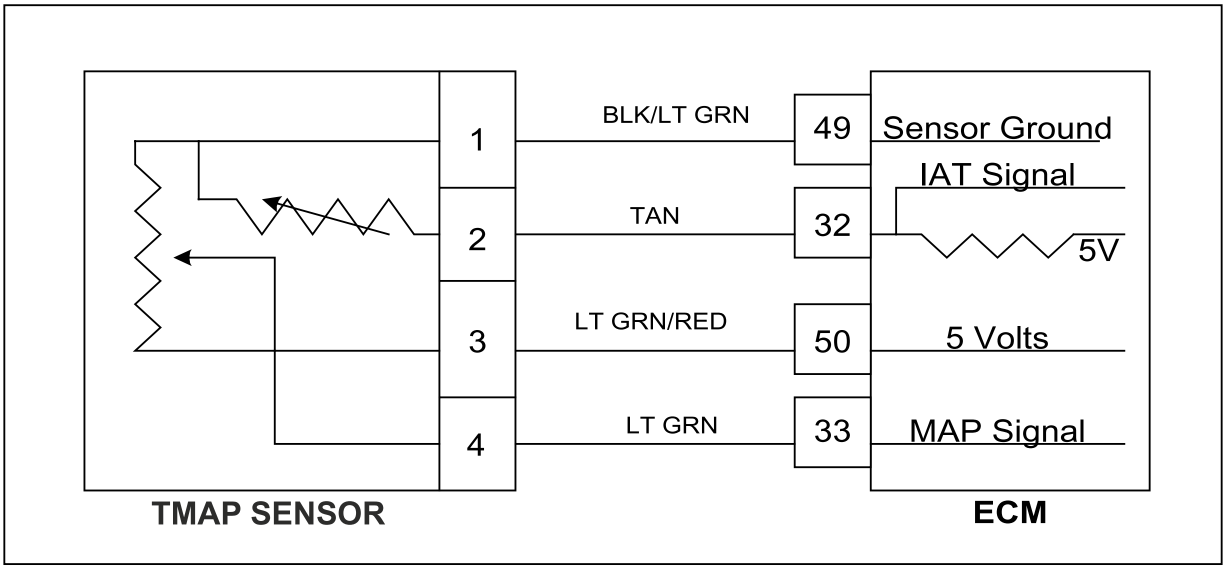
This fault will set if the signal voltage is more than 4.95 volts anytime the engine is running. The ECM will use the default value for the IAT sensor in the event of this fault.

DTC 111- IAT VOLTAGE HIGH MOTOROLA TMAP

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 Does DST display IAT voltage of 4.95 or greater?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key Off* • *Disconnect the TMAP sensor connector from the wiring and harness and jumper pins A and B together* • *Key On* Does the DST display IAT voltage of 0.1 volts or less?		Go to step (9)	*Go to step (4)*
4	• Key OFF • Jumper TMAP sensor connector signal pin B to engine ground • Key ON • Does DST display IAT voltage of 0.1 volts or less?		*Go to Step (7)*	*Go to Step (6)*
5	Replace TMAP sensor. Is the replacement complete?		*Go to Step (11)*	_
6	• Key OFF • Disconnect the ECM wire harness connector. • Check for continuity between TMAP sensor connector signal pin B and ECM IAT signal pin 32. Do you have continuity between them?	__	Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	• Check for continuity between TMAP sensor connector ground circuit pin A and ECM sensor ground circuit pin 49. Do you have continuity between them?	__	Go to step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	*Go to step (11)*	_
9	• Re-check wire harness and TMAP sensor connectors for damage corrosion or contamination Were any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (5)

10	• Re-check wire harness and TMAP sensor connectors for damage corrosion or contamination Were any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (8)
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-111 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 112-IAT Low Voltage (Bosch® TMAP)



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition Engine Cranking or Running
- Fault Condition-IAT Sensor Voltage less than 0.05
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled and allowed to stay at limit if required but will then also set the limiting fault.

Circuit Description

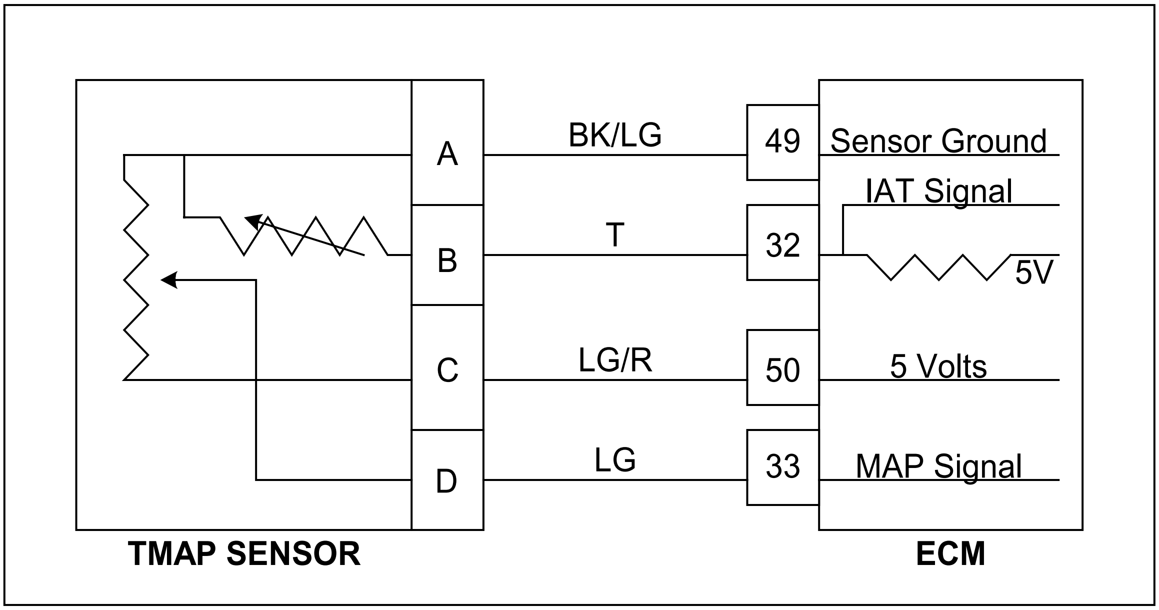
The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the signal voltage is less than 0.05 volts anytime the engine is cranking or running. The ECM will use the default value for the IAT sensor in the event of this fault.

DTC 112- IAT VOLTAGE LOW (BOSCH®) TMAP

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 Does DST display IAT voltage of 0.05 or less?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key Off* • *Disconnect the TMAP sensor wire harness connector* • *Key ON* Does the DST display IAT voltage of 4.9 volts or greater?		Go to step (4)	*Go to step (5)*
4	Replace TMAP sensor. Is the replacement complete?		*Go to Step (9)*	_
5	• Key OFF • Disconnect ECM wire harness connector. • Check for continuity between TMAP sensor connector ground pin 1 and TMAP sensor connector signal pin 2 Do you have continuity between them?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (6)
6	• Check for continuity between TMAP sensor connector signal circuit pin 2 and engine ground. Do you have continuity?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (7)*
7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-112 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 112-IAT Low Voltage Motorola TMAP



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition Engine Cranking or Running
- Fault Condition-IAT Sensor Voltage less than 0.05
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled and allowed to stay at limit if required but will then also set the limiting fault.

Circuit Description

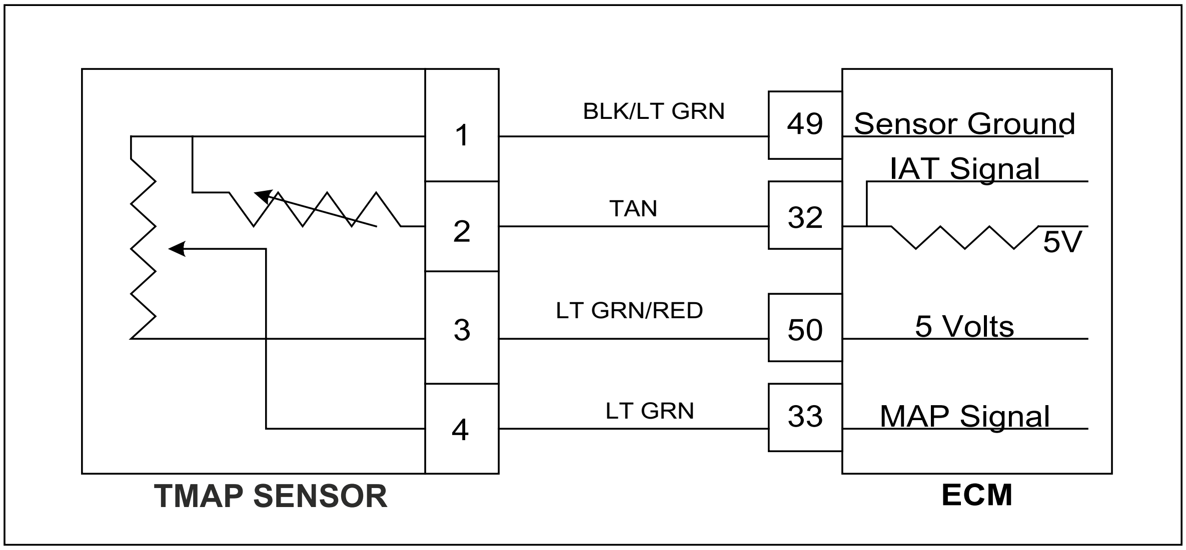
The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm. The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the signal voltage is less than 0.05 volts anytime the engine is cranking or running. The ECM will use the default value for the IAT sensor in the event of this fault.

DTC 112- IAT VOLTAGE LOW MOTOROLA TMAP

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 Does DST display IAT voltage of 0.05 or less?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key Off* • *Disconnect the TMAP sensor wire harness connector* • *Key ON* Does the DST display IAT voltage of 4.9 volts or greater?		Go to step (4)	*Go to step (5)*
4	Replace TMAP sensor. Is the replacement complete?		*Go to Step (9)*	_
5	• Key OFF • Disconnect ECM wire harness connector. • Check for continuity between TMAP sensor connector ground pin A and TMAP sensor connector signal pin B Do you have continuity between them?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (6)
6	• Check for continuity between TMAP sensor connector signal circuit pin B and engine ground. Do you have continuity?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (7)*
7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-112 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 113-IAT Higher Than Expected 1 (Bosch® TMAP)



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 210 degrees F. and engine RPM greater than 1000
- MIL-Will flash at 2 Hz (twice per second) during active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Power Derate (Level 1)

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the Intake Air Temperature is greater than 210 degrees F. and engine RPM is greater than 1000 and Power Derate 1 will be enforced. During this fault, maximum throttle position is 50% and the MIL light will flash twice per second.

Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

DTC 113-IAT Higher Than Expected 1 Bosch® TMAP

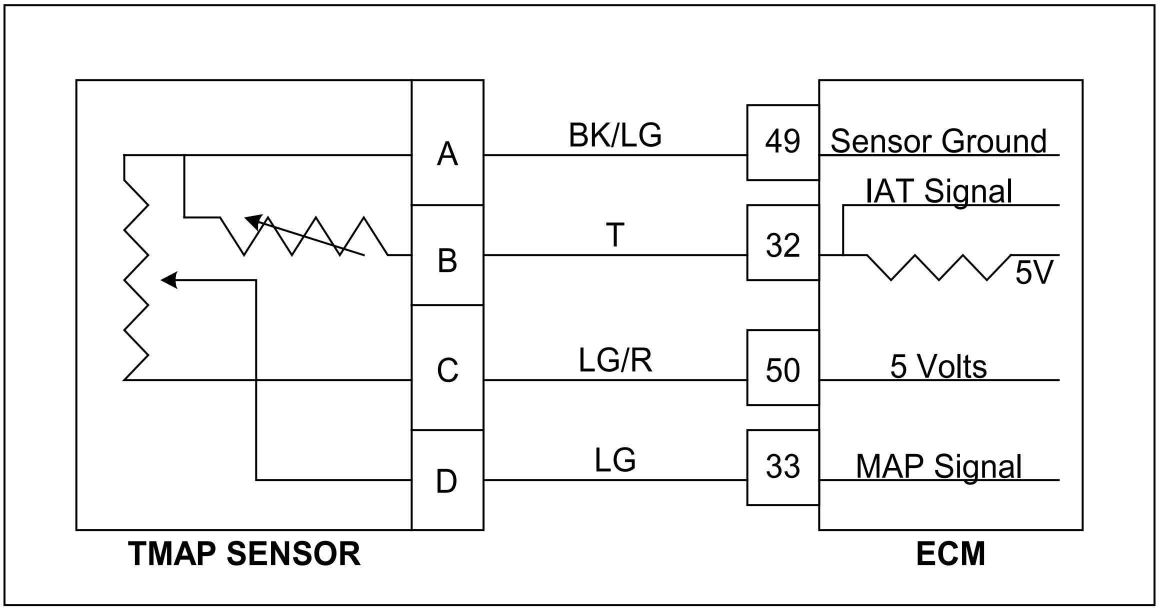
Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

- If none of the above can be found, Follow the diagnostic steps for DTC 112-IAT Low Voltage Bosch® TMAP.

DTC 113-IAT Higher Than Expected 1 Motorola TMAP



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 210 degrees F. and engine RPM greater than 1000
- MIL-Will flash at 2 Hz (twice per second) during active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Power Derate (Level 1)

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the Intake Air Temperature is greater than 210 degrees F. and engine RPM is greater than 1000 and Power Derate 1 will be enforced. During this fault, maximum throttle position is 50% and the MIL light will flash twice per second.

Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

DTC 113-IAT Higher Than Expected 1 Motorola TMAP

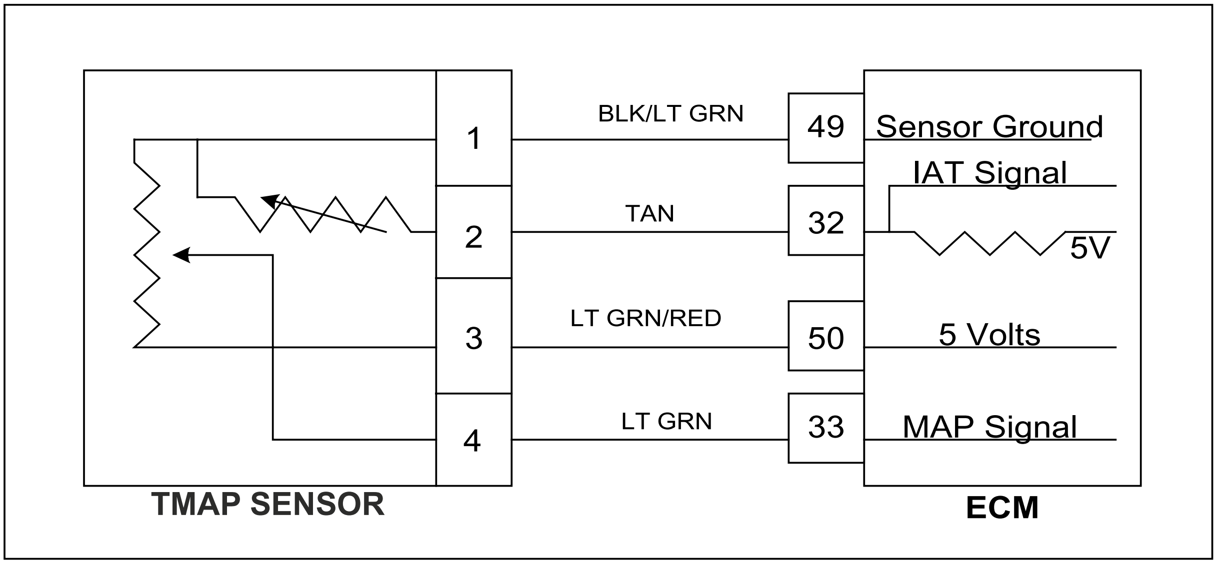
Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

* If none of the above can be found, Follow the diagnostic steps for **DTC 112-IAT Low Voltage.**

DTC 114-IAT Higher Than Expected 2 (Bosch® TMAP)



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 220 degrees F. and engine RPM greater than1000
- MIL-On for active fault and for 15 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Engine Shut Down

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the Intake Air Temperature is greater than 220 degrees F and engine RPM is greater than 1000. The MIL light will be on during this active fault and the engine will shut down.

DTC 114-IAT Higher Than Expected 2 (Bosch® TMAP)

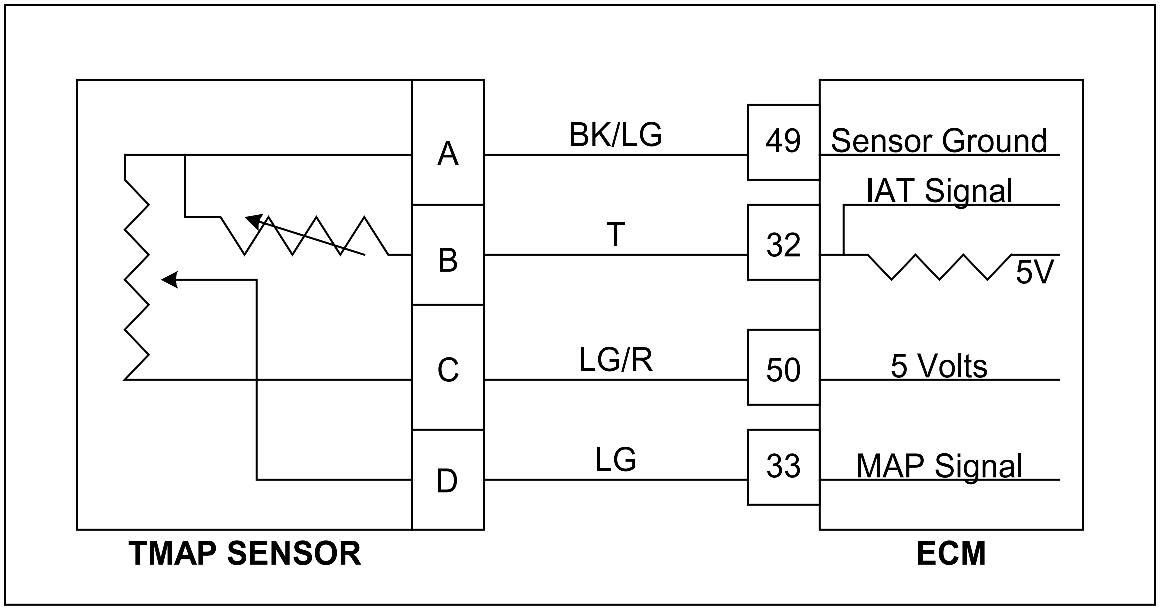
Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

* If none of the above can be found, Follow the diagnostic steps for DTC 112-IAT Low Voltage.

DTC 114-IAT Higher Than Expected 2 Motorola TMAP



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 220 degrees F. and engine RPM greater than1000
- MIL-On for active fault and for 15 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled
- Engine Shut Down

Circuit Description

The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm. The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow.

This fault will set if the Intake Air Temperature is greater than 220 degrees F and engine RPM is greater than 1000. The MIL light will be on during this active fault and the engine will shut down.

DTC 114-IAT Higher Than Expected 2 Motorola TMAP

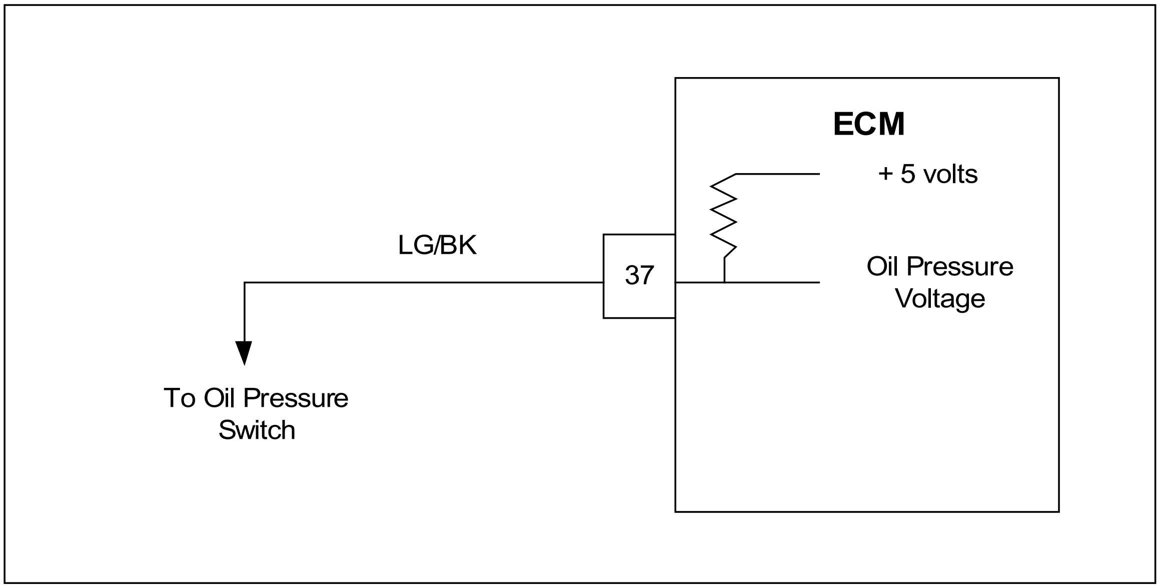
Diagnostic Aids

* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.

* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system

* If none of the above can be found, Follow the diagnostic steps for **DTC 112-IAT Low Voltage.**

DTC 115-Oil Pressure Low



Conditions for Setting the DTC

- Engine Oil Pressure low
- Check Condition-Engine running for 15 seconds and RPM greater than 1300
- Fault Condition- Open circuit/voltage high
- MIL-On during active fault and for 3 seconds after active fault
- Adaptive-Enabled
- Closed Loop-Enabled
- Engine Shut Down

Circuit Description

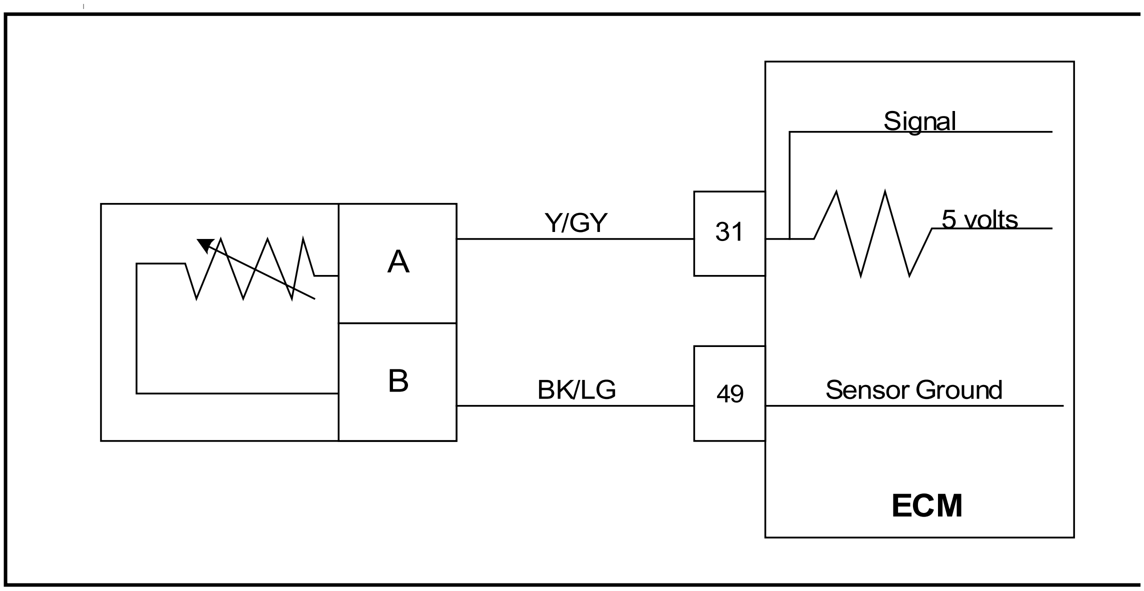
The Oil Pressure Switch is used to communicate a low oil pressure condition to the ECM. Engine damage can occur if the engine is operated with low oil pressure. The ECM uses an analog voltage input with an internal 5 volt reference. If the oil pressure circuit is grounded, the input voltage will be near zero. If it is open, the input will be near 5 volts. The switch is normally open, and the fault will set if the switch remains open with the engine running. The engine will shut down in the event of this fault to help prevent possible engine damage.

DTC 115- 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. See Engine Specifications Section 1F. Does the engine have oil pressure?		*Go to Step (3)*	Repair faulty Oiling System
3	• Key On, Engine Running DST connected in System Data Mode • Clear DTC 115 • 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 1300 RPM Does DTC115 reset and cause the engine to shut down?		*Go to Step (4)*	*Intermittent problem* Go to Intermittent section
4	• Key OFF • Disconnect oil pressure switch harness connector C005 • Jumper the pressure switch LT GRN/BLK wire to engine ground • Clear DTC 115 • Start engine, let idle for at least one minute with ECT over 160 degrees F. • Increase engine speed above 1300 RPM Does DTC 115 reset?		*Go to Step (6)*	*Go to Step (5)*
5	• Replace oil pressure switch Is the replacement complete?		*Go to Step (9)*	-
6	• Key OFF • Disconnect ECM harness connector C001 • Using a DVOM check for continuity between oil pressure switch connector LT GRN/BLK wire and ECM connector pin 37 • Do you have continuity between them?		Go to Step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	• Inspect ECM connector pin 37 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)*
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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-115 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 121-ECT / High Voltage



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-ECT sensor voltage exceeds 4.95
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant. 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 4.95 volts anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

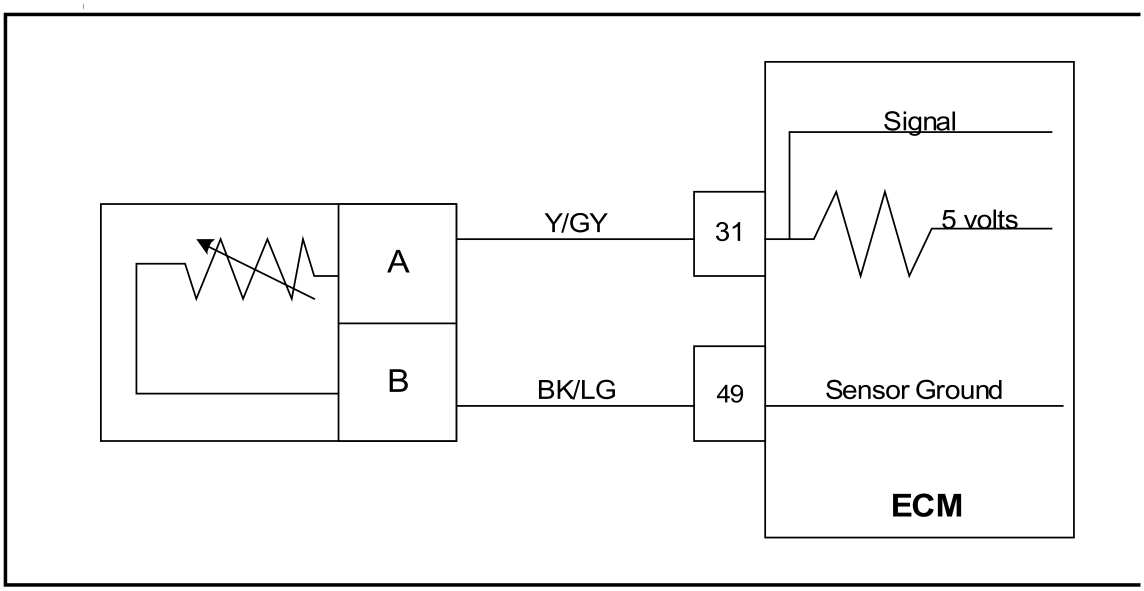
ECT Data:	
Temp (deg F)	Ohms
242.4	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-5.7	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

DTC 121- 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	• Key On • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display ECT voltage of 4.95 or greater?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key Off* • Disconnect the ECT sensor from the wiring harness and Jumper connector terminals A and B together • *Key On* Does the DST display ECT voltage of 0.05 volts or less?		Go to step (4)	*Go to Step (8)*
4	• Using a DVOM check the resistance between the two terminals of the ECT sensor and compare the resistance reading to the chart Is the resistance value correct?	See resistance chart vs. temperature in the DTC 121 circuit description	*Go to Step (6)*	*Go to step (5)*
5	• Replace ECT sensor Is the replacement complete?		*Go to Step (14)*	-
6	• Inspect the ECT wire harness 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	• Key OFF • Disconnect ECM wire harness connector • Inspect ECM connector pins 31 and 49 for damage corrosion or contamination • Did you find a problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Intermittent problem* Go to Intermittent section
8	• Jumper the ECT signal pin A at the ECT connector to engine ground Does DST display ECT voltage of 0.05 or less?		*Go to Step (9)*	*Go to Step (12)*

9	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between ECT sensor ground pin B and ECM connector pin 49 Do you have continuity between them?		*Go to Step (10)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Inspect ECM connector pins 31 and 49 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 (11)
11	• Replace ECM Is the replacement complete?		Go to Step (14)	-
12	• Key OFF • Disconnect ECM wire harness connector • Using A DVOM check for continuity between ECT connector signal pin A and ECM connector terminal 31 Do you have continuity between them?		Go to Step (13)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
13	• Inspect ECM connector pins 31 and 49 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 (11)
14	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-121 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 122-ECT Low Voltage



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition- ECT sensor voltage less than 0.05
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

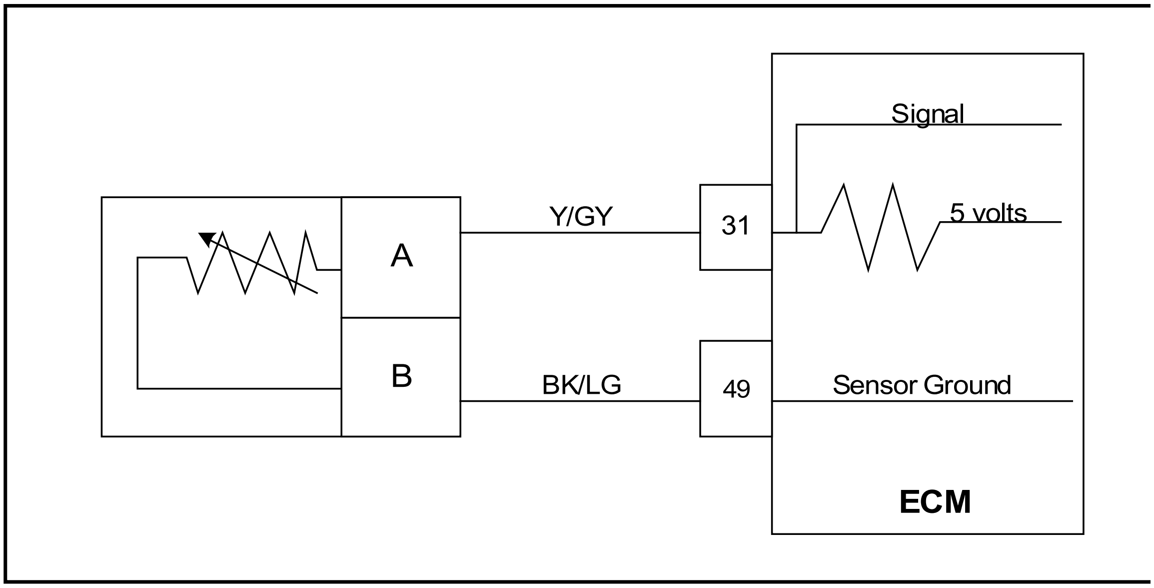
The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm

This fault will set if the signal voltage is less than 0.05 volts anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

DTC 122- ECT VOLTAGE 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 (Diagnostic Scan Tool) connected in • System Data Mode Does DST display *ECT* voltage of 0.05 or less?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key Off* • *Disconnect the ECT wire harness connector* • *Key ON* Does the DST display *ECT* voltage of 4.9 volts or greater?		Go to step (4)	*Go to step (5)*
4	Replace *ECT* sensor. Is the replacement complete?		*Go to Step (8)*	_
5	• Key OFF • Disconnect ECM wire harness connector • Check for continuity between *ECT* sensor connector signal pin A and *ECT sensor ground* pin B Do you have continuity between them?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (6)
6	• Check for continuity between *ECT* sensor connector signal circuit pin A and engine ground. Do you have continuity?	__	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (7)*
7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. 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 operate the vehicle to full operating temperature • • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-122 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 123-ECT Higher Than Expected 1



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-Engine Coolant Temperature reading or estimate greater than 240 deg. F and engine RPM greater than 650
- MIL-Will flash at 2 Hz (twice per second) during active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled and allowed to stay at limit (will still set limit fault)
- Power Derate (level1)

Circuit Description

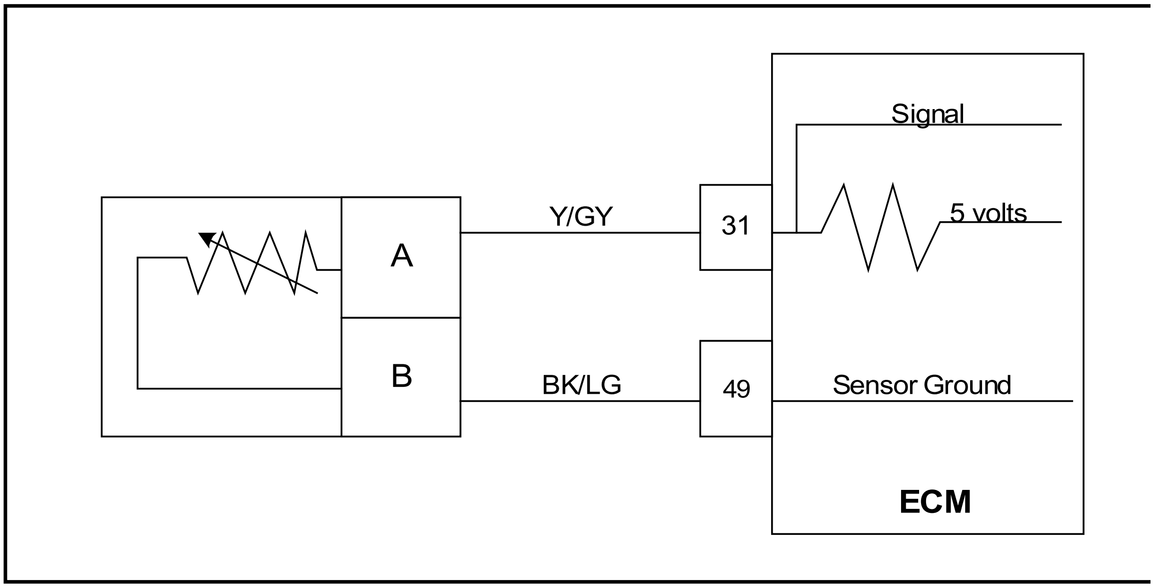
The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. The ECT (Engine Coolant Temperature) sensor that is located in the coolant near the thermostat. The ECT is used for engine airflow calculation, fuel enrichment, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

This fault will help protect the engine in the event of over temperature. When the coolant exceeds 240 degrees F. and engine RPM exceeds 650 this fault will set and Power Derate 1 will be enforced. During this fault, maximum throttle position is 50% and the MIL light will flash twice per second.

DTC 123- ECT HIGHER THAN EXPECTED 1

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 • Warm Engine to normal operating temperature, then run the engine above 650 rpm for 60 seconds Does DST display ECT temperature of 230 degrees F. or greater with the engine running over 650 rpm?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Verify with a temperature gauge that the engine coolant is over 225 degrees F. Does the temperature gauge indicate 225 degrees F. or greater?		*Repair Cooling system.*	*Go to step (4)*
4	Verify ECT circuit function. Follow diagnostic test procedure for DTC-122 ECT Low Voltage		-	-

DTC 124-ECT Higher Than Expected 2



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-Engine Coolant temperature reading or estimate greater than 250 deg. F and engine RPM greater than 650
- MIL-On for active fault and for 15 seconds after active fault
- Adaptive-Enabled
- Closed Loop-Enabled and allowed to stay at limit (will still set limit fault)
- Engine Shut Down

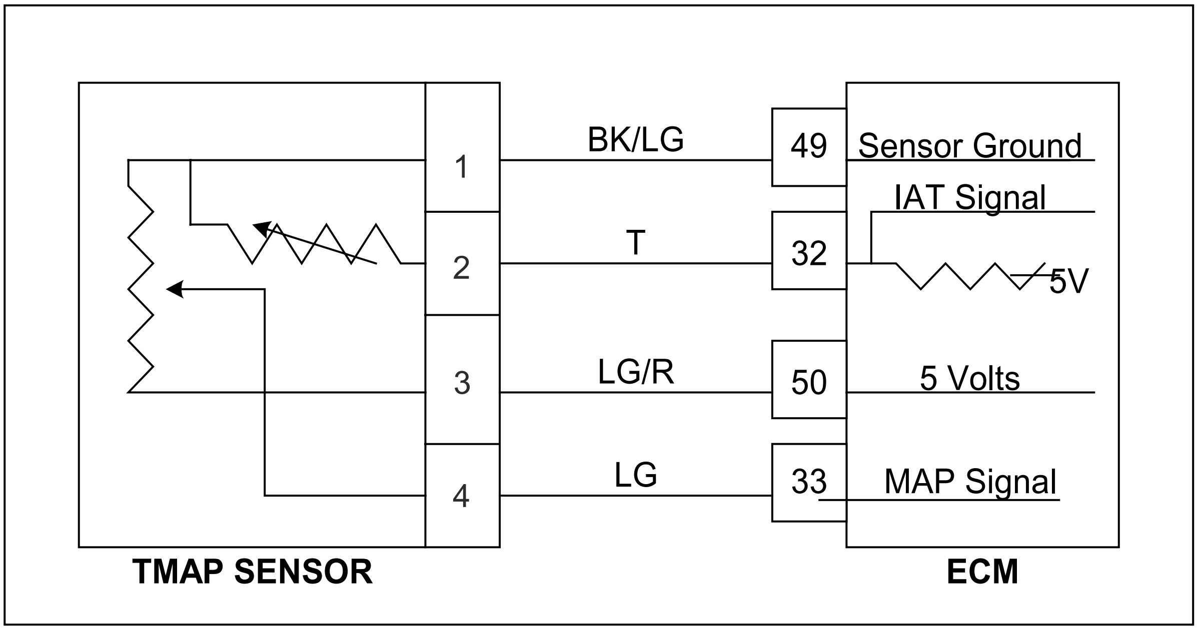
Circuit Description

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. The ECT (Engine Coolant Temperature) sensor that is located in the coolant near the thermostat. The ECT is used for engine airflow calculation, ignition timing control, fule enrichment, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit so when the sensor reading is cool, the signal reads higher voltage, and lower when warm. This fault will set if coolant temperature reaches 250 degrees F. and engine RPM exceeds 650 rpm the engine will shut down.

DTC 124 ECT Higher than expected 2

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 • Warm Engine to normal operating temperature, then run the engine above 1000 rpm for 60 seconds • Does DST display ECT temperature of 235 degrees F. or greater with the engine running over 650 rpm?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Verify with a temperature gauge that the engine coolant is over 225 degrees F. Does the temperature gauge indicate 230 degrees F. or greater?		*Repair Cooling system.*	*Go to step (4)*
4	Verify ECT circuit function. Follow diagnostic test procedure for DTC-122 ECT Low Voltage		-	-

DTC 131-MAP High Pressure Bosch® TMAP



Conditions for Setting the DTC

- Manifold Absolute Pressure
- Check Condition-RPM greater than 800, Throttle Command less than 10%, steady MAP and TPS
- Fault Condition-MAP greater than 18 psia, TPS less than 10% and engine RPM greater than 1800.
- MIL-On for remainder of key on cycle
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled and allowed to stay at limit
- Misc.-Fueling is based on RPM and TPS Limp-Home Condition during this fault.

Circuit Description

The TMAP is a combined inlet manifold temperature and pressure sensor connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the airflow rate to the engine, which also determines the fuel flow rate. This fault will set when the MAP reading is higher than it should be for the given TPS, and RPM. When the fault is set, the Adaptive Learn will be disabled for the remainder of the key on cycle and the MIL will be on. The engine will operate on a default MAP during this active fault.

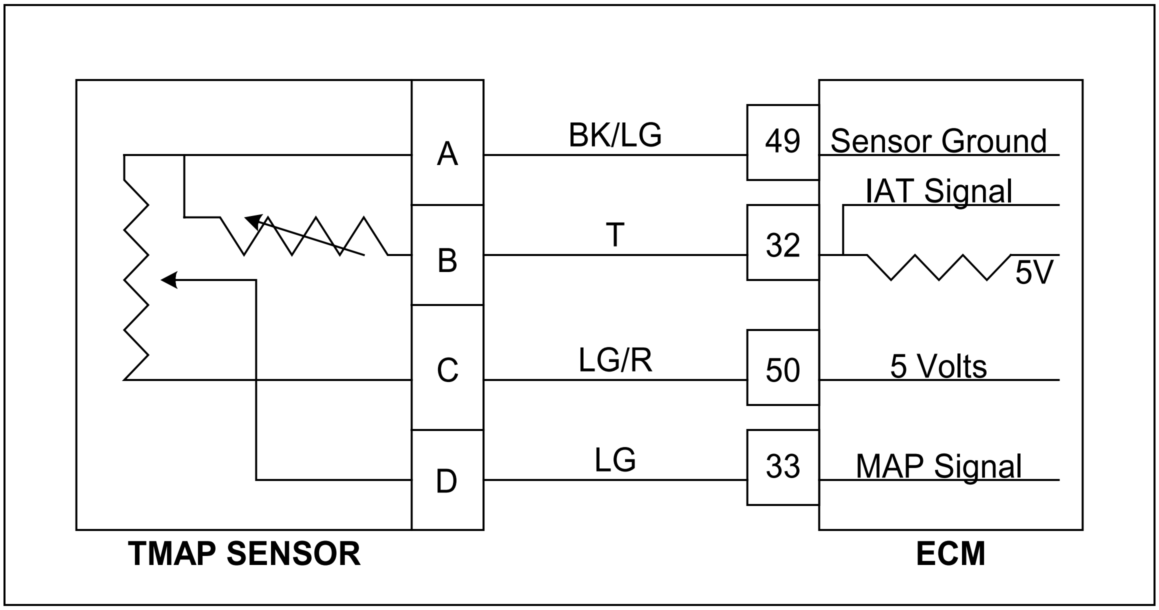
Diagnostic Aids
If the engine is running rough, unstable or missing due to a suspected mechanical problem, vacuum leak or other issue causing misfire these problems must be taken care before using the MAP diagnostic chart. Failure to follow this recommendation will result in a false MAP diagnostic and repair procedure.

DTC 131- MAP HIGH PRESSURE (Bosch TMAP®)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine running. • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAP pressure of 13.0 psia or greater with the engine idling?		*Go to step (3)*	**Intermittent problem** Go to Intermittent section
3	• *Key OFF* • *Disconnect the TMAP sensor connector* • Key ON Does the DST display MAP pressure less than 0.05 psia?		Go to step (4)	*Go to step (6)*
4	• Probe TMAP sensor connector ground circuit pin 1 with a test light connected to battery voltage. Does the test light come on?		*Go to step (5)*	*Go to step (8)*
5	• Check TMAP mechanical connection for correct mounting or possible damage causing leakage. Is the TMAP sensor mechanical connection OK?		*Go to step (6)*	*Go to Step (10)*
6	• Key OFF • Disconnect ECM connector and inspect terminals for damage corrosion or contamination. Is the connection OK?		*Go to step (7)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	Replace TMAP sensor. Is the repair complete?	__	Go to step (11)	-
8	• Disconnect ECM connector and check for continuity between TMAP connector sensor ground pin 1 and ECM sensor ground PIN 49. Do you have continuity between them?		*Go to step (9)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to step (11)*	-
10	• Correct TMAP mechanical connection Has TMAP mechanical connection been corrected?		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 vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-131 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 131-MAP High Pressure Motorola TMAP



Conditions for Setting the DTC

- Manifold Absolute Pressure
- Check Condition-RPM greater than 800, Throttle Command less than 10%, steady MAP and TPS
- Fault Condition-MAP greater than 18 psia, TPS less than 10% and engine RPM greater than 1800.
- MIL-On for remainder of key on cycle
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled and allowed to stay at limit
- Misc.-Fueling is based on RPM and TPS Limp-Home Condition during this fault.

Circuit Description

The TMAP is a combined inlet manifold temperature and pressure sensor connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the airflow rate to the engine, which also determines the fuel flow rate. This fault will set when the MAP reading is higher than it should be for the given TPS, and RPM. When the fault is set, the Adaptive Learn will be disabled for the remainder of the key on cycle and the MIL will be on. The engine will operate on a default MAP during this active fault.

Diagnostic Aids

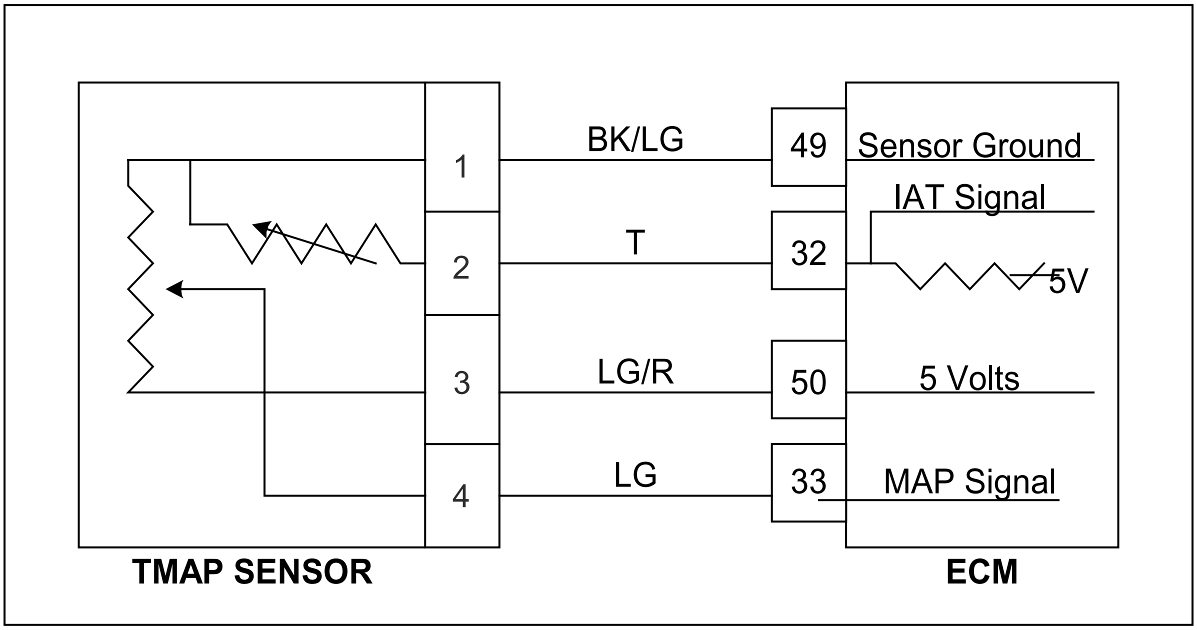
If the engine is running rough, unstable or missing due to a suspected mechanical problem, vacuum leak or other issue causing misfire these problems must be taken care before using the MAP diagnostic chart. Failure to follow this recommendation will result in a false MAP diagnostic and repair procedure.

DTC 131- MAP HIGH PRESSURE Motorola TMAP

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine running. • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAP pressure of 13.0 psia or greater with the engine idling?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key OFF* • *Disconnect the TMAP sensor connector* • Key ON Does the DST display MAP pressure less than 0.05 psia?		Go to step (4)	*Go to step (6)*
4	• Probe TMAP sensor ground circuit pin A with a test light connected to battery voltage. Does the test light come on?		*Go to step (5)*	*Go to step (8)*
5	• Check TMAP mechanical connection for correct mounting or possible damage causing leakage. Is the TMAP sensor mechanical connection Ok?		*Go to step (6)*	*Go to Step (10)*
6	• Key OFF • Disconnect ECM connector and inspect terminals for damage corrosion or contamination. Is the connection Ok?		*Go to step (7)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	Replace TMAP sensor. Is the repair complete?	__	Go to step (11)	-
8	• Disconnect ECM connector and check for continuity between TMAP connector sensor ground pin A and ECM sensor ground PIN 49. Do you have continuity between them?		*Go to step (9)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to step (11)*	-
10	• Correct TMAP mechanical connection Has TMAP mechanical connection been corrected?		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 vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-131 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 132-MAP Low Voltage (Bosch TMAP®)



Conditions for Setting the DTC

- Manifold Absolute Pressure
- Check Condition-Cranking or Running
- Fault Condition-MAP voltage less than 0.05,Throttle Position greater than 2% and engine RPM less than 7000.
- MIL-On for remainder of key on cycle
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled
- Misc.-Fueling is based on RPM and TPS Limp-Home Condition during this fault.

Circuit Description

The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the airflow rate to the engine, which determines the fuel flow rate. This fault will set when the MAP reading is lower than the sensor should normally produce. When this fault is set the Adaptive Learn will be disabled for the remainder of the key on cycle and the MIL will be on.

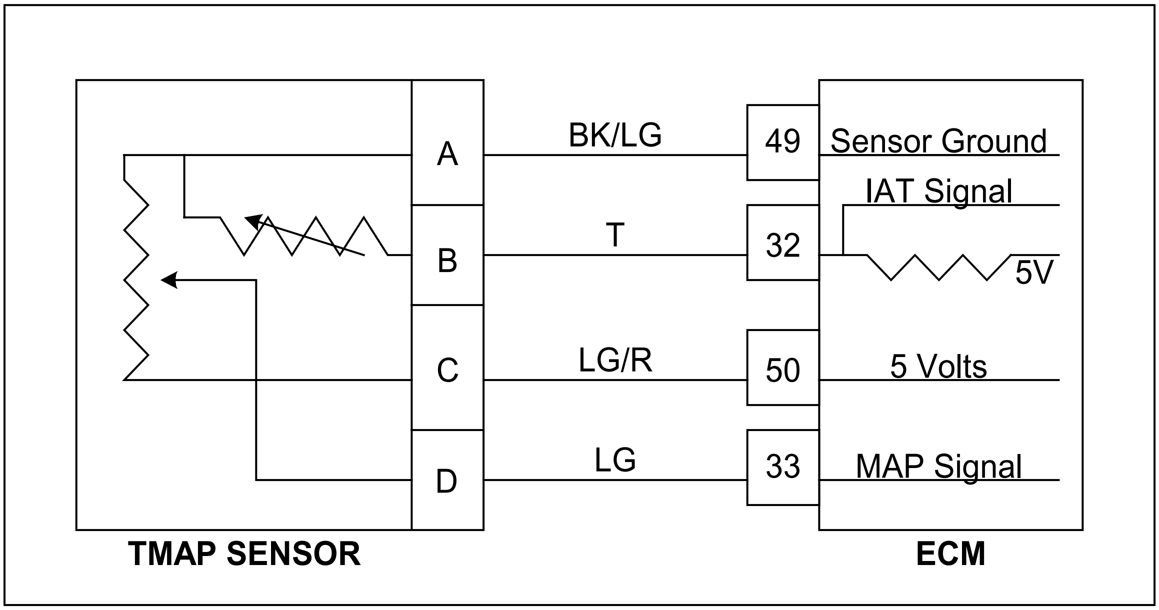
DTC 132- MAP Low Voltage (Bosch® TMAP)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine running. • DSC (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAP voltage of 0.05 or less with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key OFF* • *Disconnect the TMAP sensor from the wiring harness* • *Jumper the 5 volt reference pin 3 and MAP signal circuit pin 4 together* • Key ON Does the DST display MAP voltage of 4.5 volts or greater?		Go to Step (4)	*Go to step (8)*
4	• Inspect TMAP connector and pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (5)*
5	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector signal pin 4 and ECM MAP signal pin 33. Do you have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Check for continuity between TMAP sensor connector 5 volt supply signal pin 3 and ECM 5 volt supply pin 50 Do you have continuity between them?		*Go to step (7)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	• Check for continuity between TMAP sensor connector ground pin 1 and ECM sensor ground pin 49 Do you have continuity between them?		Go to step (17)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

8	• Probe MAP connector signal circuit pin 4 with a test light connected to battery voltage Does the DST display MAP voltage of 4.0 or greater?		*Go to Step (9)*	*Go to step (13)*
9	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector pin 3 and ECM 5 volt reference pin 50. Do you have continuity between them?		*Go to step (10)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Check for continuity between TMAP sensor connector 5 volt reference pin 3 and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (11)*
11	• Inspect ECM and TMAP wire harness connector and terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (16)*
12	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to step (17)*	-
13	• Disconnect ECM connector • Check for continuity between TMAP sensor connector signal circuit pin 4 and ECM signal PIN 33 Do you have continuity between them?		*Go to Step (14)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
14	• Check for continuity between TMAP sensor connector signal pin 4 and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (15)*
15	• Inspect ECM connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (16)*
16	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to Step (18)*	-
17	Replace TMAP sensor Is the replacement complete?		*Go to step (17)*	-

18	• Remove all test equipment except the DSC. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-132 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 132-MAP Low Voltage Motorola TMAP



Conditions for Setting the DTC

- Manifold Absolute Pressure
- Check Condition-Cranking or Running
- Fault Condition-MAP voltage less than 0.05,Throttle Position greater than 2% and engine RPM less than 7000.
- MIL-On for remainder of key on cycle
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled
- Misc.-Fueling is based on RPM and TPS Limp-Home Condition during this fault.

Circuit Description

The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the airflow rate to the engine, which determines the fuel flow rate. This fault will set when the MAP reading is lower than the sensor should normally produce. When this fault is set the Adaptive Learn will be disabled for the remainder of the key on cycle and the MIL will be on.

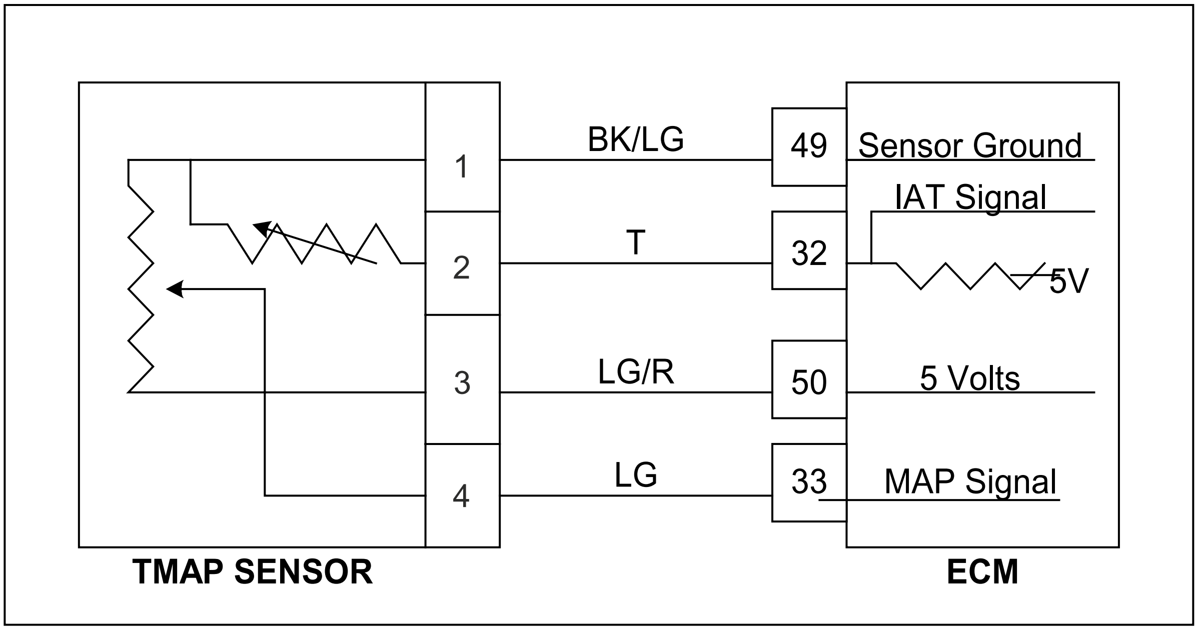
DTC 132- MAP Low Voltage Motorola TMAP

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine running. • DSC (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAP voltage of 0.05 or less with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key OFF* • *Disconnect the TMAP sensor from the wiring harness* • *Jumper the 5 volt reference pin C and MAP signal circuit pin D together* • Key ON Does the DST display MAP voltage of 4.5 volts or greater?		Go to Step (4)	*Go to step (8)*
4	• Inspect TMAP connector pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (5)*
5	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector signal pin D and ECM MAP signal pin 33. Do you have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Check for continuity between TMAP sensor connector 5 volt supply signal pin C and ECM 5 volt supply pin 50 Do you have continuity between them?		*Go to step (7)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	• Check for continuity between TMAP sensor connector ground pin A and ECM sensor ground pin 49 Do you have continuity between them?		Go to step (17)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

8	• Probe MAP signal circuit with a test light connected to battery voltage Does the DST display MAP voltage of 4.0 or greater?		*Go to Step (9)*	*Go to step (13)*
9	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector and ECM 5 volt reference signal. Do you have continuity between them?		*Go to step (10)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Check for continuity between TMAP sensor connector 5 volt reference pin C signal and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (11)*
11	• Inspect ECM connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (16)*
12	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to step (17)*	-
13	• Disconnect ECM connector • Check for continuity between TMAP sensor connector signal circuit pin D and ECM signal PIN 33 Do you have continuity between them?		*Go to Step (14)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
14	• Check for continuity between TMAP sensor connector signal pin D and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (15)*
15	• Inspect ECM connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (16)*
16	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to Step (18)*	-
17	Replace TMAP sensor Is the replacement complete?		*Go to step (17)*	-

18	• Remove all test equipment except the DSC. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-132 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 134-BP High Pressure (Bosch® TMAP)



Conditions for Setting the DTC

- Barometric Pressure
- Check Condition-Key On
- Fault Condition-BP greater than 16 psia
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

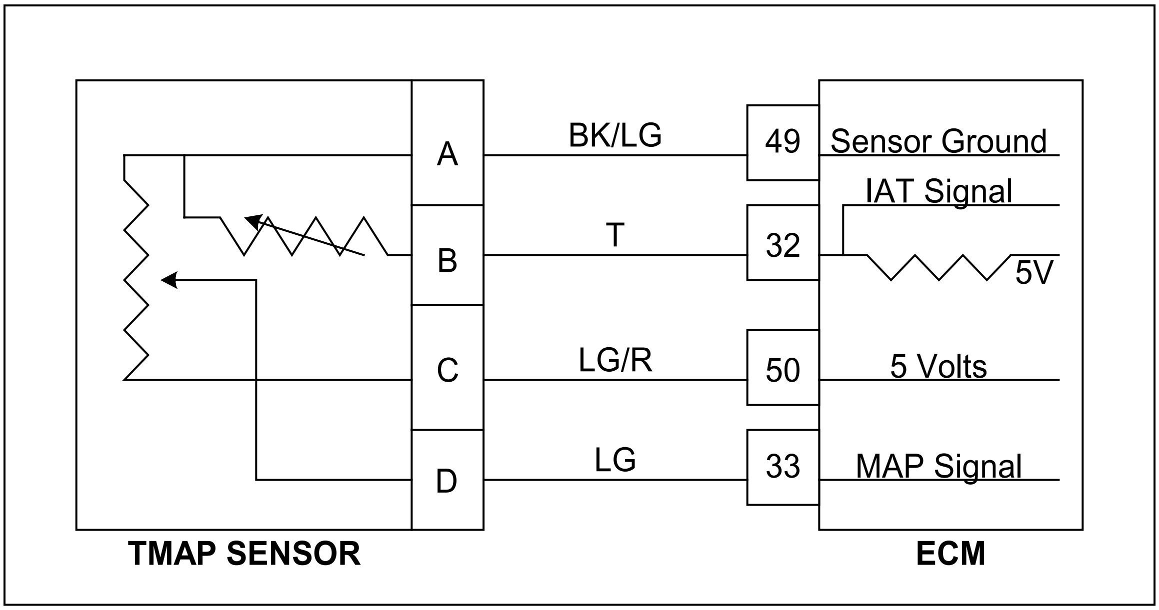
Circuit Description

The BP (Barometric Pressure) is estimated from the TMAP sensor. The barometric pressure value is used for fuel and airflow calculations. This fault sets in the event the BP value is out of the normal range.

DTC 134- BP High Pressure

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 Does DST display MAP pressure of 16 psia or greater?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	Replace TMAP sensor. Is the repair complete?			-
	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-134 check for any stored codes. Does the engine operate normally with no stored codes?		*System Ok*	*Go to OBD System Check*

DTC 134-BP High Pressure Motorola TMAP



Conditions for Setting the DTC

- Barometric Pressure
- Check Condition-Key On
- Fault Condition-BP greater than 16 psia
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

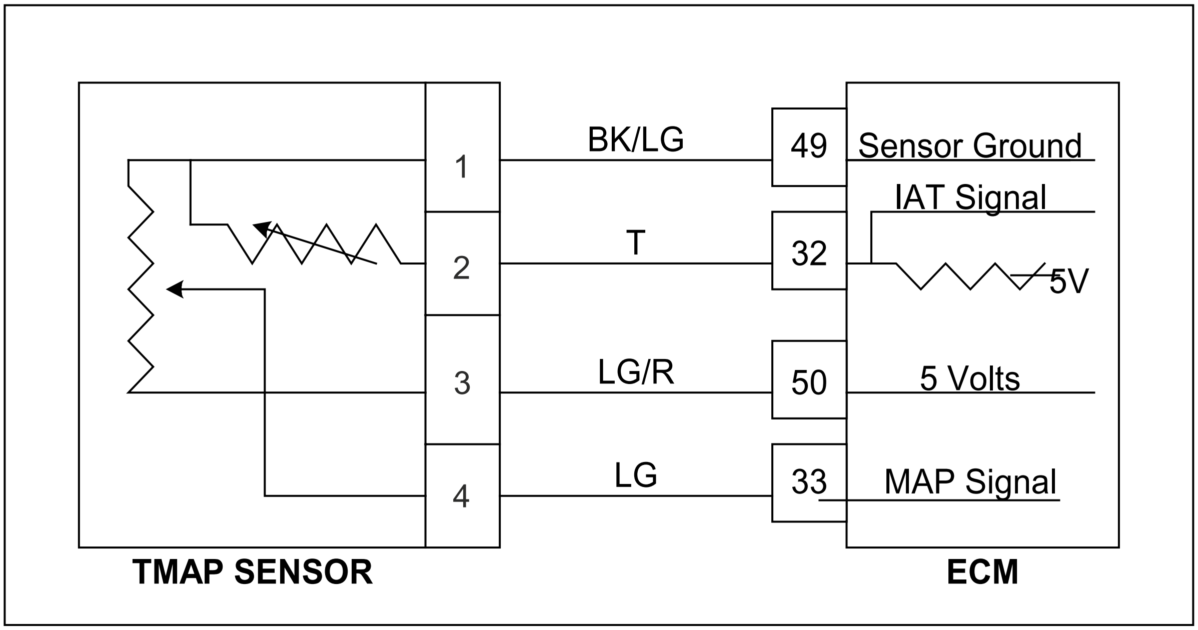
Circuit Description

The BP (Barometric Pressure) is estimated from the TMAP sensor. The barometric pressure value is used for fuel and airflow calculations. This fault sets in the event the BP value is out of the normal range.

DTC 134- BP High Pressure Motorola TMAP

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 Does DST display MAP pressure of 16 psia or greater?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	Replace TMAP sensor. Is the repair complete?			-
	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-134 check for any stored codes. Does the engine operate normally with no stored codes?		*System Ok*	*Go to OBD System Check*

DTC 135-BP Low Pressure (Bosch® TMAP)



Conditions for Setting the DTC

- Barometric Pressure
- Check Condition-Key On
- Fault Condition-BP less than 8.3 psia
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

Circuit Description

The BP (Barometric Pressure) is estimated from the TMAP sensor. The barometric pressure value is used for fuel and airflow calculations. This fault sets in the event the BP value is out of the normal range.

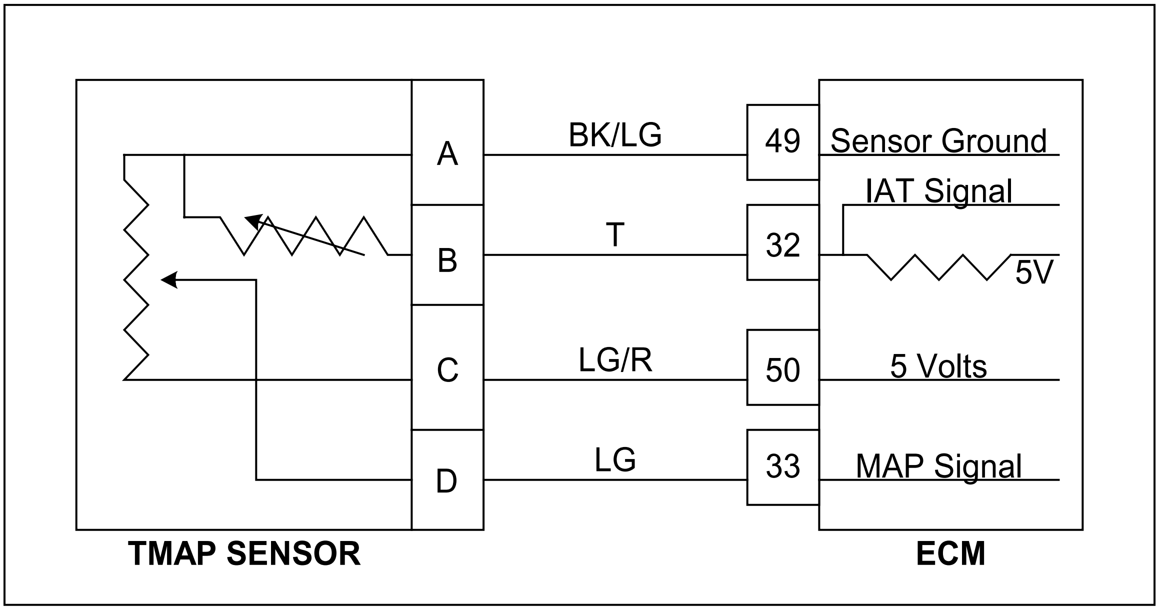
DTC 135- BP Low Pressure (Bosch® TMAP)

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 Does DST display BP pressure of 8.3 psia or less?		*Go to Step (3)*	**Intermittent problem** Go to Intermittent section
3	• *Key OFF* • *Disconnect the TMAP sensor from the wiring harness* • *Jumper the 5 volt reference pin 3 and MAP signal pin 4 together* • Key ON Does the DST display BP pressure of 16.00 psia or greater?		Go to Step (4)	*Go to step (8)*
4	• Inspect TMAP connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (5)*
5	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector pin 4 and ECM connector pin 33 Do you have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Check for continuity between TMAP sensor connector 5 volt supply pin 3 and ECM connector pin 50 Do you have continuity between them?		*Go to step (7)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	• Check for continuity between TMAP sensor connector ground pin 1 and ECM connector pin 49 Do you have continuity between them?		Go to step (17)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Remove Jumper that was installed during step 3 • Probe TMAP connector signal circuit pin 4 with a test light connected to battery voltage Does the DST display BP pressure of 16.00 psia or greater?		*Go to Step (9)*	*Go to step (13)*

9	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector pin 3 and ECM connector pin 50 Do you have continuity between them?		*Go to step (10)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Check for continuity between TMAP sensor connector 5 volt reference pin 3 and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (11)*
11	• Inspect TMAP and ECM connector pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (16)*
12	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to step(17)*	-
13	• Disconnect ECM connector C001 • Check for continuity between TMAP sensor connector pin 4 and ECM pin 33 Do you have continuity between them?		*Go to Step (14)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
14	• Check for continuity between TMAP sensor connector pin 4 and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (15)*
15	• Inspect ECM connector and wire harness connector pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (16)*
16	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to Step (18)*	-
17	Replace TMAP sensor Is the replacement complete?		*Go to step (17)*	-

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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-135 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 135-BP Low Pressure Motorola TMAP



Conditions for Setting the DTC

- Barometric Pressure
- Check Condition-Key On
- Fault Condition-BP less than 8.3 psia
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

Circuit Description

The BP (Barometric Pressure) is estimated from the TMAP sensor. The barometric pressure value is used for fuel and airflow calculations. This fault sets in the event the BP value is out of the normal range.

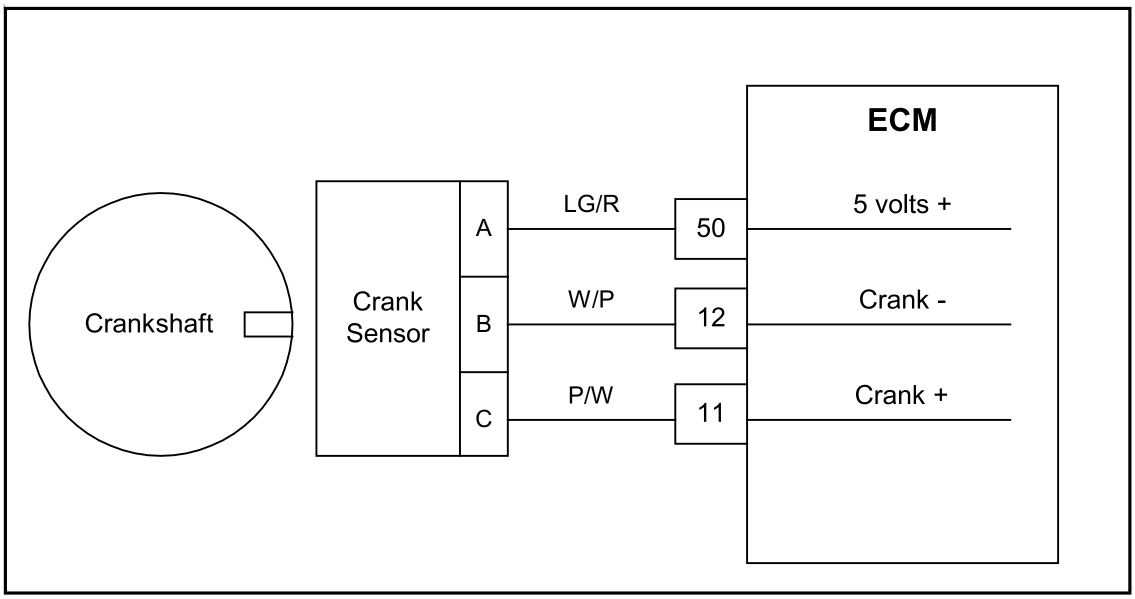
DTC 135- BP Low Pressure Motorola TMAP

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 Does DST display BP pressure of 8.3 psia or less?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• *Key OFF* • *Disconnect the TMAP sensor from the wiring harness* • *Jumper the 5 volt reference pin C and MAP signal pin D together* • Key ON Does the DST display BP pressure of 16.00 psia or greater?		Go to Step (4)	*Go to step (8)*
4	• Inspect TMAP connector and wire harness connector terminals for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (5)*
5	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector pin D and ECM connector pin 33 Do you have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Check for continuity between TMAP sensor connector 5 volt supply pin C and ECM connector pin 50 Do you have continuity between them?		*Go to step (7)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	• Check for continuity between TMAP sensor connector ground pin A and ECM connector pin 49 Do you have continuity between them?		Go to step (17)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

8	• Remove Jumper that was installed during step 3 • Probe TMAP connector signal circuit D with a test light connected to battery voltage Does the DST display BP pressure of 16.00 psia or greater?		*Go to Step (9)*	*Go to step (13)*
9	• Key OFF • Disconnect ECM connector • Check for continuity between TMAP sensor connector pin C and ECM connector pin 50 Do you have continuity between them?		*Go to step (10)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Check for continuity between TMAP sensor connector 5 volt reference signal pin C and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (11)*
11	• Inspect TMAP AND ECM connectors pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (16)*
12	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to step(17)*	-
13	• Disconnect ECM connector • Check for continuity between TMAP sensor connector pin D and ECM pin 33 Do you have continuity between them?		*Go to Step (14)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
14	• Check for continuity between TMAP sensor connector pin D and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to step (15)*
15	• Inspect ECM connector and wire harness connector pins for corrosion, contamination or mechanical damage Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (16)*
16	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		*Go to Step (18)*	-
17	Replace TMAP sensor Is the replacement complete?		*Go to step (17)*	-

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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-135 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 142-Crank Sync Noise



Conditions for setting the DTC

- Crankshaft Position sensor
- Check Condition- Engine running
- Fault Condition- 1 invalid crank re-sync
- MIL- On during active fault and for 10 seconds after active fault
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled

Circuit Description

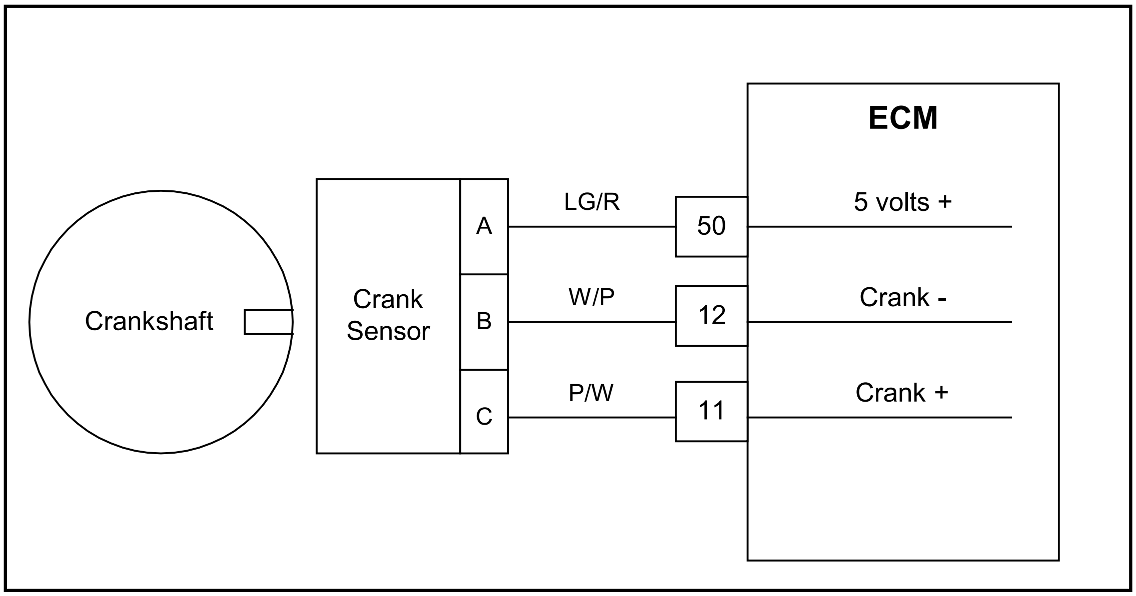
The Crankshaft Position sensor is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize the ignition and fuel systems. The ECM must see a valid Crankshaft position signal while running. If no signal is present for 800ms or longer, this fault will set.

DTC 142 Crank Sync Noise

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 ECM ground terminals G1 and G2 are clean and tight Are the ground terminals G1 and G2 clean and tight?		*Go to Step (3)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key On, Engine OFF • Disconnect the CKP (Crankshaft position) Sensor connector C009 • Using A DVOM check for voltage at the CKP sensor connector pin A and engine ground Do you have voltage?	5.0 volts	*Go to Step (4*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CKP connector pin B and ECM connector pin 12 • Do you have continuity between them?		*Go to Step (5)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between CKP connector pin C and ECM connector pin 11 Do you have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Inspect the CKP connector C009 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	• Inspect the ECM connector C001 terminals 11,12 and 50 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)*
8	• Replace CKP sensor using R&R procedure in Section 1E. Pay special attention to CKP sensor reluctor wheel inspection. Is the replacement complete?		*Go to Step (10)*	-
9	• Replace 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-142 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-142 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 143-Never Crank Synced At Start



Conditions for Setting the DTC

- CKP (Crankshaft Position Sensor)
- Check Condition- Engine cranking or running
- Adaptive- Enabled
- Fault Condition- 4 cranking revs without sync and engine RPM greater than 90
- MIL- On during active fault
- Closed Loop- Enabled

Circuit description

The CKP (Crankshaft Position Sensor) is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft position sensor is used to measure engine RPM and its signal is used to synchronize the ignition system.

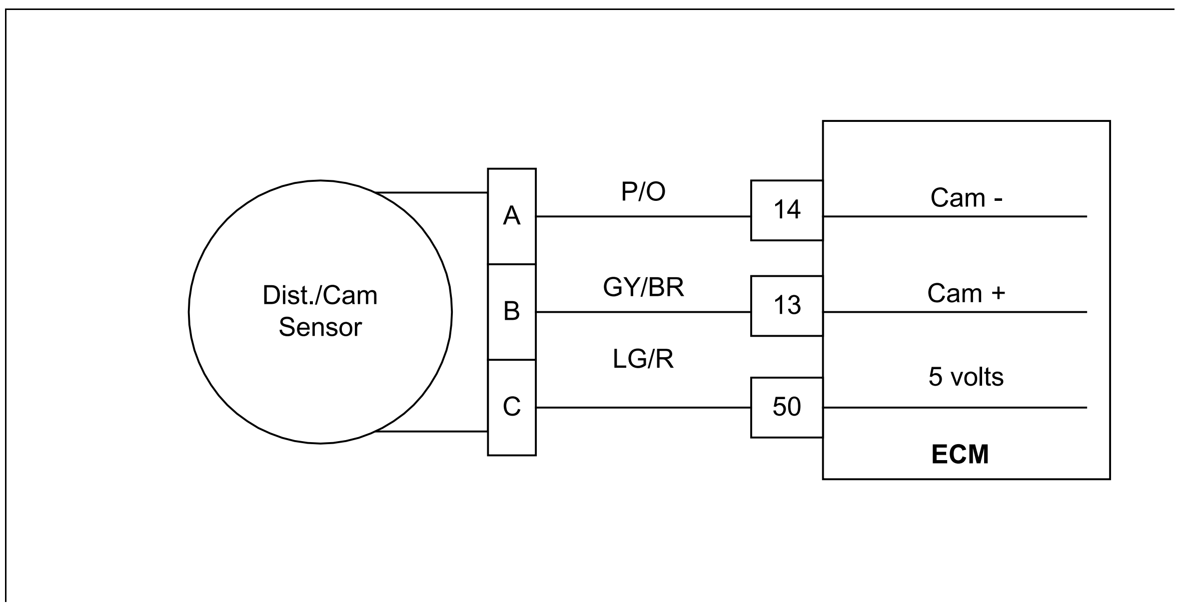
The ECM must see a valid Crankshaft Position signal while cranking before it starts. If no signal is present within 4 cranking revs, this fault will set.

DTC 143 Never Crank Sync At Start

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 ECM ground terminals G1 and G2 are clean and tight Are the ground terminals G1 and G2 clean and tight?		*Go to Step (3)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key On, Engine OFF • Disconnect the CKP (Crankshaft position) Sensor connector C009 • Using A DVOM check for voltage at the CKP sensor connector pin A and engine ground Do you have voltage?	5.0 volts	*Go to Step (4*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CKP connector pin B and ECM connector pin 12 • Do you have continuity between them?		*Go to Step (5)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between CKP connector pin C and ECM connector pin 11 Do you have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Inspect the CKP connector C009 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	• Inspect the ECM connector C001 terminals 11,12 and 50 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)*
8	• Replace CKP sensor using CKP R&R procedure in Section 1E. Pay special attention to CKP reluctor wheel inspection Is the replacement complete?		*Go to Step (10)*	-
9	• Replace 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-143 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-143 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 144-Camshaft Sensor Loss



Conditions for Setting the DTC

- CMP (Camshaft Position Sensor)
- Check Condition-Engine Cranking or Running
- Fault Condition-No cam pulse in 3 cycles
- MIL-On for active fault and for 10 seconds after active fault
- Adaptive-Disabled for remainder of key-on cycle
- Closed Loop-Enabled

Circuit Description

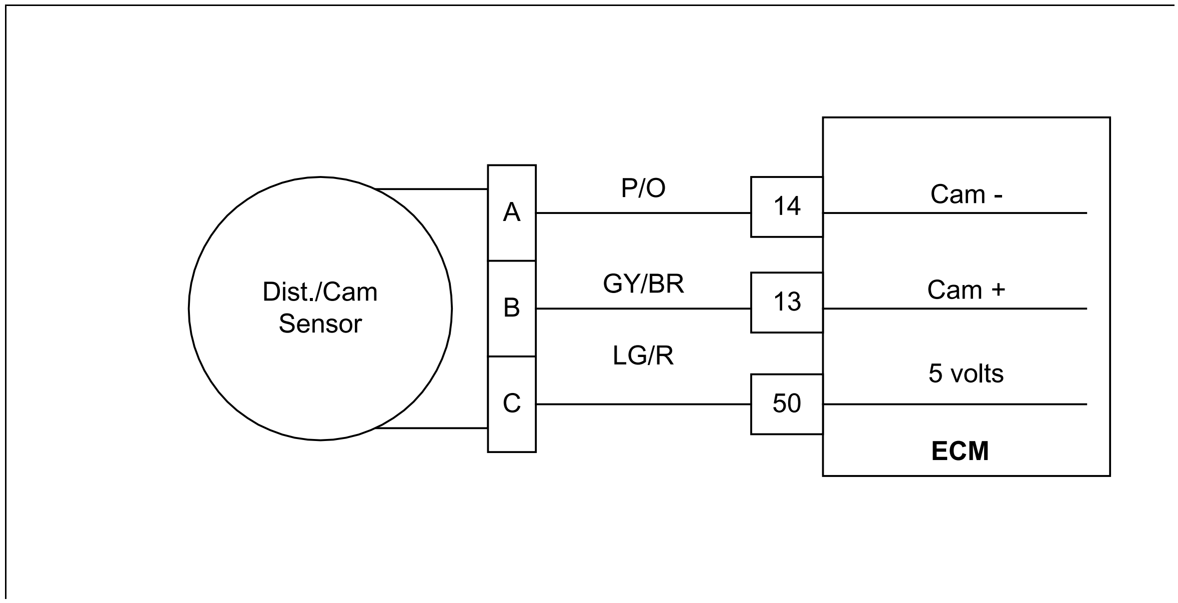
The CMP (Camshaft Position Sensor) is used to synchronize the fuel and ignition systems. This fault will set if the ECM does not detect a cam pulse in 3 engine cycles whenever the engine is cranking or running. The engine will not run with this fault present.

DTC 144 Camshaft Sensor Loss

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 ECM ground terminals G1 and G2 are clean and tight Are the ground terminals G1 and G2 clean and tight?		*Go to Step (3)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key On, Engine OFF • Disconnect the CMP (Camshaft position) Sensor connector C011 • Using A DVOM check for voltage at the CMP sensor connector pin C and engine ground Do you have voltage?	5.0 volts	*Go to Step (4*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CMP connector pin A and ECM connector pin 14 • Do you have continuity between them?		*Go to Step (5)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between CMP connector pin B and ECM connector pin 13 Do you have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Inspect the CMP connector C011 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	• Inspect the ECM connector C001 terminals 13,14 and 50 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)*
8	• Replace CMP sensor using R&R procedure in Section 1E. Pay special attention to CMP sensor reluctor wheel inspection. Is the replacement complete?		*Go to Step (10)*	-
9	• Replace 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-144 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-144 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 145-Camshaft Sensor Noise



Conditions for Setting the DTC

- Camshaft position sensor
- Check Condition-Cranking or Running
- Fault Condition-One invalid cam re-sync
- MIL-On for active fault and for 10 seconds after active fault
- Adaptive-Disabled for the remainder of the key-on cycle
- Closed Loop-Enabled

Circuit Description

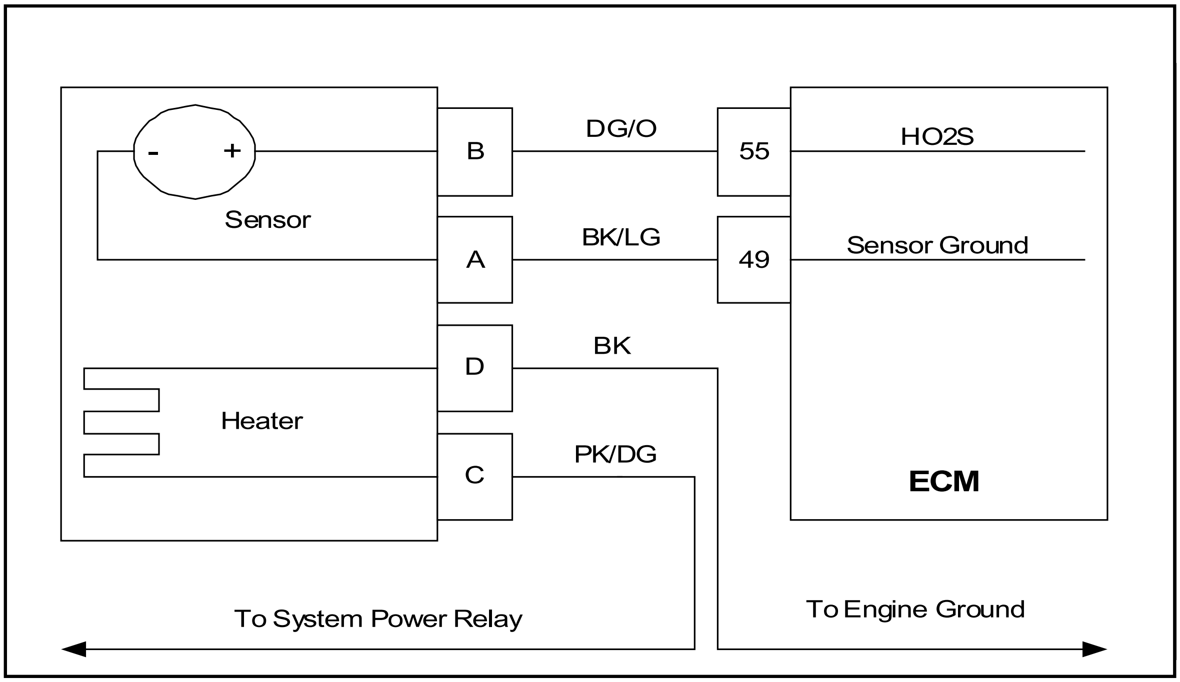
The camshaft position sensor is used to synchronize the fuel and ignition systems. This fault will set if the ECM detects erroneous pulses from the camshaft position sensor causing invalid cam re-sync. The engine will not run with this fault present.

DTC 145 Camshaft Sensor Noise

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 ECM ground terminals G1 and G2 are clean and tight Are the ground terminals G1 and G2 clean and tight?		*Go to Step (3)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key On, Engine OFF • Disconnect the CMP (Camshaft position) Sensor connector C011 • Using A DVOM check for voltage at the CMP sensor connector pin C and engine ground Do you have voltage?	5.0 volts	*Go to Step (4*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CMP connector pin A and ECM connector pin 14 • Do you have continuity between them?		*Go to Step (5)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between CMP connector pin B and ECM connector pin 13 Do you have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Inspect the CMP connector C011 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	• Inspect the ECM connector C001 terminals 13,14 and 50 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)*
8	• Replace CMP sensor using R&R procedure in Section 1E. Pay special attention to CMP sensor reluctor wheel inspection. Is the replacement complete?		*Go to Step (10)*	-
9	• Replace 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-145 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-145 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 211- Closed Loop Multiplier High (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine running
- Fault Condition- Closed Loop multiplier out of range (greater than 35%)
- MIL- Disabled
- Adaptive- Enabled but not updated when Closed Loop is at limit
- Closed Loop- Enabled

Circuit description

The HO2S 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 Closed Loop multiplier and the adaptive multiplier. This fault sets if the Closed Loop multiplier exceeds the limits of normal operation and cannot correctly modify the fuel flow within its limits.

Diagnostic Aids

Always diagnose any ECM codes that are present before beginning this diagnostic procedure.

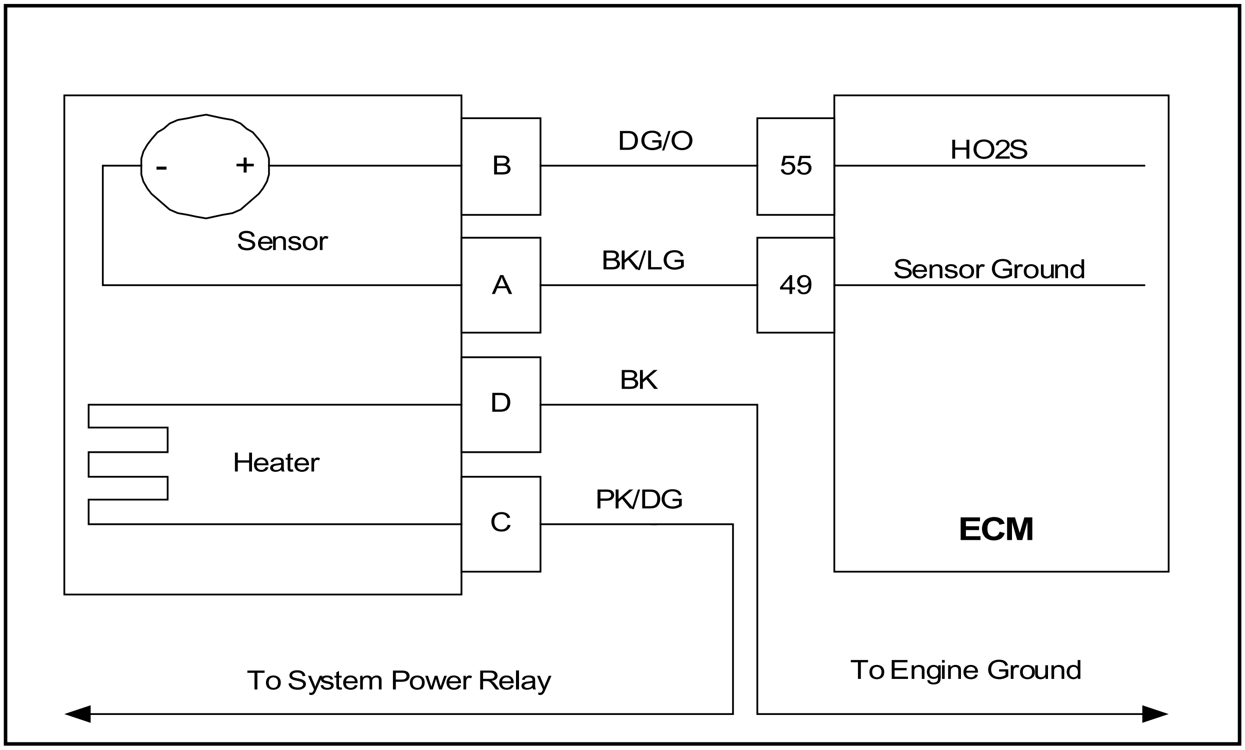
- Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
- Vacuum leaks can cause a lean exhaust condition, especially at light load and idle conditions.
- Exhaust leaks can cause a lean exhaust condition, especially at light load and idle conditions
- A poor ECU ground to the engine block or battery negative
- Problems with the fuel system causing lean fuel mixtures such as low fuel pressure, faulty mixture control solenoid or damaged fuel mixer assembly.

Never solder HO2S wires. For the correct repair procedure refer to Wiring Repairs in the Engine Electrical Section.

DTC 211- Closed Loop Multiplier High (LPG)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed below 0.35 volts after 2 minutes of idle run time?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• Key OFF • Disconnect ECM connector • Disconnect HO2S wire harness connector • Using a high impedance DVOM check for continuity between HO2S connector signal pin B and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (4)*
4	• Using a high impedance DVOM check for continuity between HO2S connector signal pin B and HO2S connector sensor ground pin A • Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (5)*
5	• Refer to Diagnostic aids for DTC 211 Did you check the diagnostic Aids for DTC 211?		*Go to Step (6)*	
6	• Replace HO2S sensor 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-211 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

212-HO2S Open/Inactive



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check condition- Engine running
- Fault condition- HO2S cold persistently more than 120 seconds
- MIL- On during active fault and for 1 second after active fault
- Adaptive- Disabled during active fault
- Closed Loop- Disabled during active fault

Circuit Description

The HO2S 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 Closed Loop multiplier and the Adaptive multiplier.

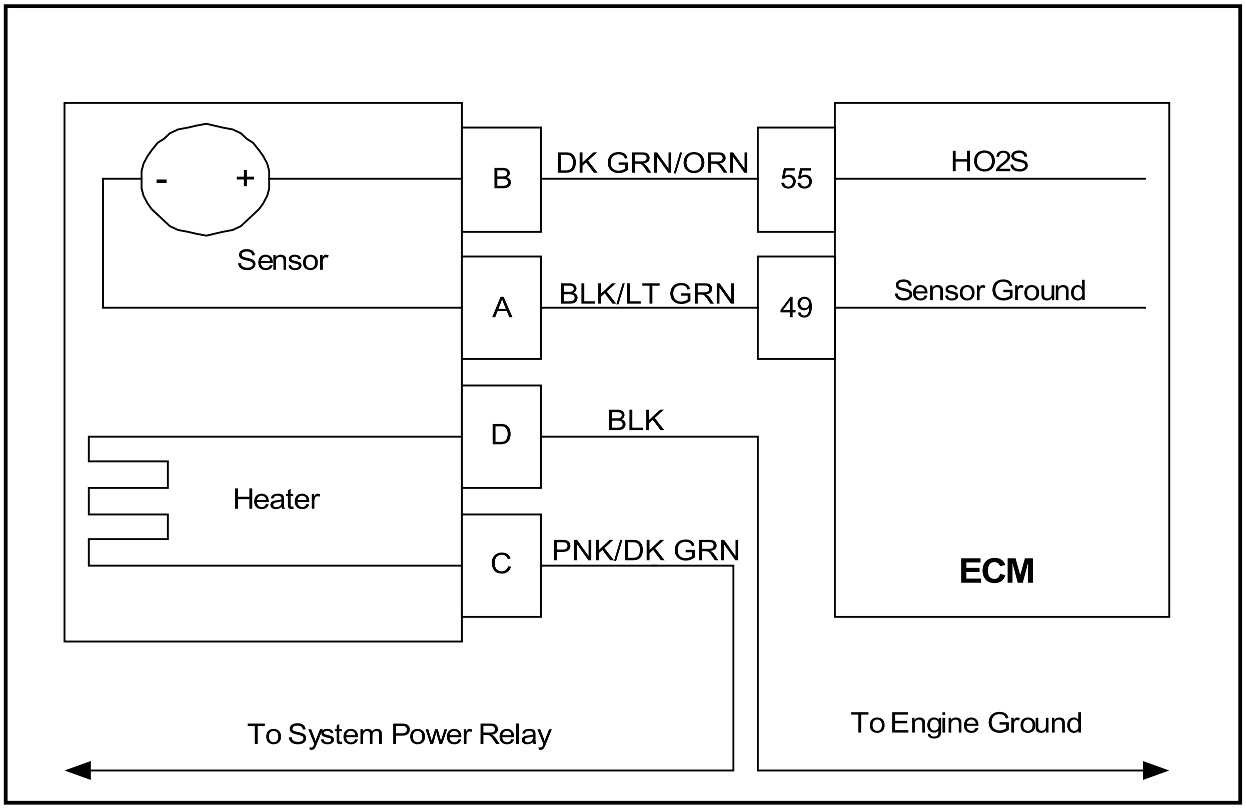
This fault will set if HO2S is cold, non-responsive, or inactive for 120 seconds or longer.

DTC 212- HO2S Open/Inactive

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key ON, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed between 0.4 and 0.5 volts after 2 minutes of idle run time?		*Go to Step (5)*	Go to Step (3)
3	• Back probe HO2S wire harness connector and check for voltage between HO2S connector heater ground pin D and battery voltage positive. Do you have power?		*Go to step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Back probe HO2S wire harness connector and check for voltage between HO2S connector heater power pin C and engine ground. Do you have power?		*Go to step (7)*	Repair the circuit as necessary. **Check System Power Relay** circuit. Refer to Wiring Repairs in Engine Electrical.
5	• Key OFF • Disconnect HO2S connector and ECM connector. • Key ON • Check for continuity between HO2S sensor connector ground pin A and ECM HO2S sensor ground PIN 49. Do you have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Check for continuity between HO2S sensor connector signal pin B and ECM connector HO2S signal pin 55 Do you have continuity between them?		Go to Step (8)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
7	Replace HO2S Sensor Is the replacement complete?		Go to Step (9)	-

8	• Inspect ECM connector pins 49 and 55 for damage, corrosion or contamination • Inspect HO2S connector terminals A, B, C and D 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)*
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-212 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 221-Closed Loop Multiplier High (Gasoline)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Functional Fault-Closed Loop multiplier out of range (at limit of 35%)
- MIL-On during active fault
- Adaptive-Enabled
- Closed Loop-Enabled

Circuit Description

The HO2S 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 Closed Loop multiplier and the Adaptive multiplier.

This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multiplier cannot correctly modify the fuel flow within its limits, the limit is enforced.

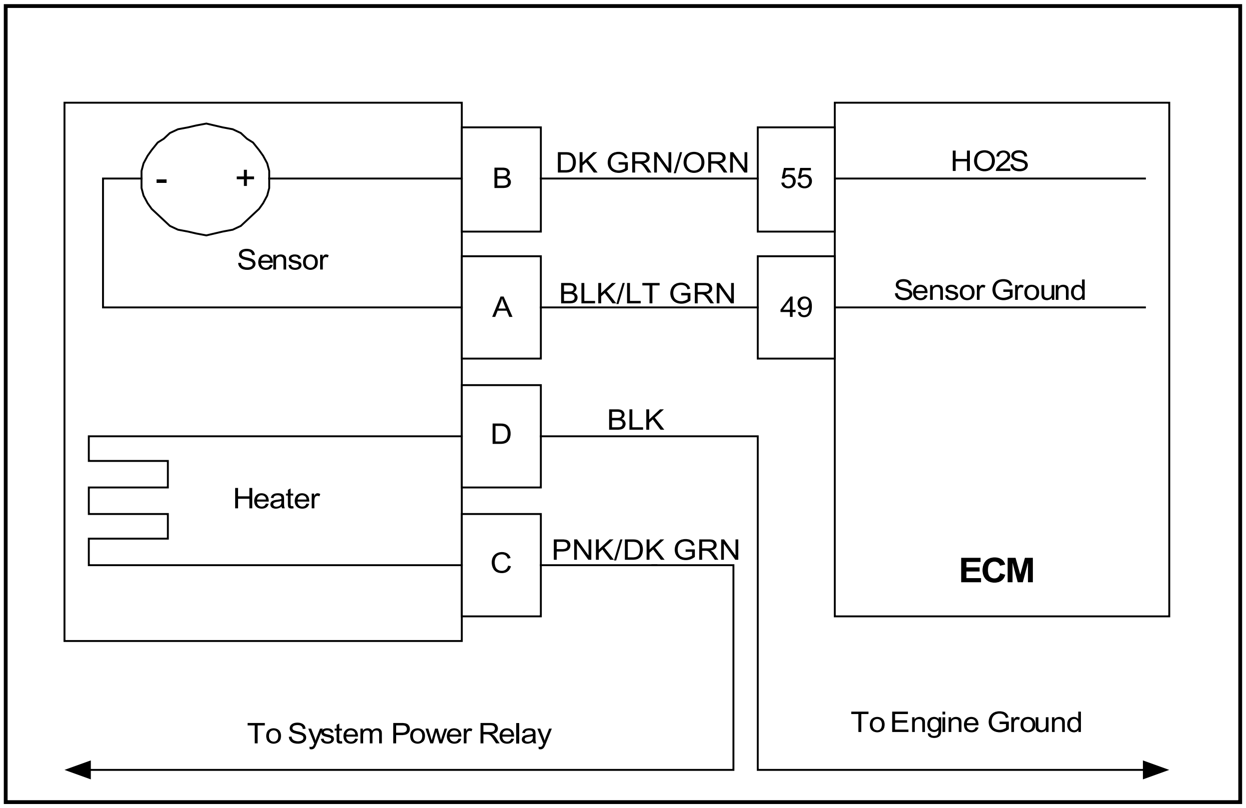
Diagnostic Aids

If any other DTCs are present, diagnose those first
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at especially at light load.
Injectors System will be lean if an injector driver or driver circuit fails open. The system will also be lean if an injector fails in a closed manner or is dirty.
Fuel Pressure Low fuel pressure, faulty fuel injector or damaged fuel pump assembly can cause fuel system to run lean
Exhaust Leaks If there is an exhaust leak, outside air can be pulled into the exhaust and past the 02 sensor causing a false lean

DTC 221 Closed Loop Multiplier High (Gasoline)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed below 0.35 volts after 2 minutes of idle run time?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• Key OFF • Disconnect HO2S sensor wire harness connector • Disconnect ECM connector • Using a high impedance DVOM Check for continuity between HO2S connector signal pin B and engine ground Do you have continuity?		*Repair the circuit as required* Refer to Wiring Repairs in Engine Electrical.	*Go to Step (4)*
4	• Using a high impedance DVOM Check for continuity between HO2S connector signal pin B and HO2S sensor ground pin A Do you have continuity?		*Repair the circuit as required* Refer to Wiring Repairs in Engine Electrical.	*Go to Step (5)*
5	• Refer to Diagnostic aids for DTC 221 Did you check the diagnostic Aids for DTC 221?		*Go to Step (6)*	-
6	• Replace HO2S sensor 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-221 check for any stored codes. Does the engine operate normally with no stored codes?			

DTC 222- Closed Loop Multiplier Low (Gasoline)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Functional Fault-Closed Loop multiplier out of range (at limit of -35%)
- MIL-On during active fault and for one update after active fault
- Adaptive-Enabled
- Closed Loop-Enabled

Circuit Description

The HO2S (Heated Oxygen Sensor) 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 Closed Loop multiplier and the adaptive multiplier. This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multiplier cannot correctly modify the fuel flow within its limits, it is limited at -35%.

Diagnostic Aids

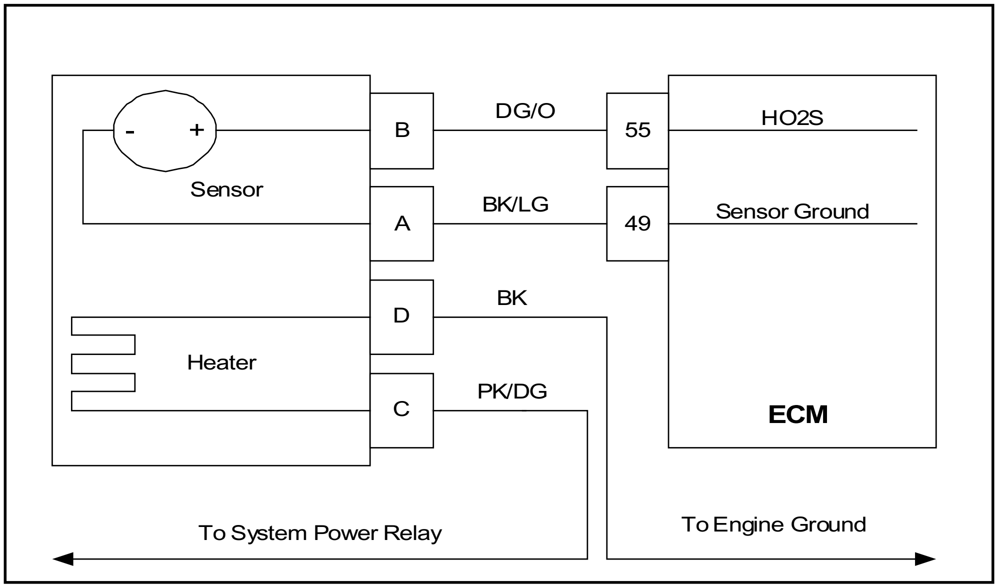
Always diagnose any other ECM codes that are present before beginning this diagnostic procedure.

Fuel System The system will be rich if an injector fails in an open manner. High fuel pressure due to a faulty fuel regulator or obstructed fuel return line will cause the system to run rich.
Ignition noise open or poor ground circuit to or in the ignition system or ECM may cause EMI (Electromagnetic interference). This noise could be interpreted by the ECM as ignition pulses, and the sensed RPM becomes higher than the actual speed. The ECM then delivers too much fuel, causing the system to run rich.
TMAP Sensor A higher manifold pressure than normal can cause the system to go rich. Temporarily disconnecting the MAP Sensor will allow the ECM to set a default value for MAP.
IAT Sensor Check for a shifted sensor that could cause the ECM to sense lower than actual temperature of incoming air. This can cause a rich exhaust condition.
ECT Sensor Check for a skewed sensor that could cause the ECM to sense engine temperature colder than it actually is. This could also cause a rich exhaust condition.

DTC 222- Closed Loop Multiplier Low (Gasoline)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed above 0.7 volts after 2 minutes of idle run time?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• Key OFF • Disconnect HO2S wire harness connector • Disconnect ECM wiring harness connector • Key ON • Using a high impedance DVOM check for voltage between HO2S connector signal pin B and engine ground Do you have voltage?		*Repair the circuit as required* Refer to Wiring Repairs in Engine Electrical.	*Refer to Diagnostic Aids for DTC 222*

DTC 224- Closed Loop Multiplier Low (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Functional Fault-Closed Loop multiplier out of range (at limit of -35%)
- MIL Disabled
- Adaptive-Disabled
- Closed Loop-Enabled

Circuit Description

The HO2S (Heated Oxygen Sensor) 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 Closed Loop multiplier and the adaptive multiplier. This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multiplier cannot correctly modify the fuel flow within its limits, it is limited at -35%.

Diagnostic Aids

Always diagnose any other ECM codes that are present before beginning this diagnostic procedure.

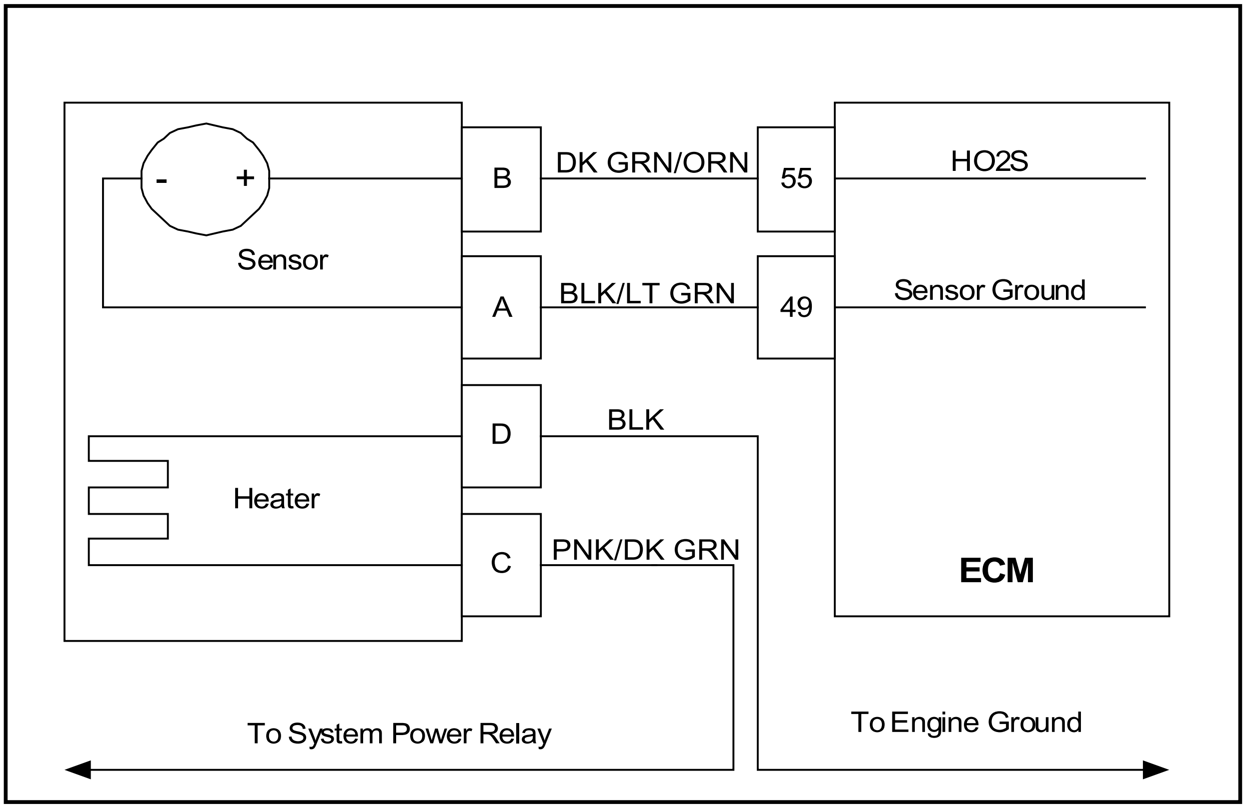
Fuel System High secondary fuel pressure can cause the system to run rich. A worn fuel mixer, faulty PTV (pressure trim valve) or FTV (fuel trim valve) can also cause the system to run rich.

Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the system to run rich. Be sure that the specified HD-5 or HD-10 motor fuel grade propane is used.

DTC 224- Closed Loop Multiplier Low (LPG)

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine to full operating temperature and then idle for a minimum of 2 minutes Does DST display HO2S voltage fixed above 0.7 volts after 2 minutes of idle run time?		*Go to step (3)*	*Intermittent problem* Go to Intermittent section
3	• Key OFF • Disconnect HO2S wire harness connector • Disconnect ECM wiring harness connector • Key ON • Using a high impedance DVOM check for voltage between HO2S connector signal pin B and engine ground Do you have voltage?		*Repair wire harness shorted signal to voltage* Refer to Wiring Repairs in Engine Electrical.	*Refer to Diagnostic Aids for DTC 224*

DTC 241-Adaptive Lean Fault (high limit-gasoline)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Functional Fault-Adaptive multiplier out of range (greater than 30%)
- MIL-On during active adaptive limit condition
- Adaptive-Enabled
- Closed Loop-Enabled

Circuit Description

The HO2S 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 Closed Loop multiplier and the Adaptive multiplier. This fault sets if the Adaptive multiplier exceeds the limits of normal operation.

Diagnostic Aids

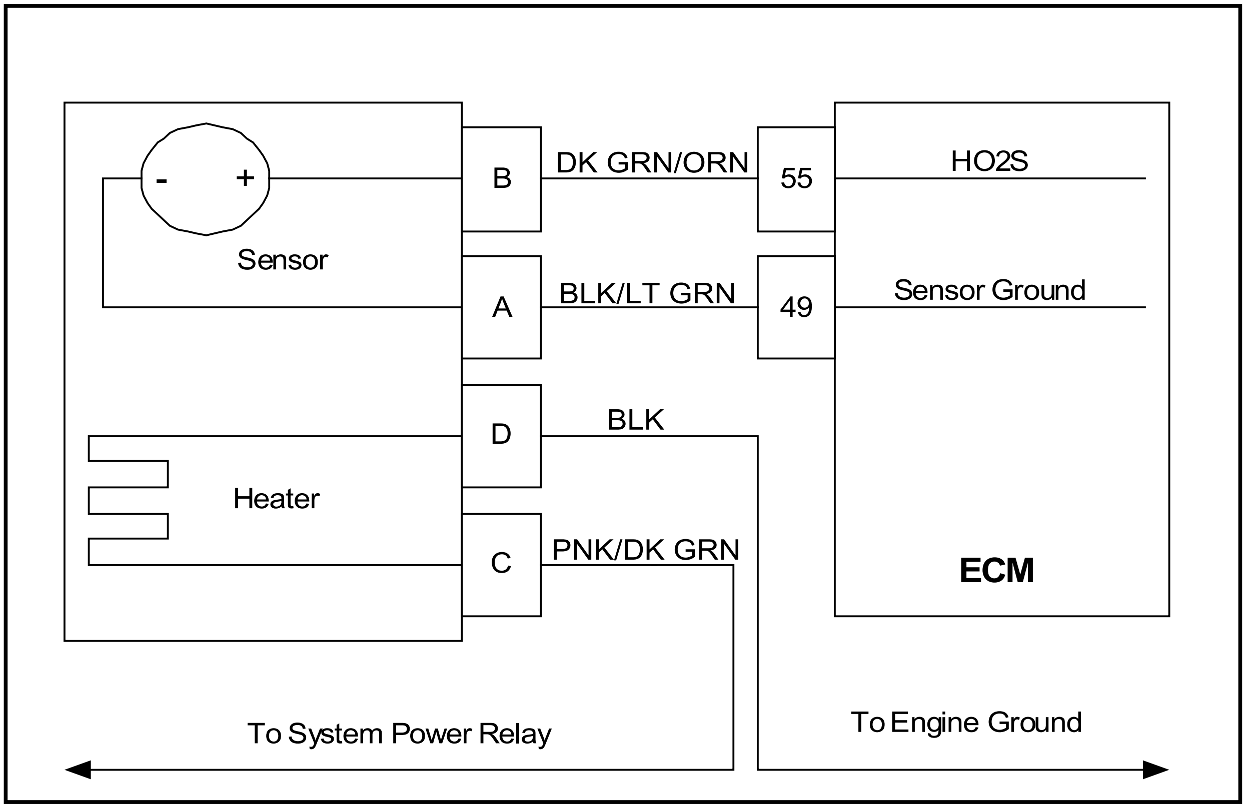
If any other DTCs are present, diagnose those first
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at especially at light load.
Injectors System will be lean if an injector driver or driver circuit fails open. The system will also be lean if an injector fails in a closed manner or is dirty.
Fuel Pressure Low fuel pressure, faulty fuel injector or damaged fuel pump assembly can cause fuel system to run lean
Exhaust Leaks If there is an exhaust leak, outside air can be pulled into the exhaust and past the 02 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 good battery or engine ground.

DTC 241 Adaptive Lean Fault (High Limit Gasoline)

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 HO2S sensor installed securely and the wire leads not contacting the exhaust manifold or ignition wires • ECM grounds for being clean and tight. Refer to Section 1C Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to Section 1B Fuel System Diagnostics Was a repair made?		*Go to Step (8)*	*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 (8)*	*Go to step (4)*
4	• Key ON Engine running • Back probe the HO2S sensor connector heater terminals D for negative and C for positive • Using a DVOM check for voltage • Do you have voltage?	Battery voltage	*Go to Step (5)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Key OFF • Disconnect HO2S sensor wire harness connector • Disconnect ECM wire harness connector • Key ON • Using a high impedance DVOM check for continuity between HO2S connector signal pin B and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (6)*
6	• Using a high impedance DVOM check for continuity between HO2S connector sensor ground pin A and HO2S signal pin B • Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (7)*
7	• Replace HO2S sensor 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-241 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 242-Adaptive Rich Fault (low limit-gasoline)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Functional Fault-Adaptive multiplier out of range (at limit of -30%)
- MIL-On during active adaptive limit condition
- Adaptive-Enabled
- Closed Loop-Enabled

Circuit Description

The HO2S 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 Closed Loop multiplier and the Adaptive multiplier. This fault sets if the Adaptive multiplier exceeds the limits of normal operation.

Diagnostic Aids

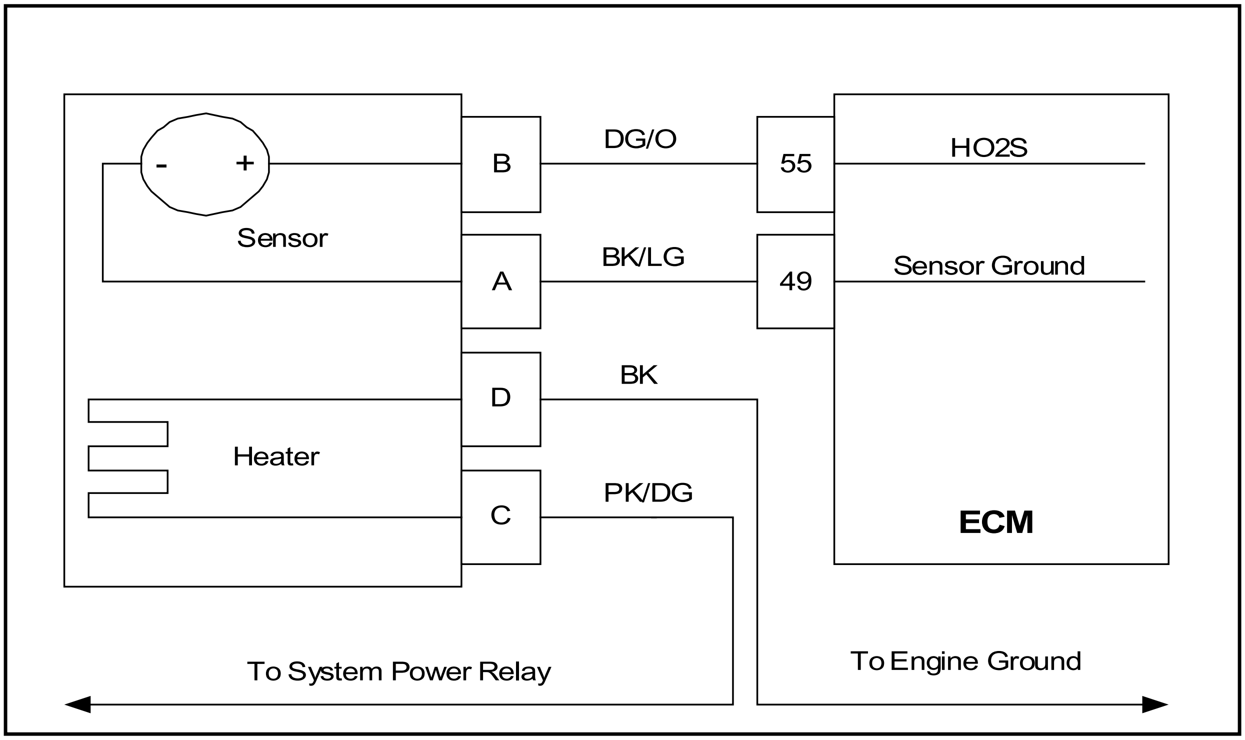
Always diagnose any other ECM codes that are present before beginning this diagnostic procedure.

Fuel System The system will be rich if an injector fails in an open manner. High fuel pressure due to a faulty fuel regulator or obstructed fuel return line will cause the system to run rich.
Ignition noise open or poor ground circuit to or in the ignition system or ECM may cause EMI (Electromagnetic interference). This noise could be interpreted by the ECM as ignition pulses, and the sensed RPM becomes higher than the actual speed. The ECM then delivers too much fuel, causing the system to go rich.
TMAP Sensor A higher manifold pressure than normal can cause the system to go rich. Temporarily disconnecting the MAP Sensor will allow the ECM to set a default value for MAP.
IAT Sensor Check for a shifted sensor that could cause the ECM to sense lower than actual temperature of incoming air. This can cause a rich exhaust condition.
ECT Sensor Check for a skewed sensor that could cause the ECM to sense engine temperature colder than it actually is. This could also cause a rich exhaust condition.

DTC 242 Adaptive Rich Fault (Low Limit Gasoline)

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 HO2S sensor installed securely and the wire leads not contacting the exhaust manifold or ignition wires • ECM grounds for being clean and tight. Refer to Section 1C Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to Section 1B Fuel System Diagnostics Was a repair made?		*Go to Step (7)*	*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 (7)*	*Go to step (4)*
4	• Key OFF • Disconnect HO2S sensor wire harness connector • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage at HO2S connector signal pin B and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (5)*
5	• Replace HO2S sensor 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-242 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 243-Adaptive Learn High (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine Running
- Fault Condition- Adaptive multiplier out of range (greater than 30%)
- MIL- Disabled
- Adaptive- Enabled
- Closed Loop- Enabled

Circuit Description

The HO2S 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 Closed Loop multiplier and Adaptive multiplier. This fault will set if the adaptive multiplier exceeds the limits of normal operation.

Diagnostic Aids

If any other DTCs are present, diagnose those first

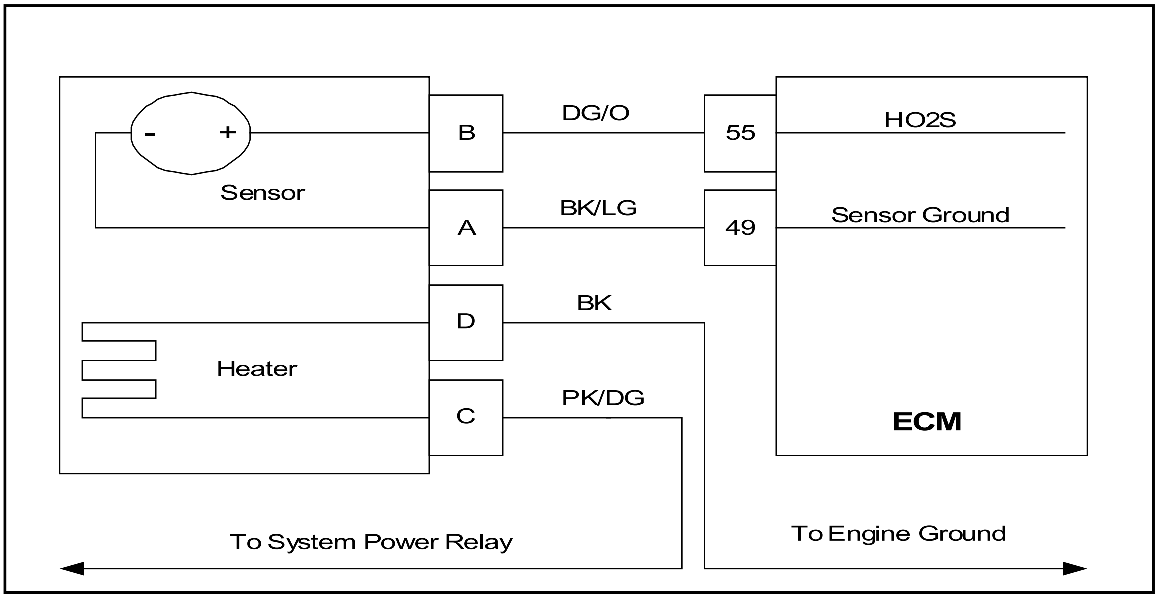
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at especially at light load.
Injectors System will be lean if an injector driver or driver circuit fails open. The system will also be lean if an injector fails in a closed manner or is dirty.
Fuel Pressure Low fuel pressure, faulty fuel injector or damaged fuel pump assembly can cause fuel system to run lean
Exhaust Leaks If there is an exhaust leak, outside air can be pulled into the exhaust and past the 02 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 good battery or engine ground.

DTC 243 Adaptive Learn High (LPG)

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 HO2S sensor installed securely and the wire leads not contacting the exhaust manifold or ignition wires • ECM grounds for being clean and tight. Refer to Section 1C Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to Section 1B Fuel System Diagnostics Was a repair made?		*Go to Step (7)*	*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 (7)*	*Go to step (4)*
4	• Key ON Engine running • Using a DVOM back probe the HO2S sensor connector heater circuit pin C for positive and D for negative. check for voltage • Do you have voltage?	Battery voltage	*Go to Step (5)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Key OFF • Disconnect HO2S sensor wire harness connector • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage at HO2S connector signal pin B and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (6)*
6	• Replace HO2S sensor 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-243 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 244-Adaptive Learn Low (LPG)



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine running
- Fault Condition- Adaptive multiplier out of range (at limit of -30%)
- MIL-Disabled
- Adaptive- Enabled
- Closed Loop- Enabled

Circuit Description

The HO2S 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 Closed Loop multiplier and Adaptive multiplier. This fault will set if the adaptive multiplier exceeds the limits of normal operation.

Diagnostic Aids

Always diagnose any other ECM codes that are present before beginning this diagnostic procedure.

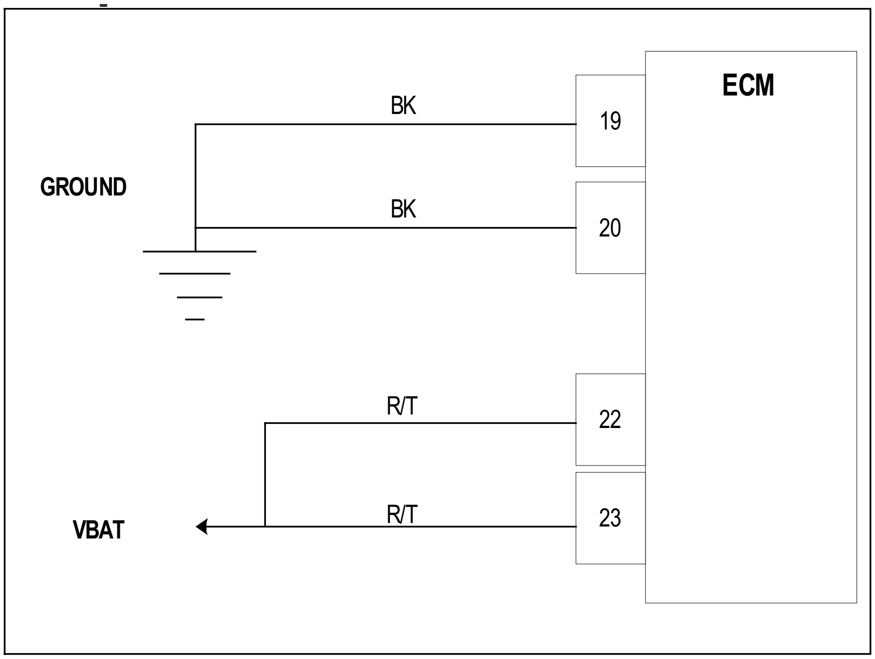
Fuel System High secondary fuel pressure will cause the system to run rich. A worn fuel mixer, faulty PTV (pressure trim valve) or FTV (fuel trim valve) can also cause the system to run rich.

Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the system to run rich. Be sure that the specified HD-5 or HD-10 motor fuel grade propane is used.

DTC 244 Adaptive Learn Low (LPG)

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 • ECM grounds for being clean and tight. Refer to Section 1C Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to Section 1B Fuel System Diagnostics Was a repair made?		*Go to Step (7)*	*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 (7)*	*Go to step (4)*
4	• Key OFF • Disconnect HO2S sensor wire harness connector • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage at HO2S connector signal pin B and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (5)*
5	• Replace HO2S sensor 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-244 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 261-System Voltage Low



Conditions for Setting the DTC

- System Voltage to ECM
- Check Condition-Key on and RPM greater than 1500
- Fault Condition-Battery voltage at ECM less than 9.0 volts continuously for 5 seconds
- MIL-On for active fault and for 10 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

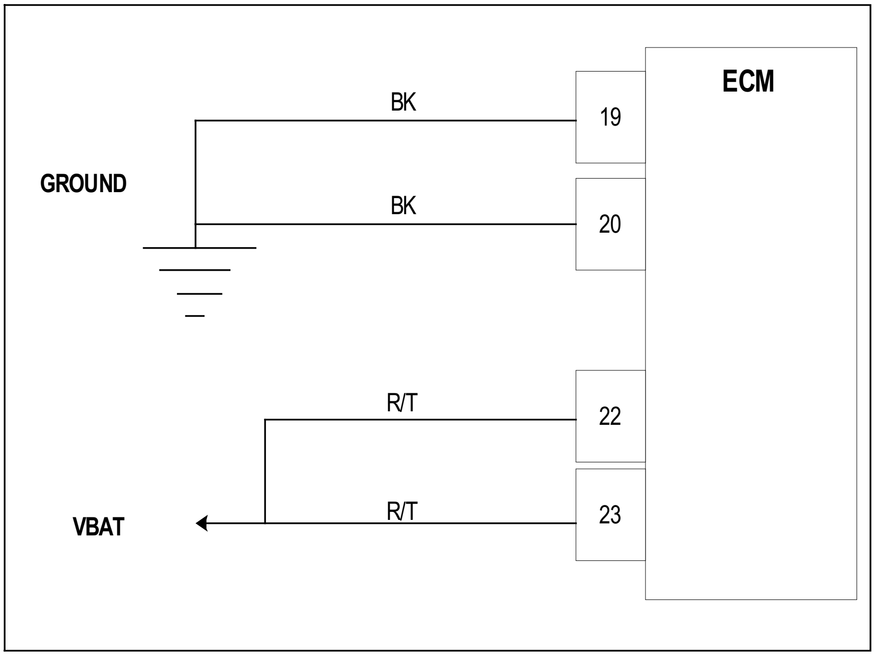
Circuit Description

The battery voltage powers the ECM and must be measured to correctly operate injector drivers, fuel trim valves and ignition coils. This fault will set if the ECM detects system voltage less than 9.0 for 5 seconds or longer while the alternator should be charging. The adaptive learn is disabled.

DTC 261- System Voltage 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, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display system voltage greater than 9.0 volts?	-	*Intermittent problem* Go to Engine Electrical Intermittent section	Go to Step (3)
3	• Check battery condition Is it OK?	-	*Go to Step (4)*	*Replace Battery*
4	• Check charging system Is it Ok?	-	*Go to Step (5)*	*Repair charging System*
5	• Back probe ECM connector pins 22 and 23 • Measure voltage with DVOM between each pin and engine ground Is the voltage greater than 9.0 volts?	-	*Repair ECM Ground circuit. Go to Power and Ground section in engine Electrical*	*Go to Step (6)*
6	• Back probe ECM connector pins 19 and 20 • Measure voltage with DVOM between each pin and battery voltage Is the voltage greater than 9.0 volts?	-	*Repair ECM power circuit. Go to Power and Ground section in engine Electrical*	*Go to step (7)*
7	Replace 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-261 check for any stored codes. Does the engine operate normally with no stored codes?	-	System OK	*Go to OBD System Check*

DTC 262-System Voltage High



Conditions for Setting the DTC

- System Voltage to ECM
- Check Condition-Cranking or Running
- Fault Condition-Switched battery voltage at ECM greater than 18 volts for 3 seconds
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key on cycle
- Closed Loop-Enabled

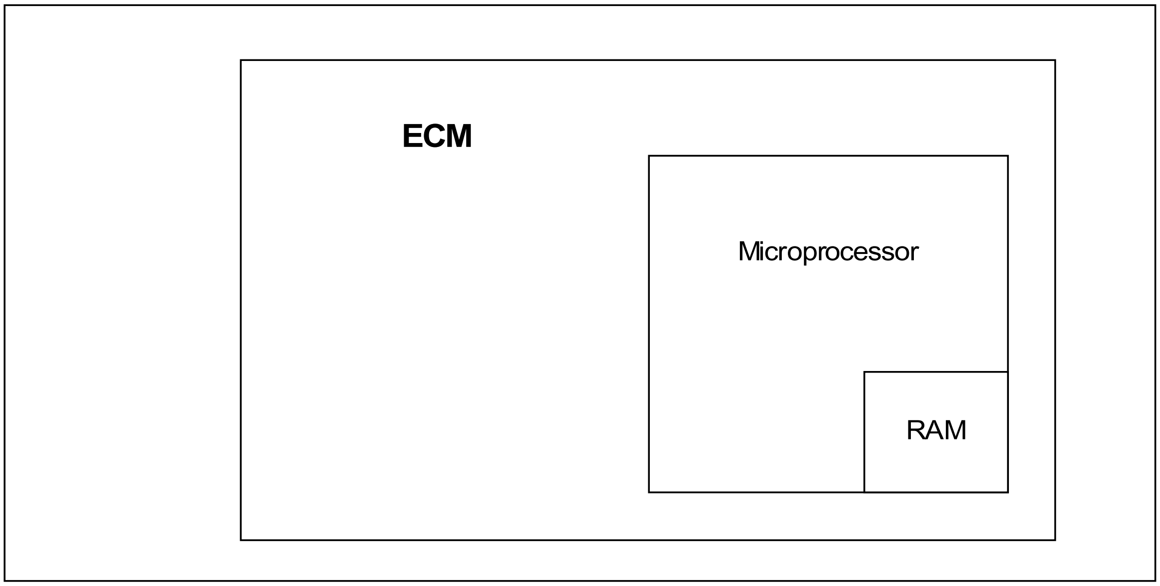
Circuit Description

The battery voltage powers the ECM and must be measured to correctly operate injector drivers, trim valves and ignition coils. This fault will set if the ECM detects voltage greater than 18 volts for 3 seconds at anytime the engine is cranking or running. The adaptive learn is disabled. The ECM will shut down with internal protection if the system voltage exceeds 26 volts. The ECM fuse will then open.

DTC 262- System 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	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in System Data Mode • Run engine greater than 1500 rpm. Does DST display system voltage less than 18 volts?	-	*Intermittent problem* Go to Engine Electrical Intermittent section	Go to Step (3)
3	• Check voltage at battery terminals with DVOM with engine speed greater than 1500 rpm Is it greater than 18 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 the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-262 check for any stored codes. Does the engine operate normally with no stored codes?	-	System OK	*Go to OBD System Check*

DTC 511-COP Failure



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

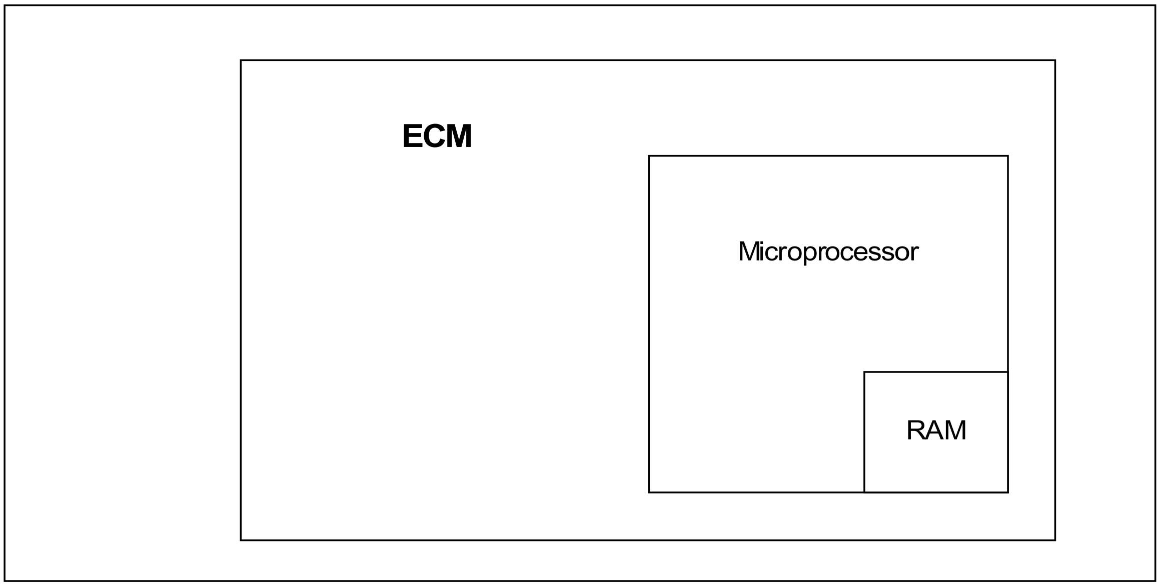
Circuit Description

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 511 COP 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	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 511 reset with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		*Go to Step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		*Go to Step (4)*	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-511 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 512-Invalid Interrupt



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

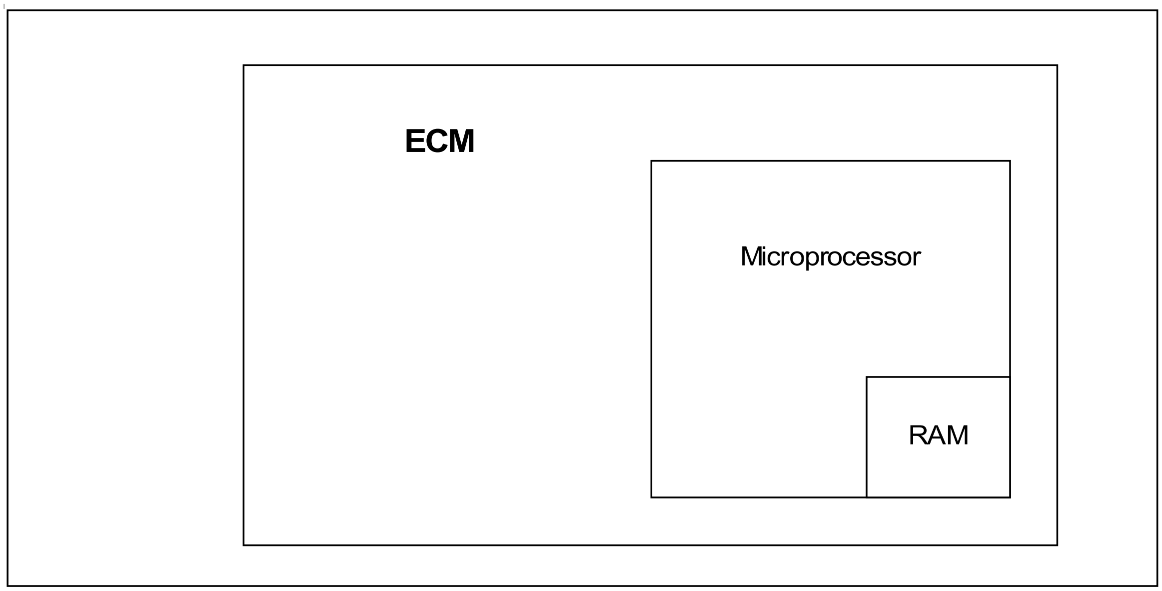
The ECM has checks that must be verified each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 512 Invalid Interrupt

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 512 reset with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		*Go to Step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		*Go to Step (4)*	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-512 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 513-A/D Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

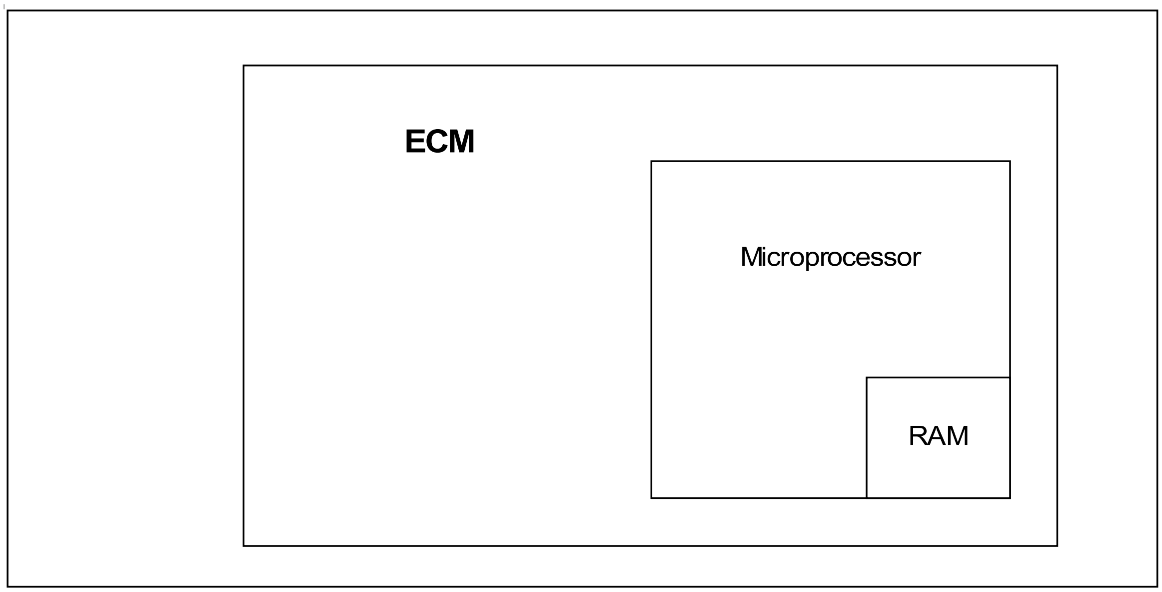
The ECM has checks that must be verified each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 513 A/D Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 513 reset with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		*Go to Step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		*Go to Step (4)*	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-513 check for any stored codes. Does the engine normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 514-RTI 1 Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

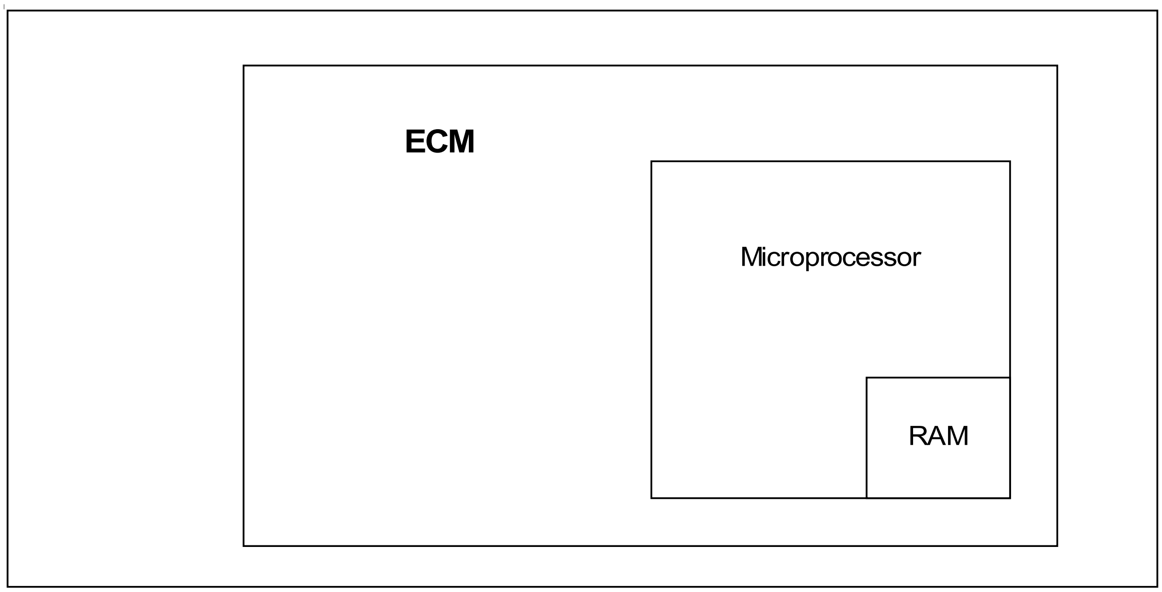
The ECM runs checks that must be verified each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 514 RTI 1 Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 514 reset with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		*Go to Step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		*Go to Step (4)*	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-514 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 515-Flash Checksum Invalid



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

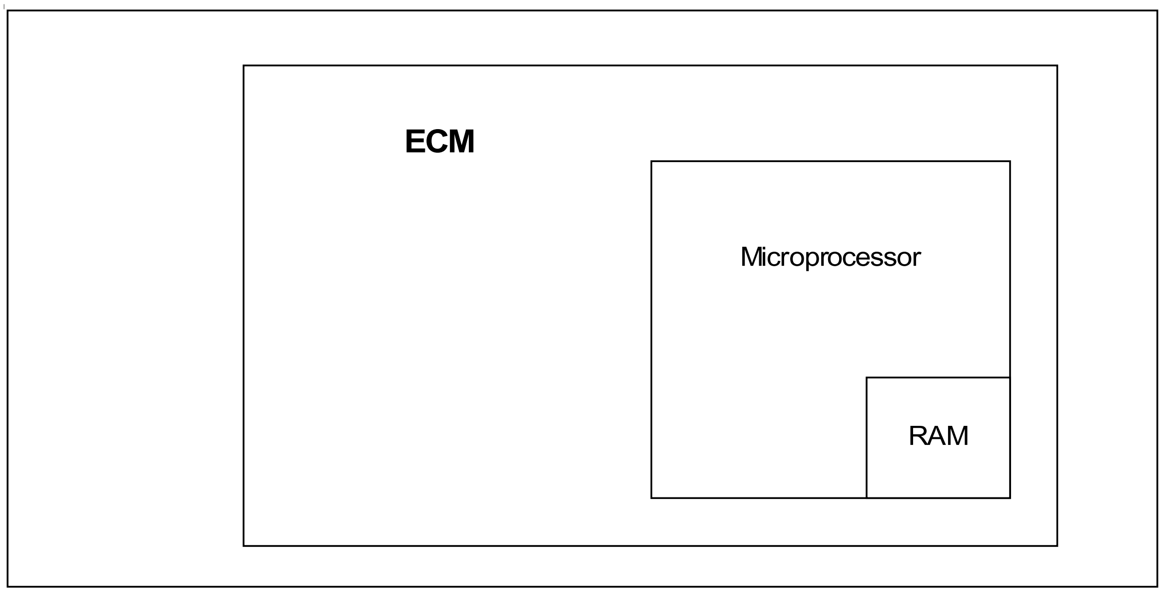
Circuit Description

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 515 Flash Checksum Invalid

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 515 reset with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		*Go to Step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		*Go to Step (4)*	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-515 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 516-Ram Failure



Conditions for Setting the DTC

- Random Access Memory
- Check Condition- Key-On
- Fault Condition- Internal ECM memory access failure
- MIL- On until fault is cleared
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2) enforced

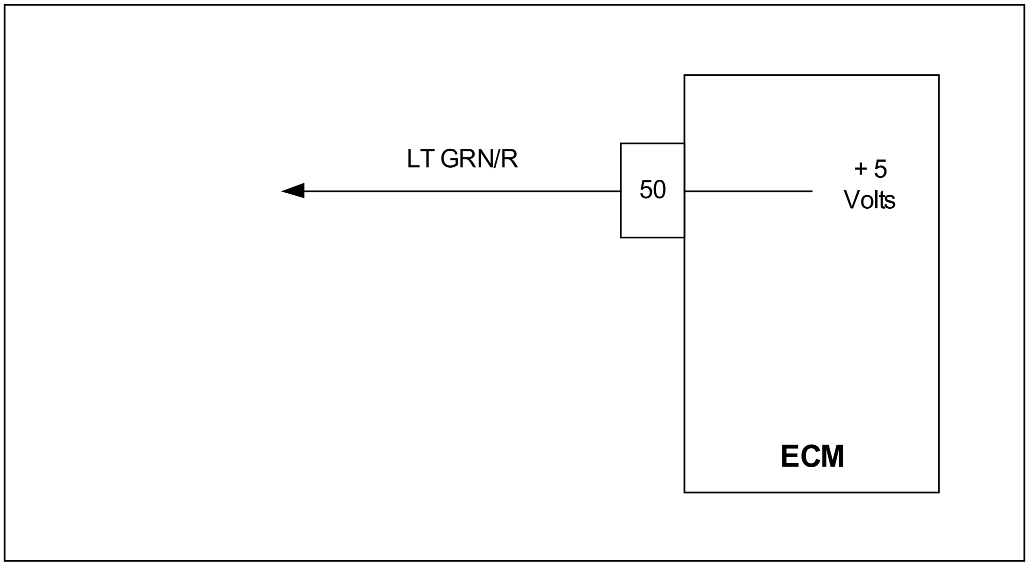
Circuit Description

Random Access Memory is located within the microprocessor that can be read from or written to at any time. The System Fault Codes and the Adaptive Learn Table are among the data stored in RAM. This fault will set if the ECM detects a problem accessing or writing information to RAM. This fault will not self erase and must be cleared manually.

DTC 516 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	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 516 reset with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		*Go to Step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		*Go to Step (4)*	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-516 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 531-External 5V Ref Lower Than Expected



Conditions for Setting the DTC

- External 5V reference
- Check Condition-Cranking with battery voltage greater than 8 volts and engine running
- Fault Condition-5V reference voltage lower than 4.6 volts
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

Circuit Description

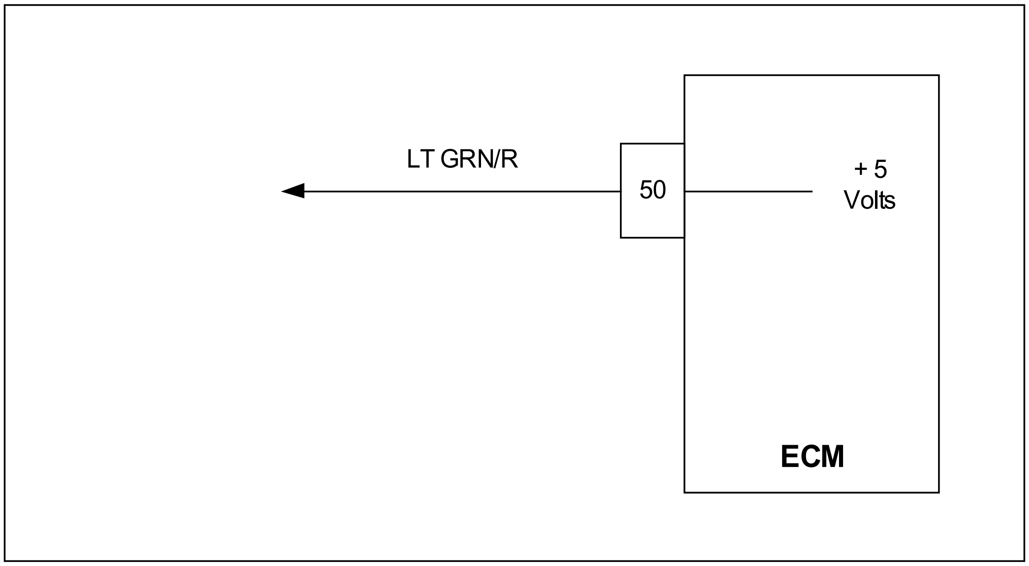
The External 5 Volt supply powers some of the sensors and other components in the system. The accuracy of the 5 Volt supply is very important to the accuracy of the sensors and therefore controlled by the ECM. The ECM monitors the 5 volt supply to determine if it is overloaded, shorted, or otherwise out of specification. This fault will set if the 5 Volt reference is below 4.6 volts.

DTC 531 External 5V Reference Lower Than Expected

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key ON, Engine Running • DST (Diagnostic Scan Tool) connected in System Fault Mode Does DST display DTC 531?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Key OFF • Disconnect ECM connector • Using DVOM check for continuity between ECM 5 volt reference LT GRN/R pin 50 and engine ground Do you have continuity?		*Go to Step (5)*	*Go to Step (4)*
4	• Replace ECM Is the replacement complete?		*Go to Step (7)*	-
5	• 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 ground is lost the last sensor disconnected is the area of suspicion. Inspect 5volt reference supply wire leads for shorts before replacing the sensor. • IAT • ECT/CHT • TMAP • FPP • TPS 1 • TPS 2 • Crankshaft Sensor • Camshaft Sensor While disconnecting each sensor one at a time did you loose continuity?		*Go to Step (6)*	-
6	• Replace Sensor 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-531 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 532-External 5 V Ref Higher Than Expected



Conditions for Setting the DTC

- External 5V reference
- Check Condition-Cranking with battery voltage greater than 8 volts or engine running
- Fault Condition-5V reference voltage higher than 5.4 volts
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault
- Closed Loop-Enabled

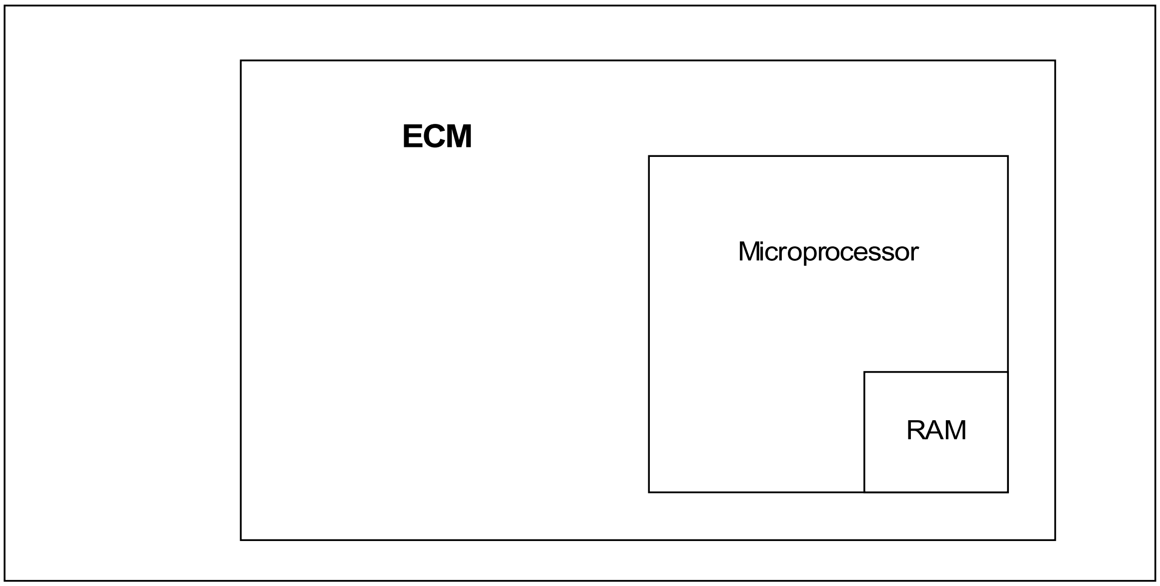
Circuit Description

The External 5 Volt supply powers some of the sensors and other components in the system. The accuracy of the 5 Volt supply is very important to the accuracy of the sensors and therefore control by the ECM. The ECM to determine if they are overloaded, shorted, or otherwise out of specification monitors the 5 Volt supply. This fault will set if the 5 Volt reference is above 5.4 volts.

DTC 532 External 5V Reference Higher Than Expected

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key ON, Engine running • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display DTC 532?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Check all ECM ground connections Refer to Engine electrical power and ground distribution. Are the ground connections Ok?		*Go to Step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Key OFF • Disconnect ECM connector • Key ON • Using DVOM check for Voltage between ECM harness wire LT GRN/R pin 50 and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (5)*
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 the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-532 check for any stored codes. Does the vehicle engine normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 555-RTI 2 Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

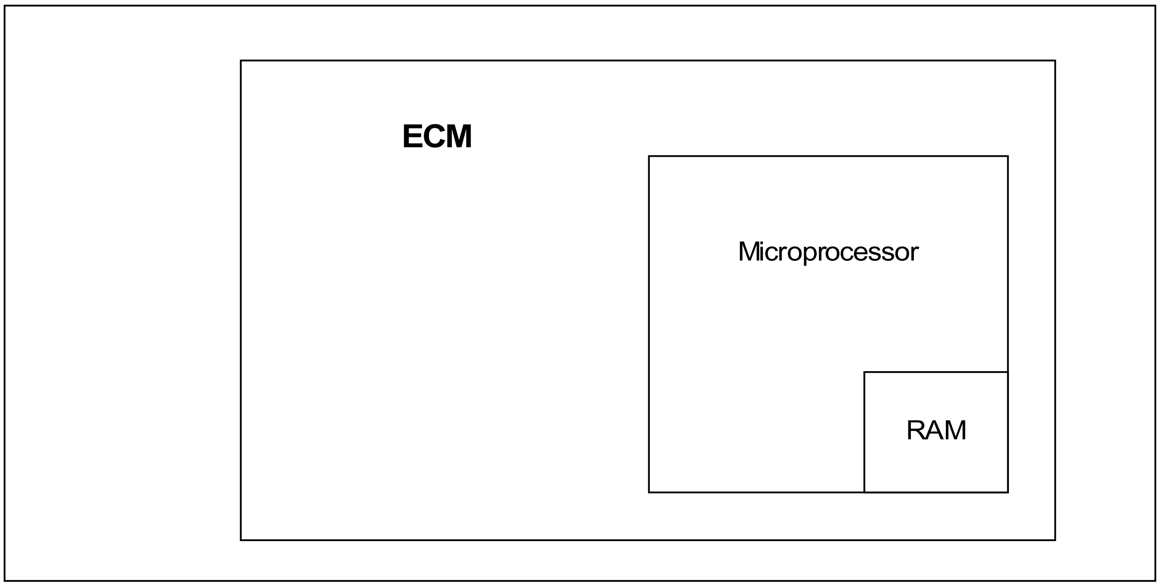
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 555 RTI 2 Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 555 reset with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		*Go to Step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		*Go to Step (4)*	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-555 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 556-RTI 3 Loss



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

Circuit Description

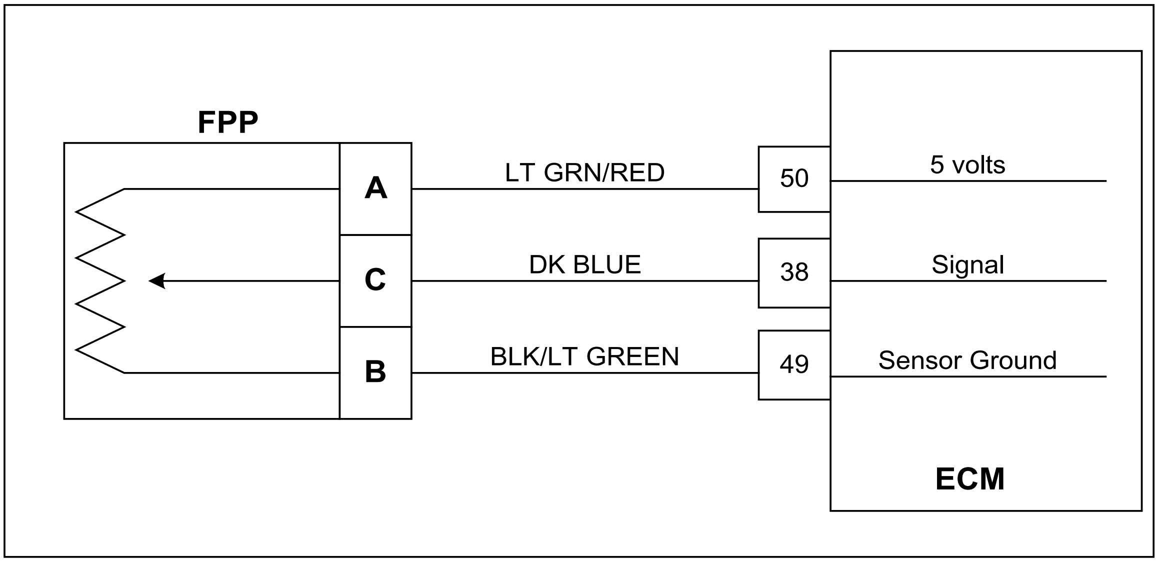
The ECM runs checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

DTC 556 RTI 3 Loss

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key On, Engine Running • DST (Diagnostic Scan Tool) connected in • System Data Mode • Clear system fault code Does DTC 555 reset with the engine idling?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Check all ECM power and ground circuits. Refer to power and ground distribution in engine electrical section. Are the power and ground circuits Ok?		*Go to Step (4)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Replace ECM Is the replacement complete?		*Go to Step (4)*	-
5	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-556 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 611-FPP High Voltage



Conditions for Setting the DTC

- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP1 sensor voltage exceeds 4.8
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycle
- Adaptive-Enabled
- Closed Loop-Enabled
- Power Derate (level 1) and Low Rev Limit enforced

Circuit Description

The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. Less depression of pedal results in lower voltage, and greater depression results in higher voltage.

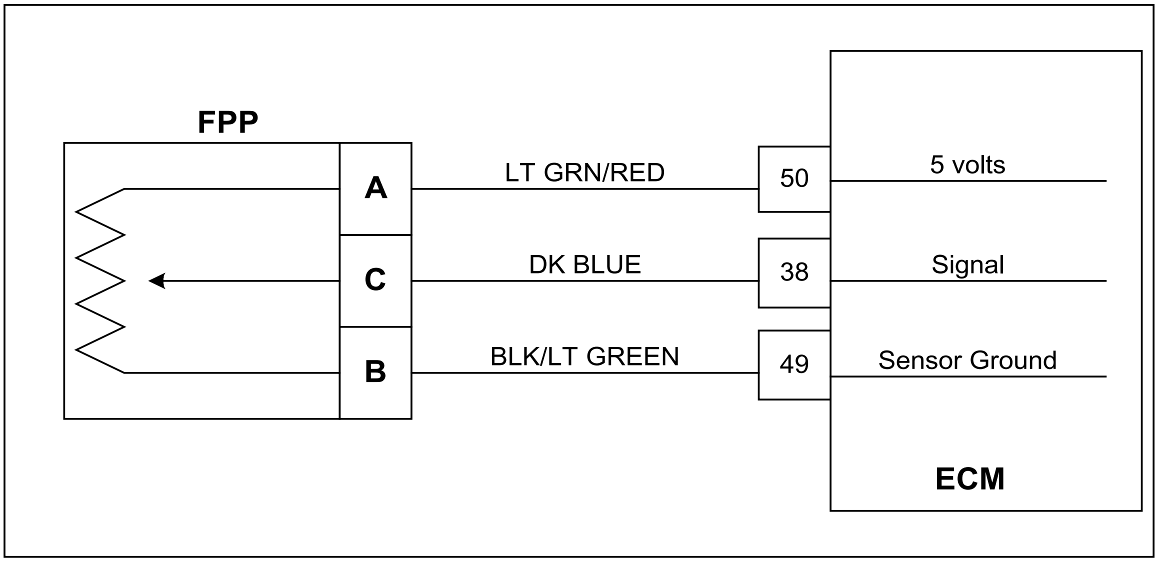
This fault will set if voltage is over 4.8 volts at any operating condition while the key is on. If the voltage exceeds 4.8, then FPP is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle. Rev limit is still enforced if the active fault is no longer present; the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.

DTC 611 FPP 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	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display FPP voltage of 4.8 volts or greater with the foot pedal in the idle position?		*Go to Step (8)*	Go to Step (3)
3	• Slowly increase FPP while observing FPP voltage Does DST FPP voltage ever exceed 4.8 volts?		*Go to step (4)*	*Intermittent problem* Go to Intermittent section
4	• Key OFF • Disconnect FPP sensor connector • Inspect connector and wire terminals for damage, corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (5)*
5	• Disconnect ECM connector C001 • Check continuity between FPP sensor connector ground pin B and ECM connector FPP sensor ground pin 49 Do have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Key ON • Using a DVOM check for voltage at ECM wire harness connector FPP signal pin 38 and ECM sensor ground terminal pin 49 Do you have voltage between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (7)*
7	• Using a DVOM check for voltage at ECM wire harness connector between ECM FPP signal pin 38 and engine ground Do you have voltage between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Intermittent problem* Go to Intermittent section
8	• Key OFF • Disconnect FPP sensor from wire harness • Key ON Does DSC display FPP voltage less than 0.2 volts?		*Go to Step (11)*	*Go to Step (9)*
9	• Disconnect ECM wire harness connector C001 • Using a DVOM check for voltage between the ECM FPP signal pin 38 and engine ground Do you have voltage between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (10)*
10	• Replace ECM Is the replacement complete?		*Go to Step (15)*	-

11	• Probe FPP sensor connector ground circuit pin B with a test light connected to battery voltage Does the test light come on?		*Go to Step (12)*	*Go to Step (14)*
12	• Key OFF • Disconnect ECM wire harness connector • Inspect the ECM wire harness 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 (13)*
13	• Replace FPP sensor Is the replacement complete?		*Go to step (15)*	-
14	• Key OFF • Disconnect ECM connector • Check continuity between FPP sensor connector ground pin B and ECM connector FPP sensor ground pin 49 Do have continuity between them?		*Go to Step (10)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-611 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 612-FPP Low Voltage



Conditions for Setting the DTC

- Foot Pedal Position
- Check Condition-Key On
- Fault Condition-FPP sensor voltage less than 0.2
- MIL-On during active fault and flashing at 2 Hz (twice per second) after active fault for the remainder of the key-on cycle
- Adaptive-Enabled
- Closed Loop-Enabled
- Power Derate (level 1) and Low Rev Limit enforced

Circuit Description

The Foot Pedal Position sensor uses a variable resistor to determine signal voltage based on pedal position. Less depression of pedal results in lower voltage, and greater depression results in higher voltage.

This fault will set if voltage is less than 0.2 volts at any operating condition while the key is on. If the voltage is less than 0.2, then FPP is considered to be out of specifications. At this point the ECM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level-1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The low rev limit is enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.

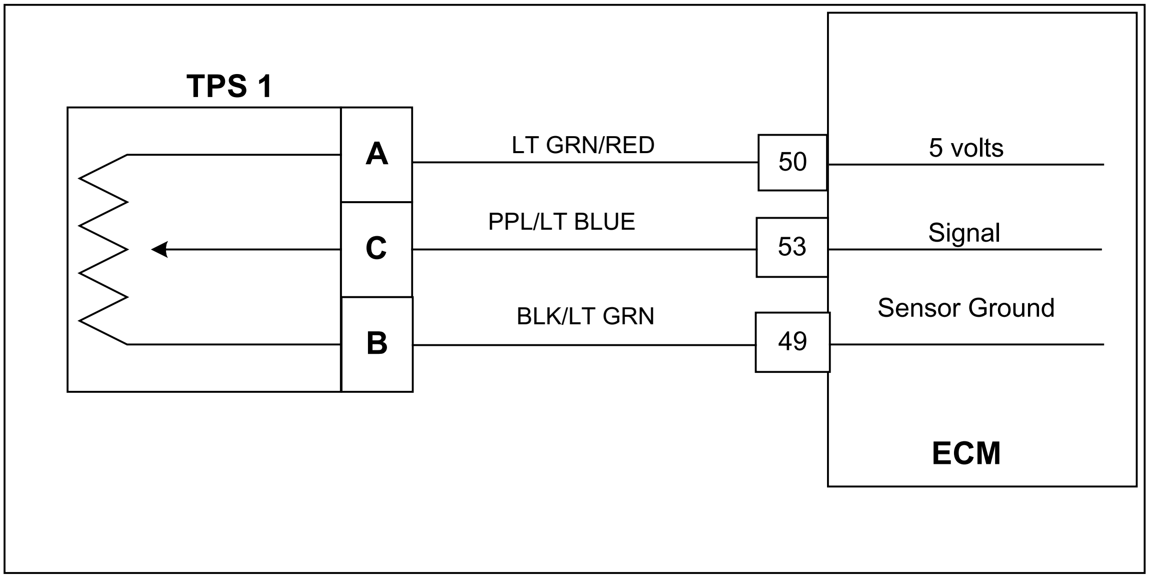
DTC 612 FPP Voltage Low

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, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display FPP voltage of 0.2 volts or less with the foot pedal in the idle position?		*Go to Step (7)*	Go to Step (3)
3	• Slowly depress FP while observing FPP voltage Does DST FPP voltage ever drop below 0.2 volts?		*Go to step (4)*	*Intermittent problem* Go to Intermittent section
4	• Key OFF • Disconnect FPP sensor connector • Inspect connector and wire terminals for damage, corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (5)*
5	• Key ON • Using A DVOM check for voltage at the FPP sensor connector between 5 volt reference pin A and FPP sensor ground pin B Do you have voltage between them?	5.0 Volts	*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace FPP Sensor Is the replacement complete?		*Go to Step (18)*	-
7	• Key OFF • Disconnect FPP Sensor from wire harness • Jumper 5 volt reference circuit pin A and FPP signal circuit pin C together • Key ON Does DST display FPP voltage of 4.8 volts or greater?		*Go to Step (8)*	*Go to Step (9)*
8	• Check FPP connector wire terminals for damage, corrosion or contamination? Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (6)*
9	• Probe FPP connector signal circuit pin C with a test light connected to battery voltage Does the DST display FPP voltage of 4.8 volts or greater?		*Go to Step (10)*	*Go to Step (14)*
10	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between FPP sensor connector 5 volt reference pin A and ECM connector 5 volt reference pin 50 Do you have continuity between them?		*Go to Step (11)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

11	• Using A DVOM check for continuity between ECM 5 volt reference pin 50 and engine ground Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (12)*
12	• Using a DVOM check for continuity between ECM connector 5 volt reference pin 50 and ECM sensor ground pin 49 Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (13)*
13	• Inspect FPP and ECM connector terminal terminals for damage, corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (17)*
14	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between FPP connector signal pin C and ECM connector FPP signal pin 38 Do you have continuity between them?		*Go to Step (15)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
15	• Using a DVOM check for continuity between ECM connector FPP signal pin 38 and engine ground Do you have continuity?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (16)*
16	• Using a DVOM check for continuity between ECM FPP signal pin 38 and ECM connector FPP sensor ground pin 49 Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (13)*
17	• Replace 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-612 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 631-TPS 1 Signal Voltage High



Conditions for Setting the DTC

- Throttle Position Sensor #1
- Check Condition-Cranking or Running
- Fault Condition-TPS sensor voltage exceeds 4.8
- MIL-On during active fault
- Engine Shut Down

Circuit Description

The Electronic Throttle has two counter acting Throttle Position Sensors. Two sensors are used for improved safety and redundancy. The Throttle Position sensor uses a variable resistor to determine signal voltage based on throttle plate position, and is connected to the throttle shaft. Less opening results in lower voltage, and greater opening in higher voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded.

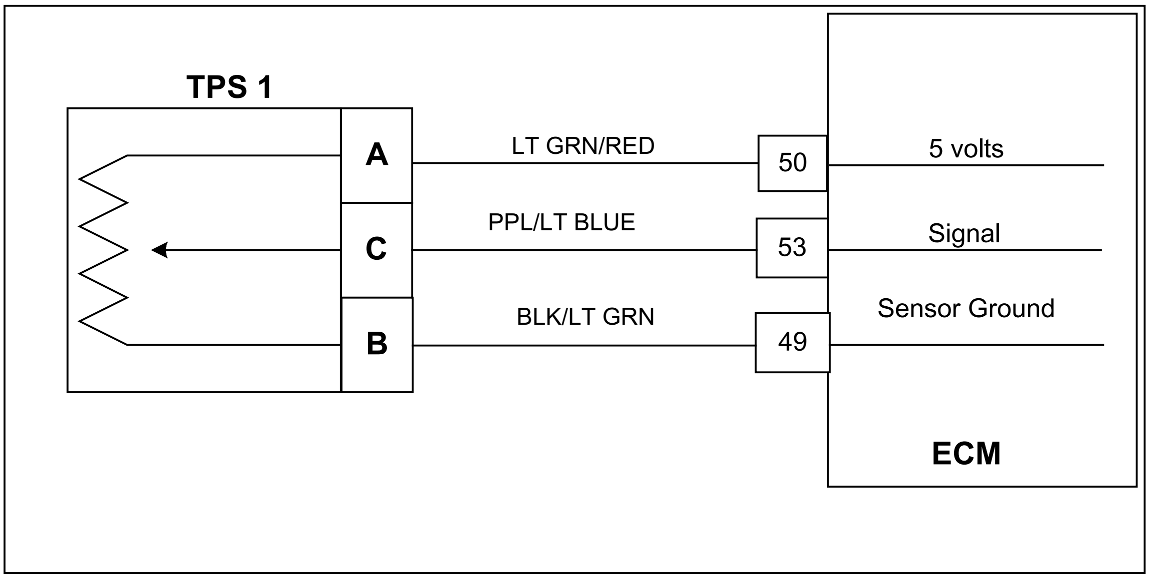
This fault will set if voltage is above 4.8 volts at any operating condition while the engine is cranking or running. The engine will not start or run during this active fault.

DTC 631 TPS 1 Signal 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	• Key ON, Engine OFF DST (Diagnostic Scan Tool) connected Does the DST display TPS 1 voltage of 4.8 volts or greater with the throttle closed		*Go to Step (4)*	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 1 voltage Does TPS 1 voltage ever exceed 4.8 volts?		*Go to Step (4)*	*Intermittent problem* Go to Intermittent section
4	• Key OFF • Disconnect TPS 1 electrical connector • Key ON Does DST display TPS 1 voltage less than 0.2 volts?		*Go to Step (7)*	*Go to Step (5)*
5	• Key OFF • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage between TPS 1 signal at the ECM connector pin 53 and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (6)*
6	• Replace ECM Is the replacement complete?		*Go to Step (11)*	-
7	• Back probe sensor ground circuit at the ECM side of the wire harness pin 49 with a test light connected to battery voltage Does the test light come on?		*Go to Step (8)*	*Go to Step (10)*
8	• Inspect the TPS 1 electrical 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 (9)*
9	• Replace TPS 1sensor Is the replacement complete?		*Go to Step (11)*	-
10	• Key OFF • Disconnect ECM connector • Using a DVOM check for continuity between the TPS 1 connector sensor ground pin B and ECM connector TPS 1 sensor ground pin 49 Do have continuity between them?		*Go to Step (6)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-631 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 632-TPS 1 Signal Voltage Low



Conditions for Setting the DTC

- Throttle Position Sensor #1
- Check Condition-Cranking or Running
- Fault Condition-TPS sensor voltage less than 0.2
- MIL-On during active fault
- Engine Shut Down

Circuit Description

The Electronic Throttle has two counter acting Throttle Position Sensors. Two sensors are used for improved safety and redundancy.

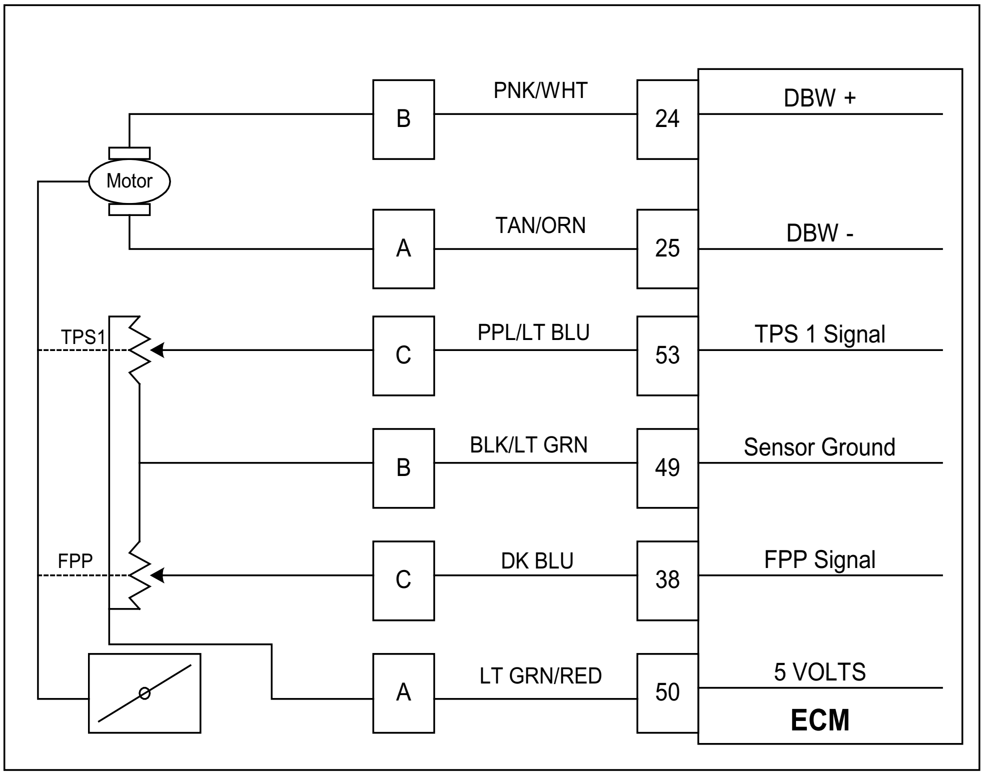
The Throttle Position sensor uses a variable resistor to determine signal voltage based on throttle plate position, and is located within the throttle. Less opening results in lower voltage, and greater opening in higher voltage. The TPS value is used by the ECM to determine if the throttle is opening as commanded.

This fault will set if voltage is less than 0.2 volts at any operating condition while the engine is cranking or running. The engine will not start or run during this active fault.

DTC 632 TPS 1 Signal Voltage 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, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive by Wire) throttle test mode Does the DST display TPS 1 voltage of 0.2 volts or less with the throttle closed		*Go to Step (4)*	Go to Step (3)
3	• Slowly depress Foot Pedal while observing TPS 1 voltage Does TPS 1 voltage ever fall below 0.2 volts?		*Go to Step (4)*	*Intermittent problem* Go to Intermittent section
4	• Key OFF • Disconnect the TPS 1 electrical connector • Jumper the 5 volt reference circuit pin A and TPS 1 signal circuit pin C together at the throttle connector • Key ON Does DST display TPS 1voltage of 4.0 volts or greater?		*Go to Step (7)*	*Go to Step (5)*
5	• Key OFF • Disconnect ECM wire harness connector Using a DVOM check continuity between TPS 1 connector signal pin C and ECM connector TPS 1 signal pin 53 Do have continuity between them?		*Go to Step (6)*	*Repair the circuit as necessary. Refer to Section 1C2 for wiring repairs*
6	• Replace ECM Is the replacement complete?		*Go to Step (9)*	-
7	• Inspect the throttle wire harness 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 (8)*
8	• Replace the TPS 1 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 operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-632 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 637-Throttle Unable To Open



Conditions for Setting the DTC

- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition-Throttle command is 20% more than actual throttle position
- MIL-On during active fault
- Adaptive-Enabled
- Closed Loop-Enabled
- Engine Shut Down

Circuit Description

There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded.

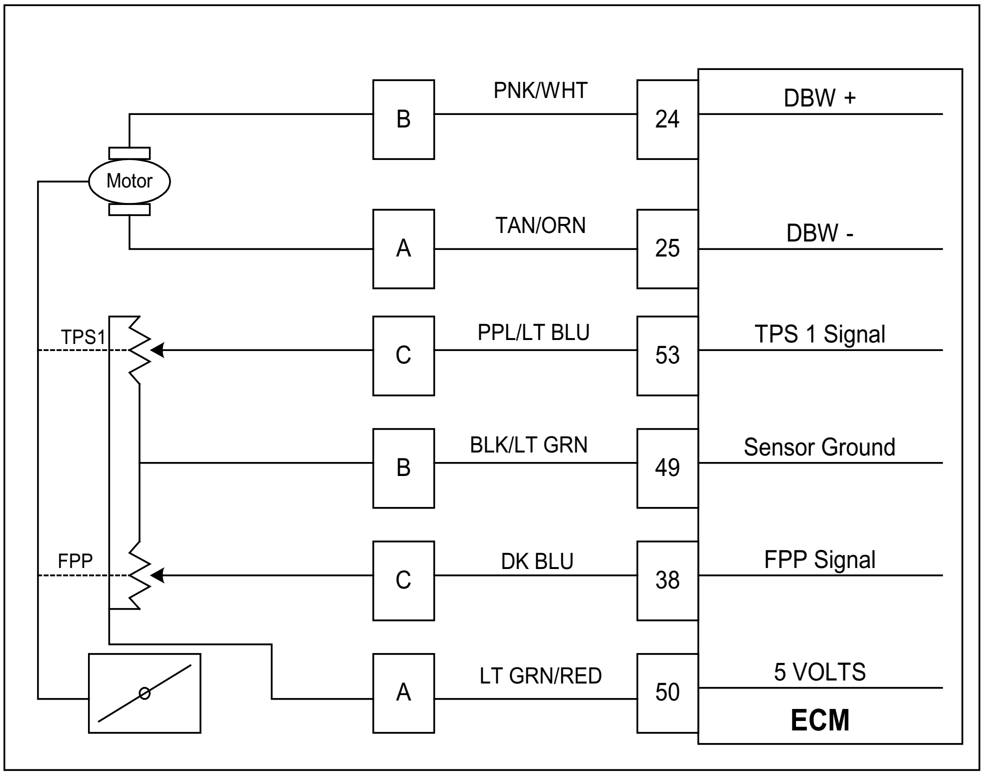
This fault will set if the throttle command is 20% or more than the actual throttle position. During this active fault the MIL light will be on and the engine will shut down.

DTC 637 Throttle Unable to Open

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive By Wire) test mode • Depress Foot Pedal until theThrottle Command is 63%-68% Is the TPS voltage less than 2.0 volts?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Key OFF • Disconnect wire harness connector from throttle • Probe TPS 1 signal circuit with test light connected to battery voltage • Key ON Is TPS voltage 4.0 volts or greater?		*Go to Step (4)*	*Go to Step (8)*
4	• Check throttle bore for foreign object Did you find a problem?		*Go to Step (5)*	*Go to step (6)*
5	• Remove the foreign object Has the object been removed?		*Go to Step (11)*	-
6	• Check 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 throttle Is the replacement complete?		*Go to Step (11)*	-
8	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between throttle connector TPS 1 signal terminal and ECM TPS 1 signal terminal Do you have continuity between them?		*Go to Step (9)*	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Using a DVOM check for continuity between throttle connector TPS 1 signal and engine ground Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (10)*
10	• Replace 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 vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-637 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 638-Throttle Unable To Close



Conditions for Setting the DTC

- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition-Throttle command is 20% less than throttle position for 200ms or longer
- MIL-On during active fault
- Adaptive-Enabled
- Closed Loop-Enabled
- Engine Shut Down

Circuit Description

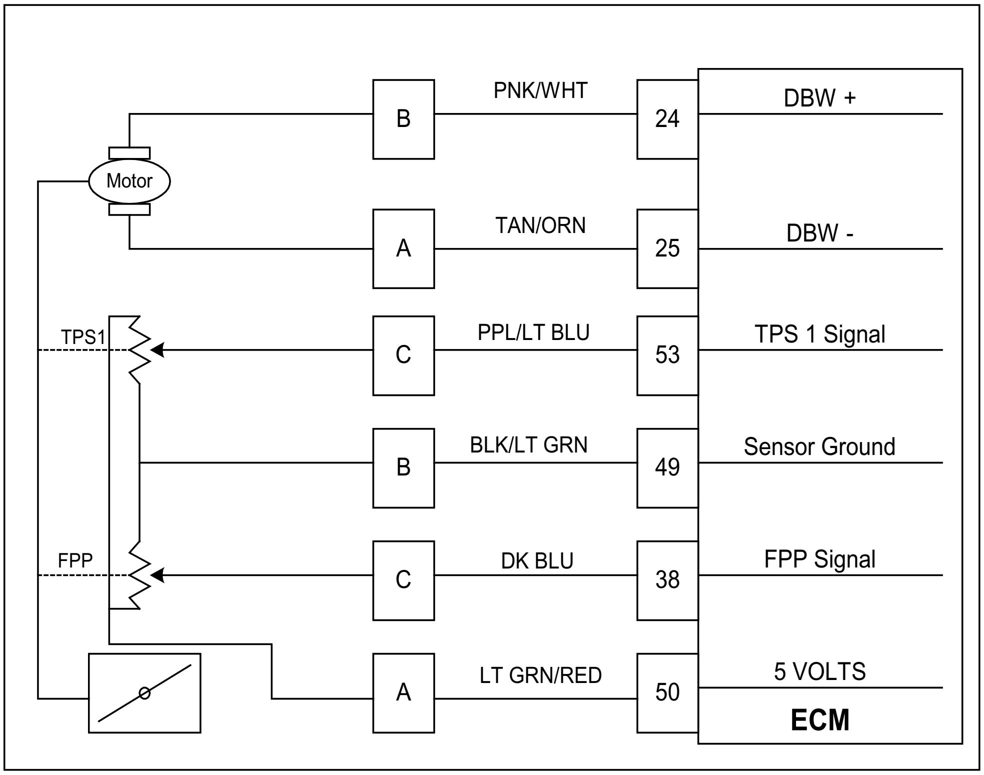
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 percentages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position percentages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded. This fault will set if the throttle command is 20% less than the actual throttle position. During this active fault the MIL light will be on and the engine will shut down.

DTC 638 Throttle Unable to Close

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key ON, Engine OFF • DST (Diagnostic Scan Tool) connected in DBW (Drive By Wire) test mode • Depress Foot Pedal until theThrottle Command is between 63%-68% Is the TPS 1 voltage greater than 2.0 volts?		*Go to Step (3)*	*Intermittent problem* Go to Intermittent section
3	• Key OFF • Disconnect wire harness connector from throttle • Probe TPS 1 signal circuit with test light connected to battery voltage • Key ON Does DST display TPS 1 voltage less than 0.2 volts		*Go to Step (6)*	*Go to Step (4)*
4	• Key OFF • Disconnect ECM wire harness connector • Key ON • Using a DVOM check for voltage between throttle connector signal terminal and engine ground Do you have voltage?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (5)*
5	• Replace ECM Is the replacement complete?		*Go to Step (13)*	-
6	• Back probe sensor ground circuit at ECM connector with test light connected to battery voltage Does the test light come on?		*Go to Step (9)*	*Go to Step (7)*
7	• Key OFF • Disconnect ECM wire harness connector • Using a DVOM check for continuity between throttle connector signal ground and ECM signal ground circuit terminals Do you have continuity between them?		*Go to Step (8)*	*Repair the circuit as necessary. Refer to Section 1C2 for wiring repairs*
8	• Replace ECM • Is the replacement complete?		*Go to Step (13)*	-
9	• Check throttle for foreign object in bore Did you find a foreign object in the bore?		*Go to Step (10)*	*Go to Step (11)*
10	• Remove foreign object Is the removal complete?		*Go to Step (13)*	-
11	• Inspect the throttle wire harness connector terminals for damage, corrosion or contamination Did you find the problem?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	*Go to Step (12)*
12	• Replace throttle Is the replacement complete?		*Go to Step (13)*	-

13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-638 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 651-Max Govern Speed Override



Conditions for Setting the DTC

- Max Govern Speed Override
- Check Condition- Engine Running
- Fault Condition- Engine RPM greater than 3800 for 2 seconds continuously
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled

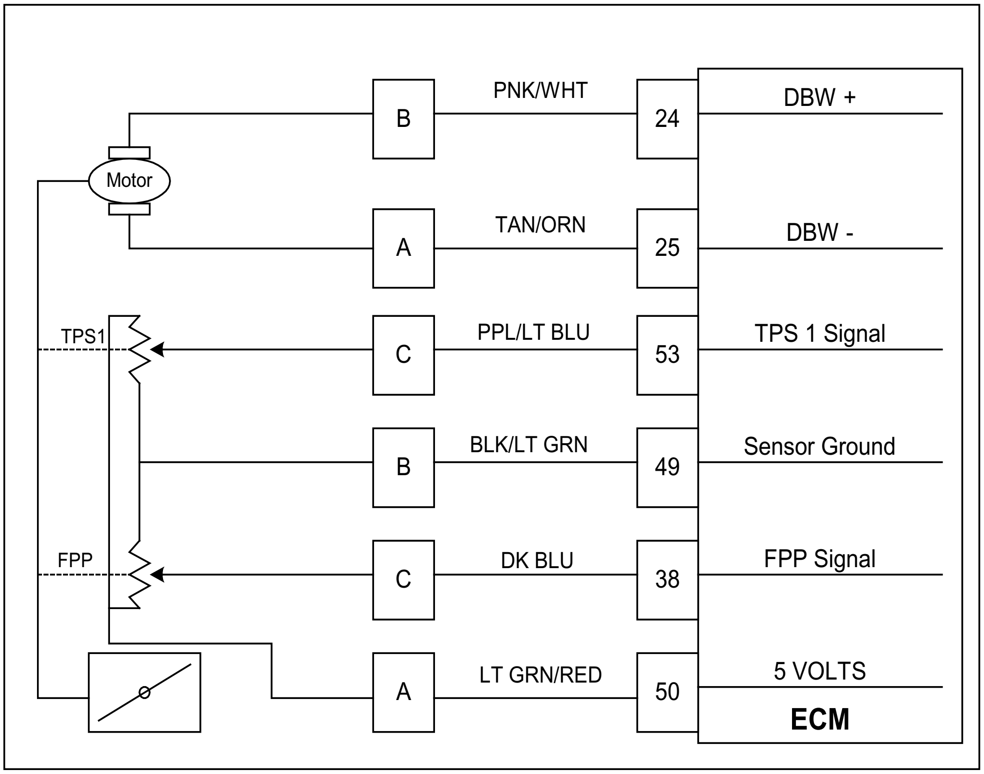
Circuit description

This fault will set anytime the engine RPM exceeds 3800 for 2 seconds or more continuously. This speed overrides any higher max governor speeds programmed by the user. This is to help prevent engine or equipment damage. The MIL will be on during this active fault.

DTC 651 Max Govern Speed Override

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key ON, Engine OFF • DST in Active Fault Mode Are any other DTC codes present with DTC 651?		*Go to Step (3)*	*Go to Step (4)*
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been diagnosed and repaired?		*Go to step (4)*	-
4	• Check the Service Part Number on the ECM to ensure correct calibration is in use Is the Service Part Number Correct?		*Go to Step (6)*	*Go to Step 5*
5	• Replace ECM with correct Service Part Number Is the replacement complete?		*Go to Step (9)*	-
6	• Check the mechanical operation of the throttle Is the mechanical operation of the throttle OK?		*Go to Step (8)*	*Go to Step (7)*
7	• Correct mechanical operation of the throttle. Refer to Engine & Component R&R Section 1E Has the mechanical operation of the throttle been corrected?		*Go to step (9)*	-
8	• Check engine for large manifold vacuum leaks. Refer to Fuel Systems Section 1B Symptom Diagnostics Did you find and correct the vacuum leak?		*Go to Step (9)*	*Go to OBD System Check Section*
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-651 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 652-Fuel Rev Limit



Conditions for Setting the DTC

- Fuel Rev Limit
- Check Condition- Engine Running
- Fault Condition- Engine RPM greater than 4000 for 2 seconds continuously
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled

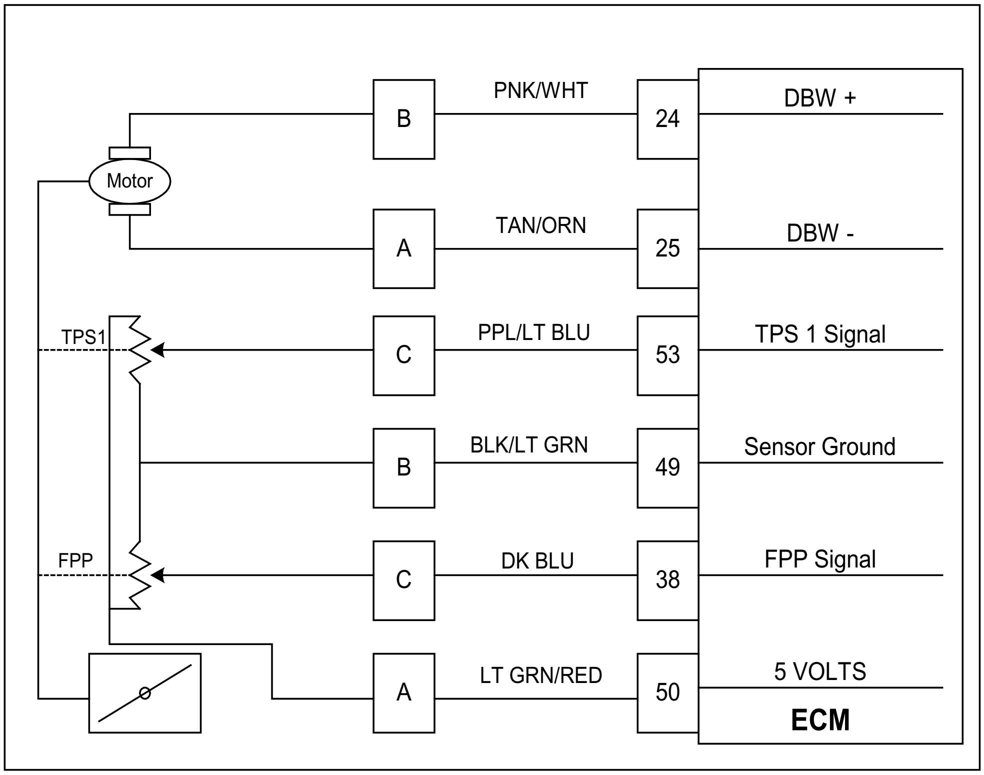
Circuit Description

This fault will set anytime engine RPM exceeds 4000 for 2 seconds or more continuously. When these conditions are met, the ECM shuts off the fuel injectors. This is to help prevent engine or equipment damage. The MIL will be on during this active fault.

DTC 652 Fuel Rev Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key ON, Engine OFF • DST in Active Fault Mode Are any other DTC codes present with DTC 651?		*Go to Step (3)*	*Go to Step (4)*
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been diagnosed and repaired?		*Go to step (4)*	-
4	• Check the Service Part Number on the ECM to ensure correct calibration is in use Is the Service Part Number Correct?		*Go to Step (6)*	*Go to Step 5*
5	• Replace ECM with correct Service Part Number Is the replacement complete?		*Go to Step (9)*	-
6	• Check the mechanical operation of the throttle Is the mechanical operation of the throttle OK?		*Go to Step (8)*	*Go to Step (7)*
7	• Correct mechanical operation of the throttle. Refer to Engine & Component R&R Section 1E Has the mechanical operation of the throttle been corrected?		*Go to step (9)*	-
8	• Check engine for large manifold vacuum leaks. Refer to Fuel Systems Section 1B Symptom Diagnostics Did you find and correct the vacuum leak?		*Go to Step (9)*	*Go to OBD System Check Section*
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-652 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

DTC 653-Spark Rev Limit



Conditions for Setting the DTC

- Spark Rev Limit
- Check Condition- Engine running
- Fault Condition- Engine RPM greater than 4100 for 2 seconds continuously
- MIL- On during active fault
- Adaptive- Enabled
- Closed Loop- Enabled

Circuit description

This fault will set anytime the engine RPM exceeds 4100 for 2 seconds or more continuously. When these conditions are met, the ECM will shut off spark to the engine. This is to help prevent engine or equipment damage. The MIL will be on during this active fault.

DTC 653 Spark Rev Limit

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	*Go to Step (2)*	*Go to OBD System Check Section*
2	• Key ON, Engine OFF • DST in Active Fault Mode Are any other DTC codes present with DTC 651?		*Go to Step (3)*	*Go to Step (4)*
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been diagnosed and repaired?		*Go to step (4)*	-
4	• Check the Service Part Number on the ECM to ensure correct calibration is in use Is the Service Part Number Correct?		*Go to Step (6)*	*Go to Step 5*
5	• Replace ECM with correct Service Part Number Is the replacement complete?		*Go to Step (9)*	-
6	• Check the mechanical operation of the throttle Is the mechanical operation of the throttle OK?		*Go to Step (8)*	*Go to Step (7)*
7	• Correct mechanical operation of the throttle. Refer to Engine & Component R&R Section 1E Has the mechanical operation of the throttle been corrected?		*Go to step (9)*	-
8	• Check engine for large manifold vacuum leaks. Refer to Fuel Systems Section 1B Symptom Diagnostics Did you find and correct the vacuum leak?		*Go to Step (9)*	*Go to OBD System Check Section*
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-653 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	*Go to OBD System Check*

GENERAL INFORMATION

English and Metric Fasteners

CAUTION

Late model engines use a combination of English and Metric threaded fasteners. The components effected are starter motor, engine mounts, and flywheel housing mounting. Verify that the proper fasteners are used whenever removing or replacing one of these components.

CRANKING CIRCUIT

The cranking circuit consists of the battery, starter motor, and ignition switch.

STARTER MOTOR

Two different starter motors are used on GM engines. The SD300 is a straight drive starter with the pinion driven directly by the armature shaft. Each starter has pole pieces arranged around the armature that are energized by wound field coils.

The PG260 achieves gear reduction at a ratio of 5:1 through planetary gears. It's relatively small size and light weight offers improved cranking performance and reduced current requirements.

Solenoid windings are energized when the ignition switch is in the start position. The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear, the solenoid main contacts to close, and cranking takes place. When the engine starts, the pinion overrunning clutch protects the armature from excessive speed until the ignition switch or engine control switch is released, at the time the plunger return spring causes the pinion to disengage. To prevent excessive overrunning, release the ignition switch or engine control switch from the crank position as soon as the engine starts.

DIAGNOSIS

Before removing any unit in a cranking circuit for repair, the following checks should be made:

Battery - Refer to the appropriate service manual to determine battery condition.

Wiring - Inspect wiring for damage. Inspect all connections to the starter motor, solenoid, ignition switch, battery and all ground connections. Clean and tighten all connections as required.

Starter Solenoid and Ignition Switch - Inspect to determine their condition.

Starter Motor Noise - To correct starter motor noise during starting, use the following procedure:

1. Refer to Starter Motor Noise Diagnosis Chart in this Section to determine the problem.
2. When starter motor noise diagnosis indicates that the pinion should be closer to the flywheel, check to make sure the proper starter motor was installed. When initial starter motor installation is performed, shim(s) are not used.
3. When starter motor noise diagnosis indicates that the pinion should be moved away from the flywheel, add 0.015 inch double shims until noise disappears (do not exceed 0.045 inches).

Starter Motor - If the battery, wiring and switches are in satisfactory condition, and the engine is known to be functioning properly, remove the motor and refer to Starter Motor Disassembly, Test and Assembly procedures in the appropriate Section. Never operate the starter motor more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating, caused by excessive cranking, seriously damages the starer motor.

STARTER MOTOR NOISE DIAGNOSIS CHART

PROBLEM	POSSIBLE CAUSE	CORRECTION
High-pitched whine during cranking (before engine fires) but engine cranks and fires normally.	Distance too great between the starter pinion and the flywheel.	Remove shims at the starter mount if installed. Refer to "Starter Motor Noise" in this section.
High-pitched whine after the engine fires as key is being released. The engine cranks and fires normally. This complaint is often diagnosed as "starter hang-in" or "solenoid weak."	Distance too small between the starter pinion and the flywheel. Flywheel runout contributes to the intermittent nature of the problem.	Add shims at the starter mount. Refer to "Starter Motor Noise" in this section.
A loud "whoop" after the engine fires but while the starter is still held engaged. Sounds like a siren if the engine is revved while the starter is engaged.	Usually due to a worn starter motor clutch.	Remove the starter motor and check the clutch.
A "rumble," "growl" or in severe cases a "knock" as the starter is coasting down to a stop after starting the engine.	Usually due to a bent or unbalanced starter armature.	Remove the starter motor and check the armature.

131-075

SD300 STARTER MOTOR

IDENTIFICATION

Figure 4-1

The starter identification number is stamped into the starter-motor end cap (figure 4-1). Always refer to this number when servicing or ordering parts.

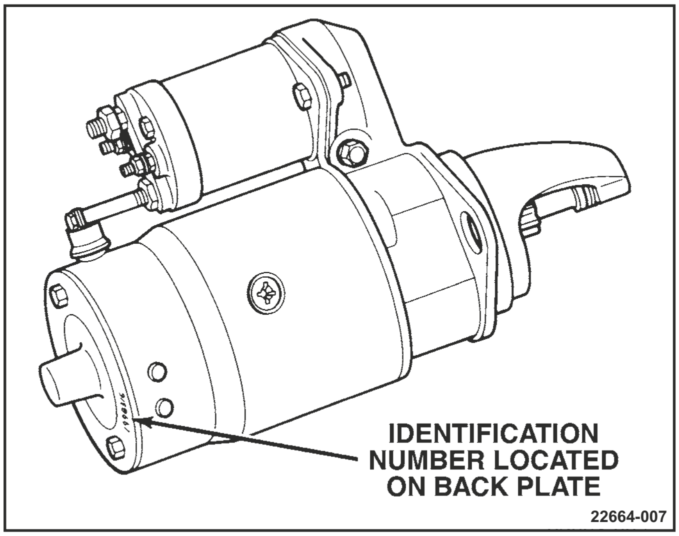


Figure 4-1 *Starter Motor I.D. Number*

STARTER MOTOR MAINTENANCE

The starter motor and solenoid are completely enclosed in the drive housing to prevent entrance of moisture and dirt. Periodic inspection, however, is required as follows:

1. Inspect terminals for corrosion and loose connections.
2. Inspect wiring for frayed and worn insulation.
3. Check the mounting bolts for tightness.

STARTER MOTOR REMOVAL

WARNING

Disconnect battery cables at battery before removing starter.

1. Disconnect battery cables from battery.
2. Disconnect wires from starter solenoid terminals.
3. Remove starter mounting nuts.
4. Pull starter assembly away from flywheel and remove it from engine.

STARTER MOTOR DISASSEMBLY

Figure 4-2 through 4-4

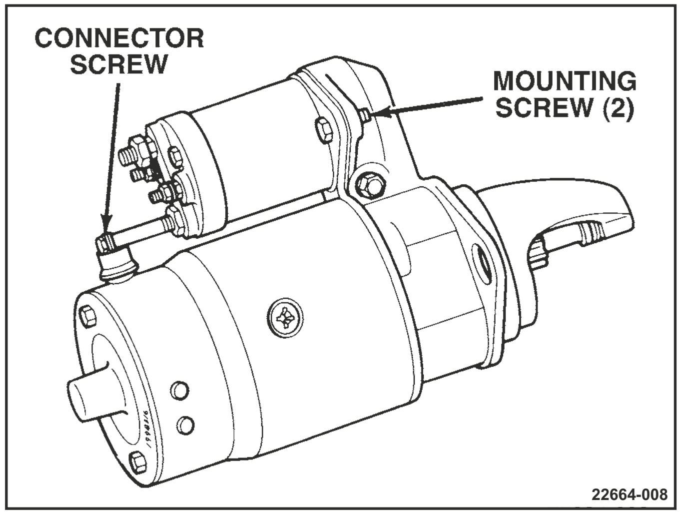


Figure 4-2 *Solenoid Screw Removed*

1. Remove solenoid switch and mounting screws (figure 4-2).
2. Remove screw from solenoid connector.
3. Rotate solenoid housing and remove solenoid and plunger spring.
4. Remove end cap through-bolts, end cap, washer and field frame (figure 4-3).
5. Remove center bearing-plate screws and remove armature from housing (figure 4-4).
6. Slide thrust collar off armature shaft.
7. Drive retainer ring collar toward armature.

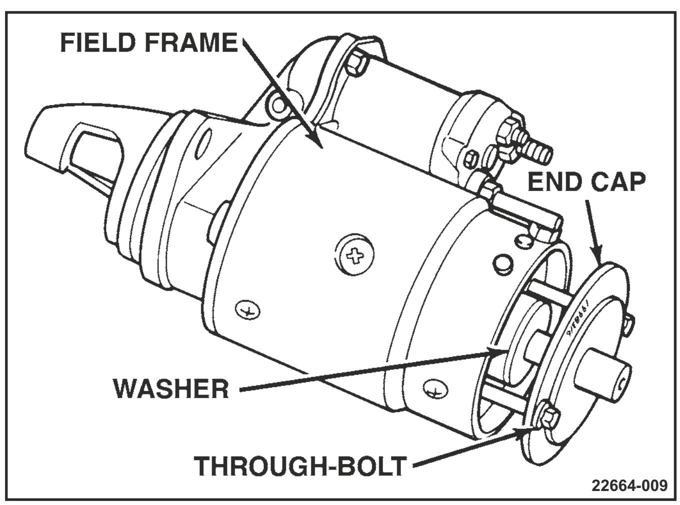


Figure 4-3 *End Frame Removal*

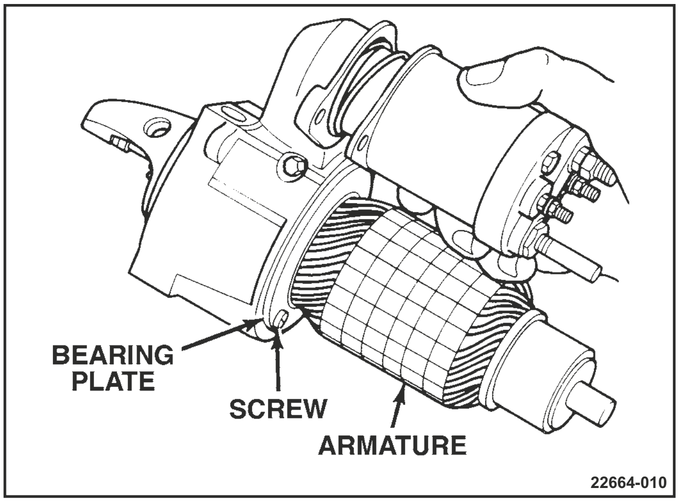


Figure 4-4 *Bearing Plate and Armature*

8. Remove snap ring, retaining collar, clutch assembly and bearing plate.

CLEANING AND INSPECTION

With the starter motor completely disassembled, except for removal of field coils, component parts should be cleaned and inspected. Field coils should be removed only when defects are indicated by tests. Defective parts should be replaced or repaired.

1. Clean all starter motor parts. Do not use dissolving agents for cleaning overrunning clutch, armature and field coils. Such a solvent would dissolve grease packed in clutch mechanism and damage armature and field-coil insulation.
2. Test overrunning clutch action. Pinion should turn freely in overrunning direction and must not slip in cranking direction. Check pinion teeth. Check spring for tension and drive collar for wear. Replace if necessary.
3. Check that brush holders are not damaged or bent and will hold brushes against commutator.
4. Check brushes. Replace if pitted or worn to one-half their original length (5/16 in. [8 mm] or less).
5. Check fit of armature shaft in bushing of drive housing. Shaft should fit snugly. Replace bushing if worn. Apply SAE 20 oil to bushing before reassembly. Avoid excessive lubrication.
6. Check fit of bushing in commutator end cap. If bushing is damaged or worn excessively, replace end cap assembly. Apply SAE 20 oil to bushing before reassembly. Avoid excessive lubrication.
7. Inspect armature commutator. If rough or out-of-round, turn down and undercut. Inspect points where armature conductors join commutator bars for good, firm connection. Burned commutator bar usually is evidence of poor connection.

ARMATURE TESTS

Figure 4-5

Test For Short Circuits

Check armature for short circuits by placing on growler and holding hacksaw blade over armature core while rotating armature (figure 4-5). If saw blade vibrates, armature is shorted. After cleaning between commutator bars, recheck. If saw blade still vibrates, replace armature.

Test For Grounded Circuit

1. With continuity meter, place one lead on armature core or shaft and other lead on commutator.
2. If meter needle moves, armature is grounded and must be replaced.

FIELD COIL TESTS

Figures 4-6 and 4-7

Test For Open Circuit

1. With continuity meter, place one lead on each end of field coils (insulated brush and field connector bar) (figure 4-6).
2. If meter does not move, field coils are open and must be replaced.

Test For Ground

IMPORTANT: Be sure that positive brushes and leads do not contact field frame assembly during test, or false reading will result.

1. With continuity meter, place one lead on field connector bar and other lead on grounded brush (figure 4-7).
2. If meter needle moves, field coils are grounded and must be replaced.

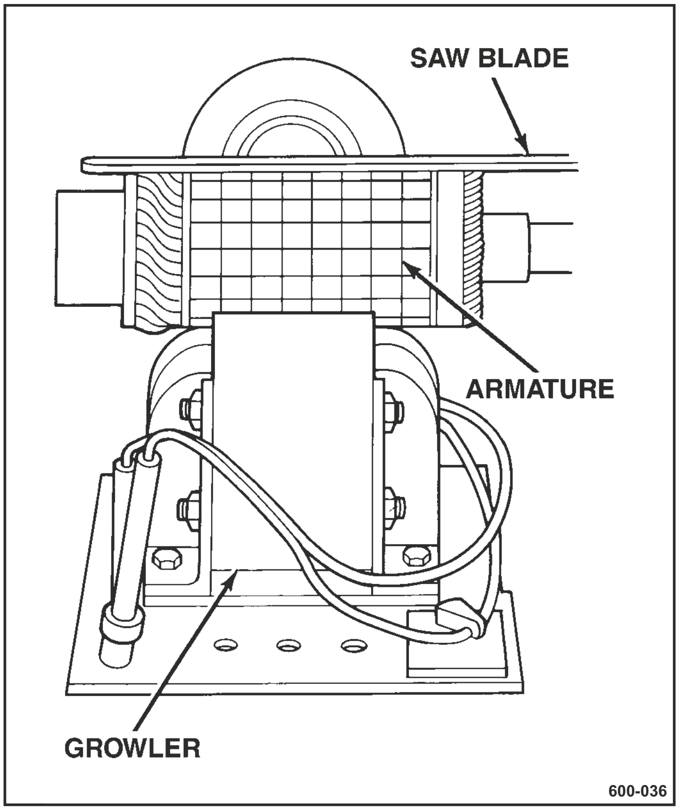


Figure 4-5 *Testing Armature for Short Circuits*

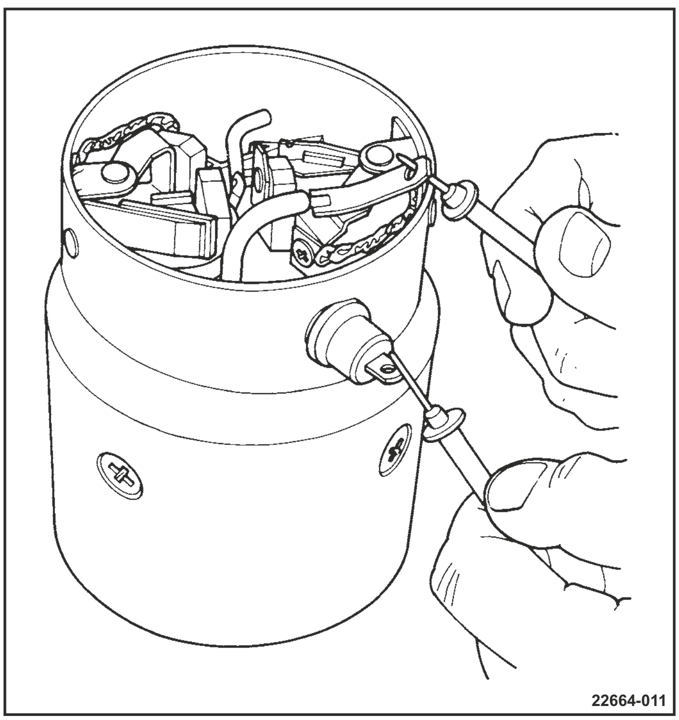


Figure 4-6 *Testing Field Coils for Circuit*

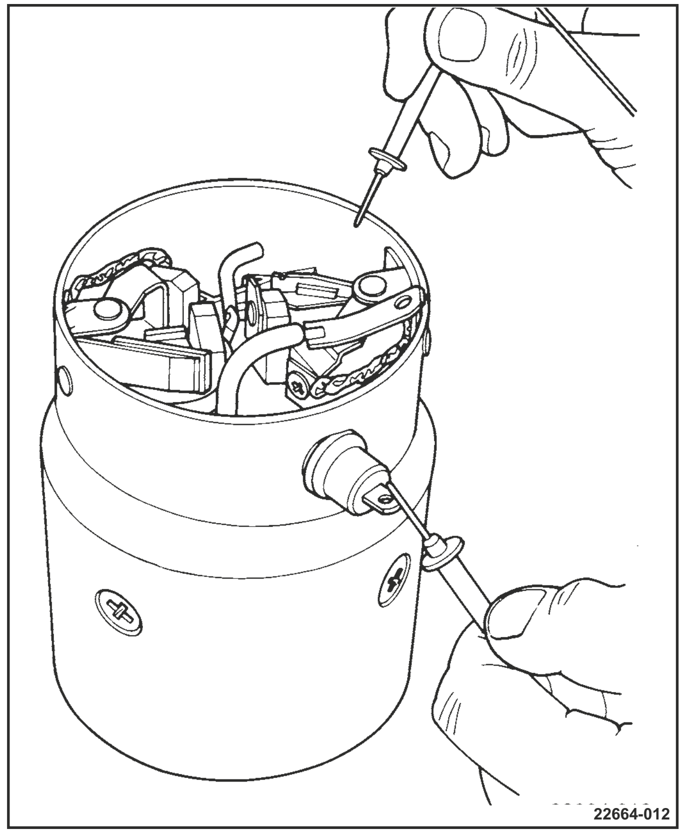


Figure 4-7 *Testing Field Coil for Grounded Circuit*

LOOSE ELECTRICAL CONNECTIONS

If an open soldered connection of armature-to-commutator leads is found during inspection, resolder it with resin flux.

IMPORTANT: Never use acid flux on electrical connections.

Turning the Commutator

When inspection shows commutator roughness, clean as follows:

1. Turn down commutator in a lathe until thoroughly cleaned.
2. Recheck armature for shorts as outlined.

STARTER MOTOR ASSEMBLY

Figure 4-8

After all parts are thoroughly tested and inspected, and worn or damaged parts replaced, reassemble starter as follows:

1. Assemble brushes and related parts to field frame as follows:
   A. Assemble brushes to brush holders. Attach ground wire to grounded brush and field lead wire to insulated brush.
   B. Assemble insulated and grounded brush holders together with V-spring. Position as a unit and install support pin. Push holders and spring to bottom of support and rotate spring to engage center of V-spring in slot of support.
2. Assemble overrunning clutch assembly to armature shaft as follows (figure 4-8):
   A. Lubricate drive end of armature shaft with SAE 10 oil.
   B. Install bearing plate, washer and clutch assembly onto armature shaft with pinion outward.
   C. Slide retaining collar onto shaft with cupped surface facing end of shaft away from pinion.
   D. Drive snap ring onto shaft and slide down into groove.
   E. Assemble the thrust collar on shaft with shoulder next to snap ring.
   F. Place thrust collar and retaining collar next to snap ring. Using two pliers, squeeze both until snap ring is forced into retainer.
3. Place four or five drops of light engine oil in drive housing bushing. Slide armature and clutch assembly into place while engaging shift lever with clutch. Install center bearing attaching screws and tighten securely.
4. Position field frame over armature. Carefully apply liquid neoprene between frame and drive housing. Use caution to prevent damage to brushes.
5. Place four or five drops of light engine oil in bushing in commutator end frame. Place washer and commutator end-frame onto shaft.

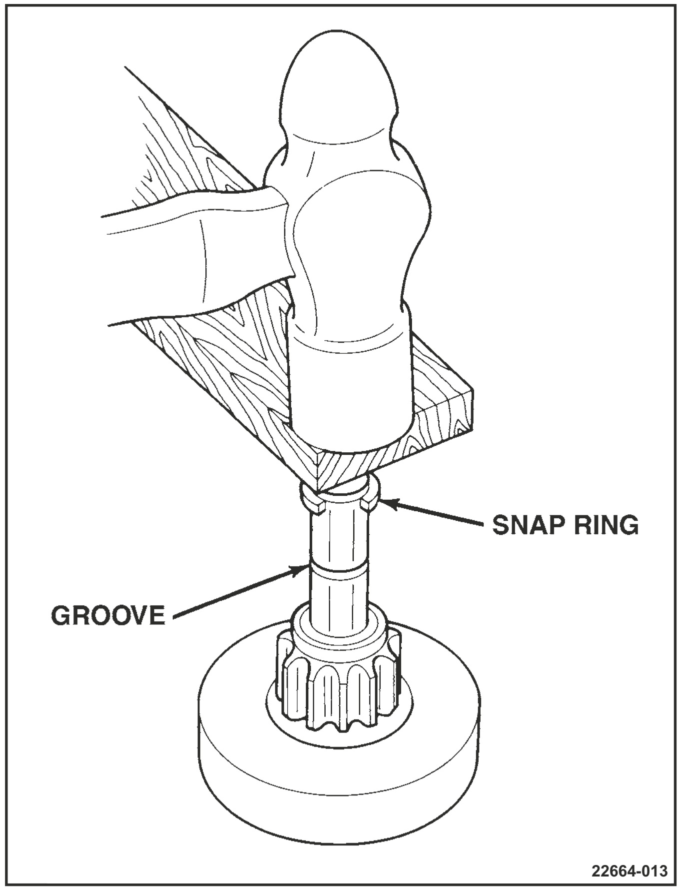


Figure 4-8 *Assembling Overrunning Clutch to Armature*

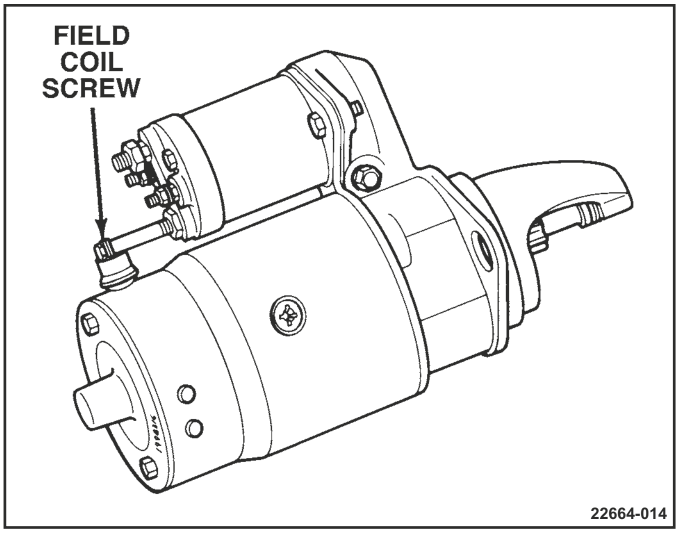


Figure 4-9 *Disconnecting Field Coil From Solenoid Strap*

6. Install through-bolts and tighten securely.
7. Install solenoid return spring on plunger.
8. Position solenoid assembly to starter motor end-frame and turn solenoid to engage flange in slot.
9. Install screws which hold solenoid assembly to end frame and tighten securely.
10. Install field coil screw and tighten securely.

STARTER MOTOR ADJUSTMENTS

Figures 4-9 through 4-11

Pinion Clearance

Pinion clearance must be checked as follows after reassembly of motor to insure proper adjustment:

1. Disconnect motor field coil connection from solenoid motor terminal and insulate it carefully (figure 4-9).
2. Connect 12-volt battery from solenoid switch terminal to solenoid frame.

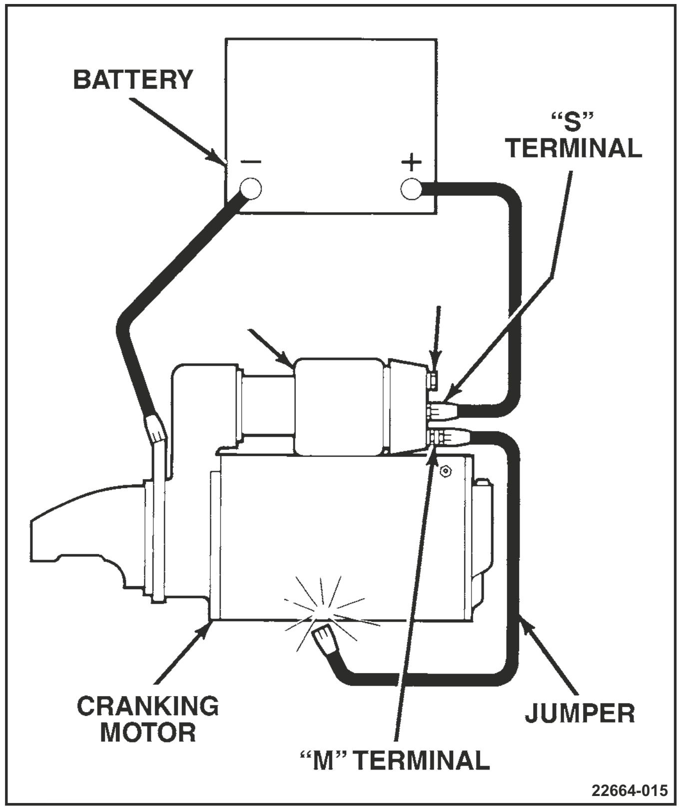


Figure 4-10 *Shifting Starter Pinion to Check Clearance*

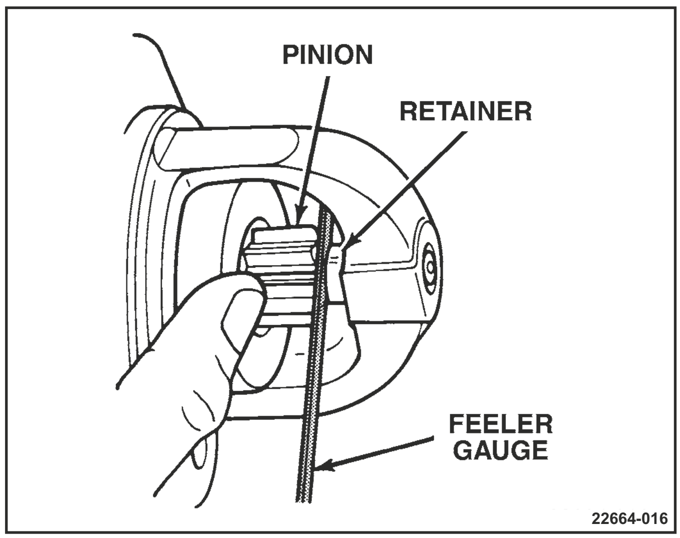


Figure 4-11 *Checking Starter Pinion Clearance*

3. Momentarily touch a jumper lead from solenoid motor terminal to starter motor frame (figure 4-10). This shifts pinion into cranking position where it will remain until battery is disconnected.
4. Push pinion back toward commutator end to eliminate slack (figure 4-11).
5. Use feeler gages to check clearance

between end of pinion and pinion stop retainer. Clearance should be 0.25 to 4.06 mm (0.010 to 0.160 in.).

6. Disconnect negative (ground) lead from motor housing (drive pinion will retract into drive end housing), then disconnect positive lead from “S” terminal.
7. When clearance is outside specifications, recheck motor for proper assembly and for worn or damaged parts in shift mechanism and drive assembly. Replace worn parts.

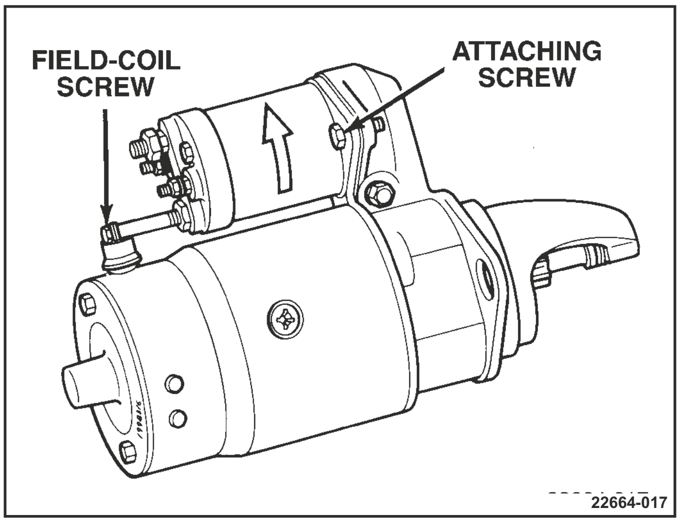


Figure 4-12 *Field Coil-to-Solenoid Strap Removal*

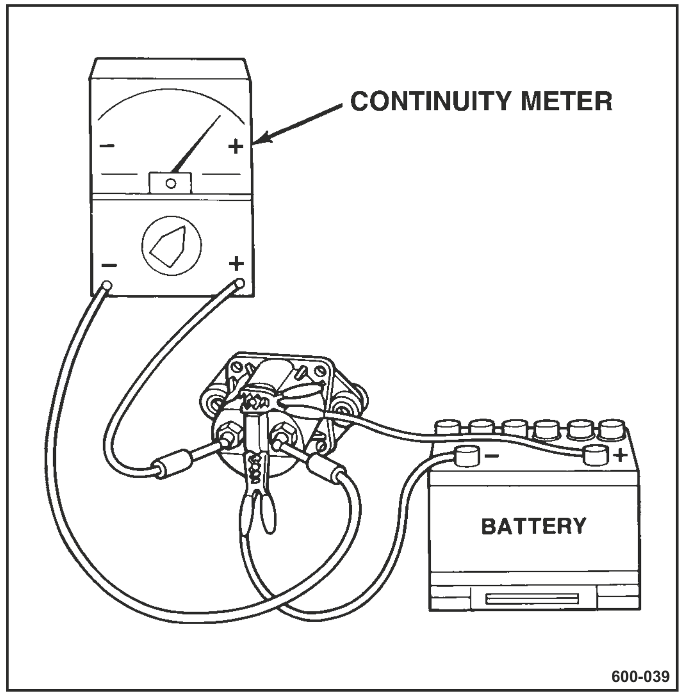


Figure 4-13 *Testing Standard Solenoid, Four Connection Type*

STARTER MOTOR INSTALLATION

1. Place starter motor and solenoid assembly in position and install attaching nuts. Torque to specifications.
2. Fasten wires as outlined in wiring diagram.

SOLENOID REMOVAL

Figure 4-12

1. Disconnect battery cables from battery.
2. Disconnect wires from solenoid terminals.
3. Remove screw from field coil connector and solenoid attaching screws (figure 4-12).
4. Twist solenoid to disengage tab and remove.

SOLENOID SWITCH INSTALLATION

1. Place plunger spring over plunger. Install solenoid onto plunger.
2. Twist solenoid to engage lock tab.
3. Install attaching screws and tighten securely.
4. Install field coil connector screw and tighten securely.
5. Connect solenoid wires and battery cables.

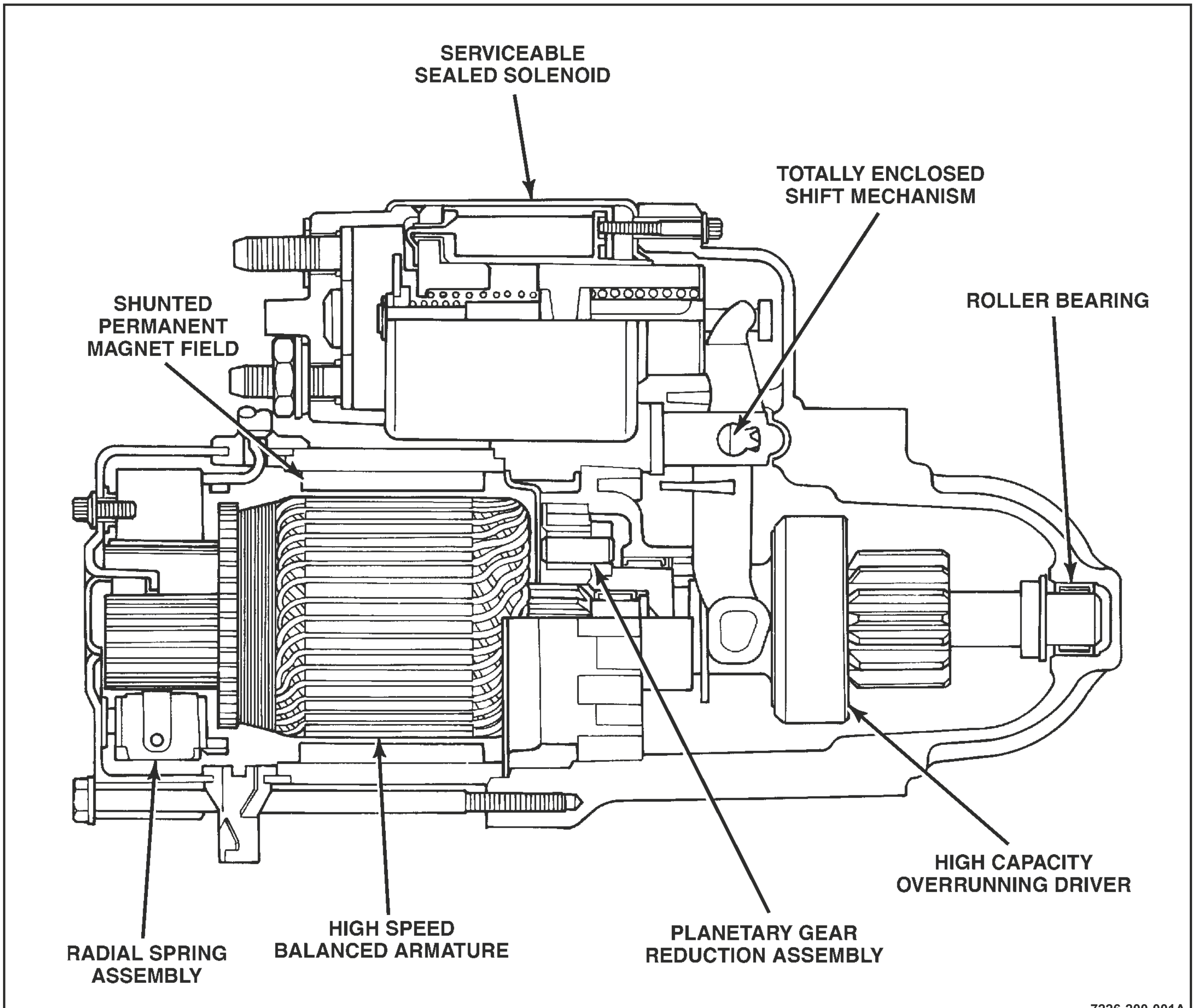


Figure 4-14 Cross Section of PG260 Starter Motor

SOLENOID SWITCH TESTING

Figure 4-13

1. Using continuity meter, connect test leads as shown in figure 4-13, and connect 12-volt battery with jumper leads.
2. If no meter movement is present, replace solenoid.

PG260 STARTER MOTOR

IDENTIFICATION

Figure 4-14

The PG260 starter motor can easily be identified by the 3 Torx® bolts that retain the solenoid to the drive end housing. The starter motor features small permanent magnets mounted inside the field frame. A permanent magnet motor is about half the weight and size of a field coil motor having the same cranking performance. The drive housing encloses the shift lever, the shift lever mechanism, and the solenoid plunger to protect them from exposure to dirt, icing conditions, and splash.

LUBRICATION

Starter motors do not require lubrication except during overhaul.

SOLENOID REPLACEMENT

When a "no crank and no sound" starter conditions exists, check solenoid before disassembling starter. Solenoid can be checked without removal. Refer to "Cleaning, Inspection and Testing" in this Section. Solenoid can be serviced separately from the drive and housing. Refer to Starter Motor Disassembly and Starter Motor Assembly in this Section.

STARTER REPLACEMENT

Remove or Disconnect

1. Negative battery cable.
2. Bolts to flywheel inspection cover.
3. Starter wiring.
4. Flywheel inspection cover.
5. Starter mounting bolts.
6. Starter.

Install or Connect

NOTICE: Before installing starter motor to engine, tighten inner nuts on solenoid terminals to be sure they are secure in cap. Tighten inner nuts on battery terminal and motor terminal to 10 N•m (88 lb. in.). If nuts are not properly tightened, starter may fail later due to terminal or cap damage.

1. Starter.
2. Starter mounting bolts.

Tighten

- Bolts to 30 N•m (22 lb. ft).

3. Starter wiring.

Tighten

- Nut on solenoid battery terminal to 8 N•m (71 lb. in.).
- Nut on "S" terminal to 3 N•m (26 lb. in.).

4. Flywheel inspection cover.

Tighten

- Bolts to 7 N•m (62 lb. in.).

5. Negative battery cable.

Tighten

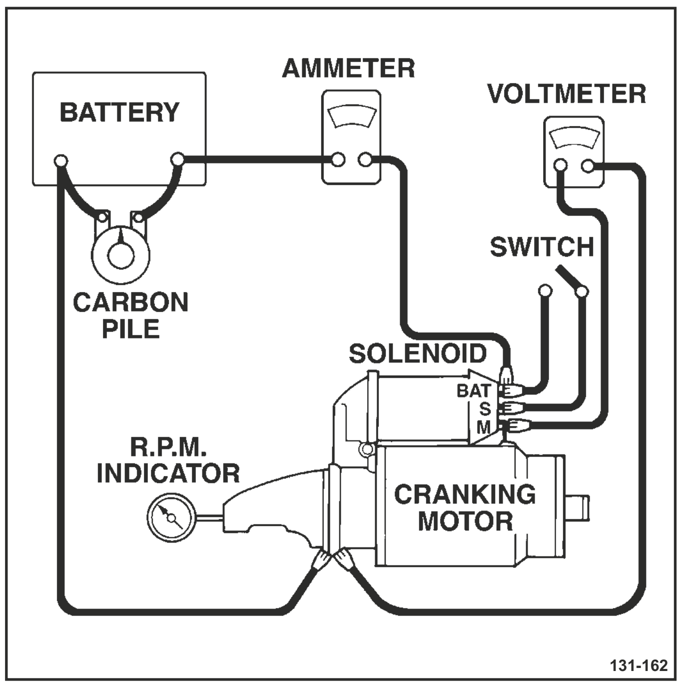


Figure 4-15 *No Load Test (Typical)*

- Cable bolt to 15 N•m (11 lb. ft.).

NO LOAD TEST

Figure 4-15

With the starter motor removed from the engine, the pinion should be checked for freedom of rotation by turning it on the shaft. The armature should be checked for freedom of rotation by prying the pinion with a screwdriver. If the armature does not turn freely, The motor should be disassembled immediately. However, if the armature does rotate freely, the motor should be given a no-load test before disassembly.

Make connections as shown in figure 4-15. Close the switch and compare RPM, current and voltage readings with the specifications.

If the specified current draw does not include the solenoid, deduct from the armature reading the specified current draw of the solenoid hold-in winding. Make disconnections only with the switch open. Use the test results as follows:

1. Rated current draw and no-load speed indicates normal condition of the starter motor.
2. Low free speed and high current draw indicates:
   - Too much friction - tight, dirty or worn bearings, bent armature shaft allowing armature to drag.
   - Grounded armature. This can be further checked on a growler after disassembly.
3. Failure to operate with high current draw indicates:
   - A direct ground in the terminal.
   - “Frozen” bearings.
4. Failure to operate with no current draw indicates:
   - Open brush circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.
   - Open armature coils. Inspect the commutator for badly burned bars after disassembly.
   - Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.
5. Low no-load speed and low current draw indicates:
   - High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under number 4.
6. High free speed and high current draw may indicate shorted armature, Check for shorted armature using a growler.

STARTER MOTOR DISASSEMBLY

Figure 4-16

Refer to “Specifications” in this section for application.

Remove or Disconnect

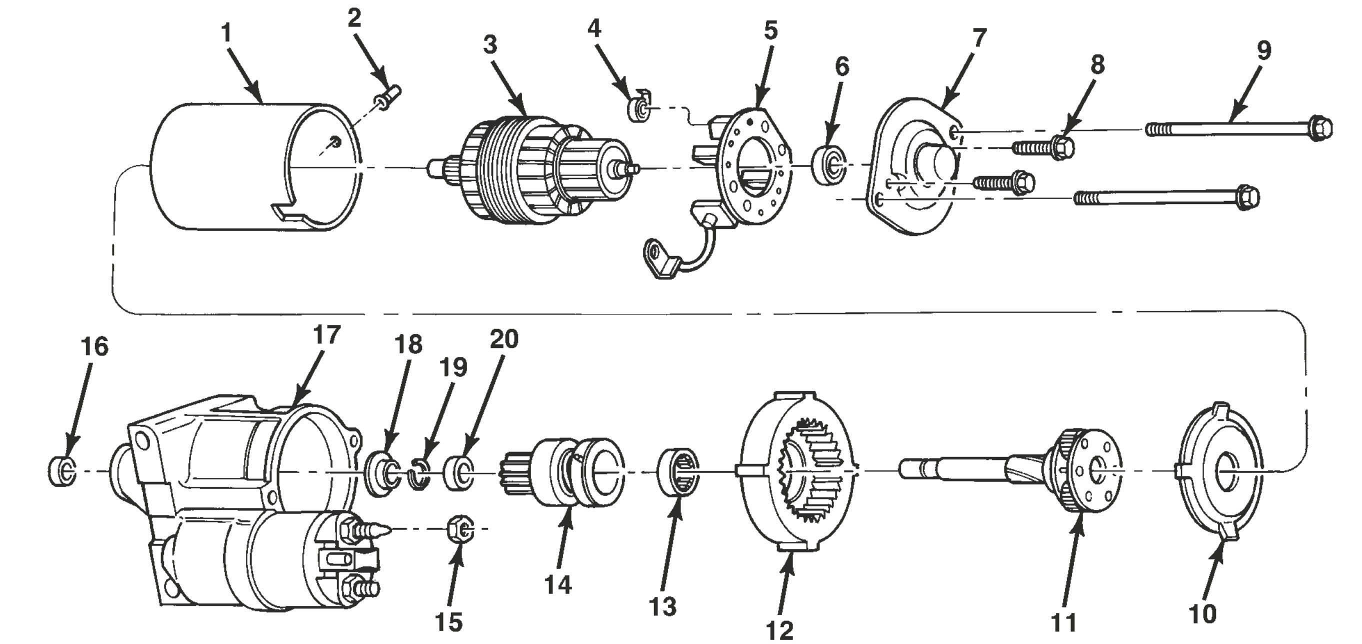
1. Lead from solenoid terminal.
2. Solenoid retaining bolts.
3. Through bolts.
4. Screws and commutator end frame from motor assembly (brush assembly and bearing remain on armature).

> **CAUTION**
>
> Magnets in frame have strong attraction to metal parts. Keep fingers clear of pinch points to avoid personal injury.

5. Armature from field frame.
6. Frame and shield from drive end housing assembly.
7. Use J 28509-A or equivalent to pull bearing from armature. The bearing is press fit over shaft.

NOTICE: Before removing, lift each brush spring and rest against side of brush; this prevents brush damage when assembly is pulled off of commutator. If springs are allowed to push brushes down when brush is moved off of commutator, the brush pigtail lead may be separated from the brush.

8. Slightly separate gear and drive assembly from drive end frame and use screwdriver to pry “plastic” shift lever off drive pins.
9. Gear and drive from drive end frame.
10. Thrust collar from armature shaft, then slide deep socket over shaft, tap socket to drive pinion stop collar off retainer ring.
11. Retainer ring and drive from shaft.



1. FRAME AND FIELD
2. TUBE, DRAIN
3. ARMATURE
4. SPRING, BRUSH
5. BRUSH HOLDER ASSEMBLY
6. BALL BEARING
7. FRAME, COMMUTATOR END
8. SCREW, BRUSH HOLDER ATTACHMENT (2 REQUIRED)
9. THRU BOLT (2 REQUIRED)
10. SHIELD AND GEAR ASSEMBLY
11. SHAFT AND GEAR ASSEMBLY
12. GEAR AND BEARING ASSEMBLY
13. BEARING ROLLER, INTERNAL TOOTH
14. DRIVE ASSEMBLY
15. NUT, FIELD LEAD TO SOLENOID
16. BEARING
17. HOUSING, DRIVE END
18. COLLAR, THRUST
19. RING, PINION STOP
20. COLLAR, PINION STOP

131-153

Figure 4-16 *PG260 Starter Motor (Disassembled)*

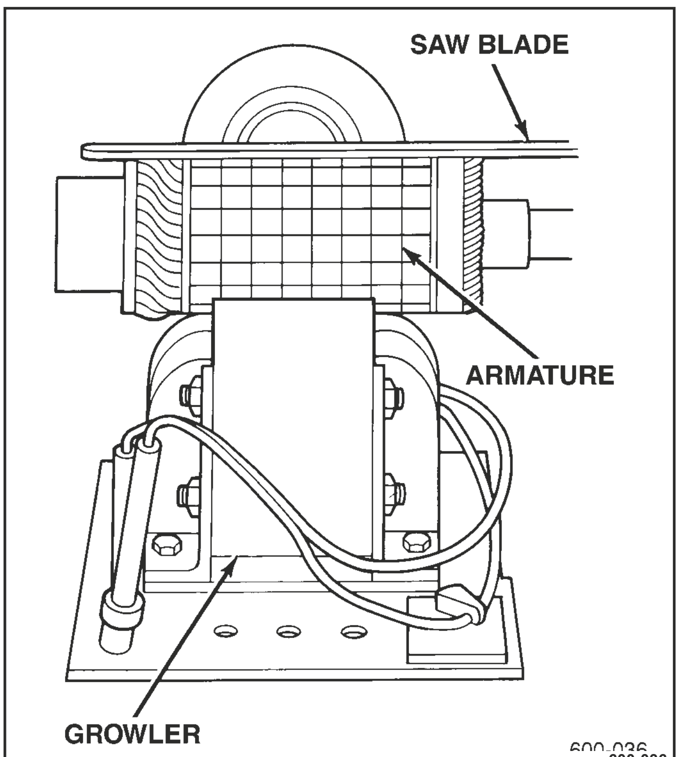


Figure 4-17 *Testing Armature for Short Circuits*

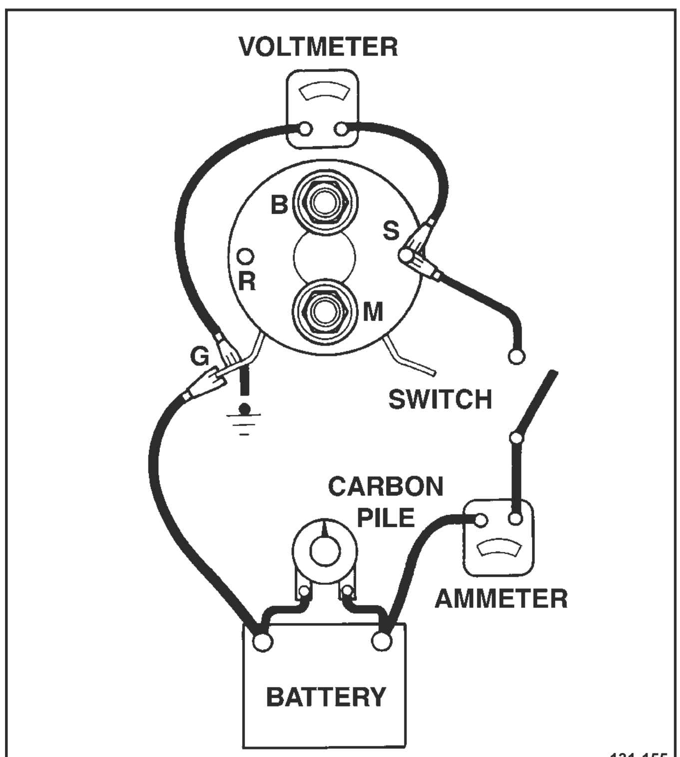


Figure 4-18 *Testing Solenoid Windings*

CLEANING, INSPECTION, AND TESTING

Figures 4-17 and 4-18

Inspect

1. Clean all starting motor parts, but DO NOT USE GREASE DISSOLVING SOLVENTS FOR CLEANING THE OVERRUNNING CLUTCH OR ARMATURE because solvents dissolve the grease packed in the clutch and damage armature insulation.
2. Test drive assembly action. The pinion should turn freely in the overrunning direction. Check pinion teeth to see that they have not been chipped, cracked, or excessively worn. Replace assembly when necessary. Badly chipped pinion teeth can indicate chipped ring gear teeth, which should be replaced when necessary.
3. The roll type drive assembly acquires no lubrication; however. the drive assembly should be wiped clean. Do not clean in degreasing tank, or with grease dissolving solvents; this dissolves the lubricant in the drive mechanism.
4. Armature commutator. When commutator is dirty, clean with 400 grit polishing cloth. When commutator is rough, the armature should be replaced. Do not undercut or turn commutators. Inspect the points where the armature conductors join the commutator bars to make sure they have a good connection. A burned commutator bar is usually evidence of a poor connection.
5. Brushes and brush holders. When brushes are excessively worn when compared to a new brush they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance. Check to insure that brush springs are giving firm contact between the brushes and commutator. When the springs are distorted or discolored, they should be replaced.
6. When test equipment is available:
   - Check the armature for short circuits by placing on growler, and holding hack saw blade over armature core while armature is rotated (figure 4-17). If saw blade vibrates, armature is shorted. Clean between the commutator bars and recheck armature for short circuits. If saw blade still vibrates, replace the armature.
   - Using a self-powered test lamp, place one lead on the commutator and the other lead on the armature core or shaft. If the lamp lights, the armature is grounded and must be repaired or replaced.
7. Check solenoid windings:
   - To check hold-in winding, connect an ammeter and switch in series with a 12-volt battery and the “switch” terminal on the solenoid. Connect a voltmeter to the “S” terminal and to ground. Connect carbon pile across battery. Adust the voltage to 10 volts and note the ammeter reading. Refer to figure 4-18.
   - PG260 starter motor reading should be 10 to 20 amperes. To check both windings, connect as for previous test. Ground the solenoid motor terminal “S.” Adjust the voltage to 10 Volts and note the ammeter reading. It should be 60 to 85 amperes for PG260 motors.

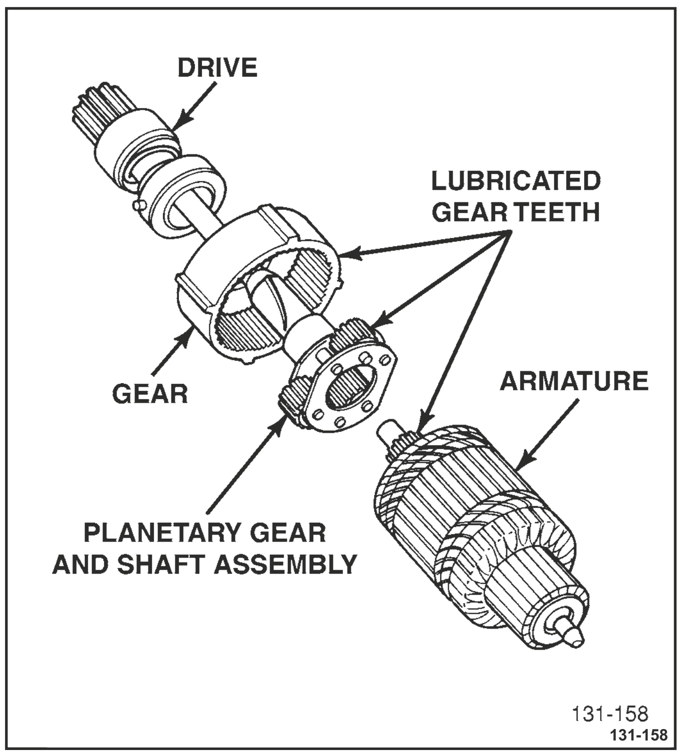


Figure 4-19 *Armature and Drive Assembly*

   - Current draw readings that are over specifications indicate shorted turns or a ground in the solenoid windings. Replace the starter

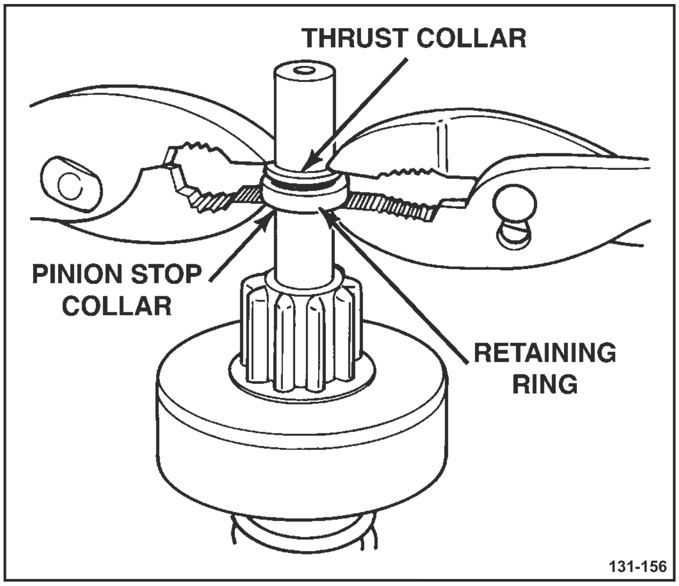


Figure 4-20 *Installing Retainer, Washer and Ring*

solenoid.

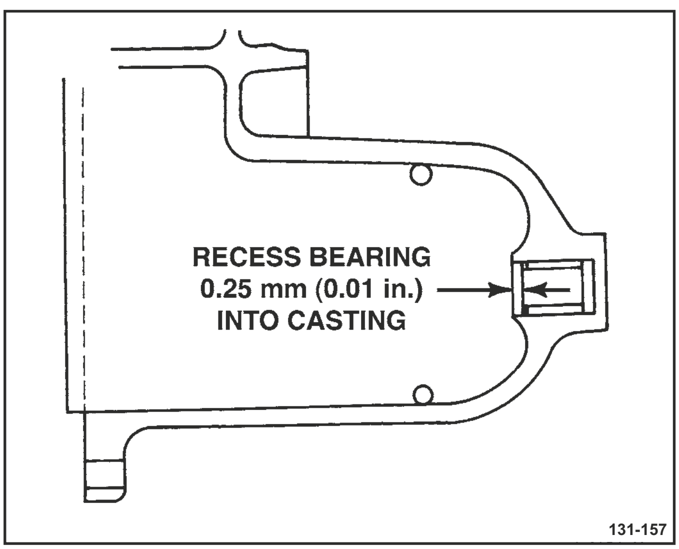


Figure 4-21 *Drive End Housing Bearing*

- Current draw readings that are under specifications indicate excessive resistance. A zero indicates an open. Check/repair connections when possible, otherwise replace starter solenoid.
- The starter solenoid and drive end housing are serviced as an assembly.

STARTER MOTOR ASSEMBLY

Figures 4-16, 4-19 through 4-21

Assemble

1. Lubricate inner gear teeth and bearing, planetary gears, and armature shaft gear teeth lightly with lubricant. Refer to figure 4-19.
2. Inner gear and drive over armature shaft with pinion away from armature.
3. Pinion stop collar onto armature shaft.
4. New pinion stop retainer ring into groove on shaft. Do not reuse old ring.
5. Thrust collar to end of shaft with small flange toward retainer ring. Use pliers as shown in figure 4-20 to snap pinion stop collar over retainer ring.

Inspect

Drive end housing bearing and armature commutator end bearing. When dry, the armature commutator end bearing may be lightly lubricated with lubricant. Bearing in drive end housing is a roller type bearing and is permanently lubricated. DO NOT ADD LUBRICANT. If dry, replace the drive end housing bearing using a small bearing puller; recessed 0.25 mm (0.01 in.) into casting (figure 4-21). Replace bearings when damaged.

6. Drive and shaft assembly into drive end housing. Use a screwdriver to gently guide shift lever over shift collar pins on drive assembly.

CAUTION

Field frame magnets have strong attraction to armature. Keep fingers clear of pinch points to avoid personal injury.

7. Shield, field frame and armature to drive end housing.

Inspect

- Brushes. When damaged or excessively worn, replace brush holder assembly.

8. Brush holder assembly onto armature.
9. Commutator end frame to brush assembly using screws.

Tighten

- Screws to 6.5 N•m (60 lb. in.).

10. Through-bolts.

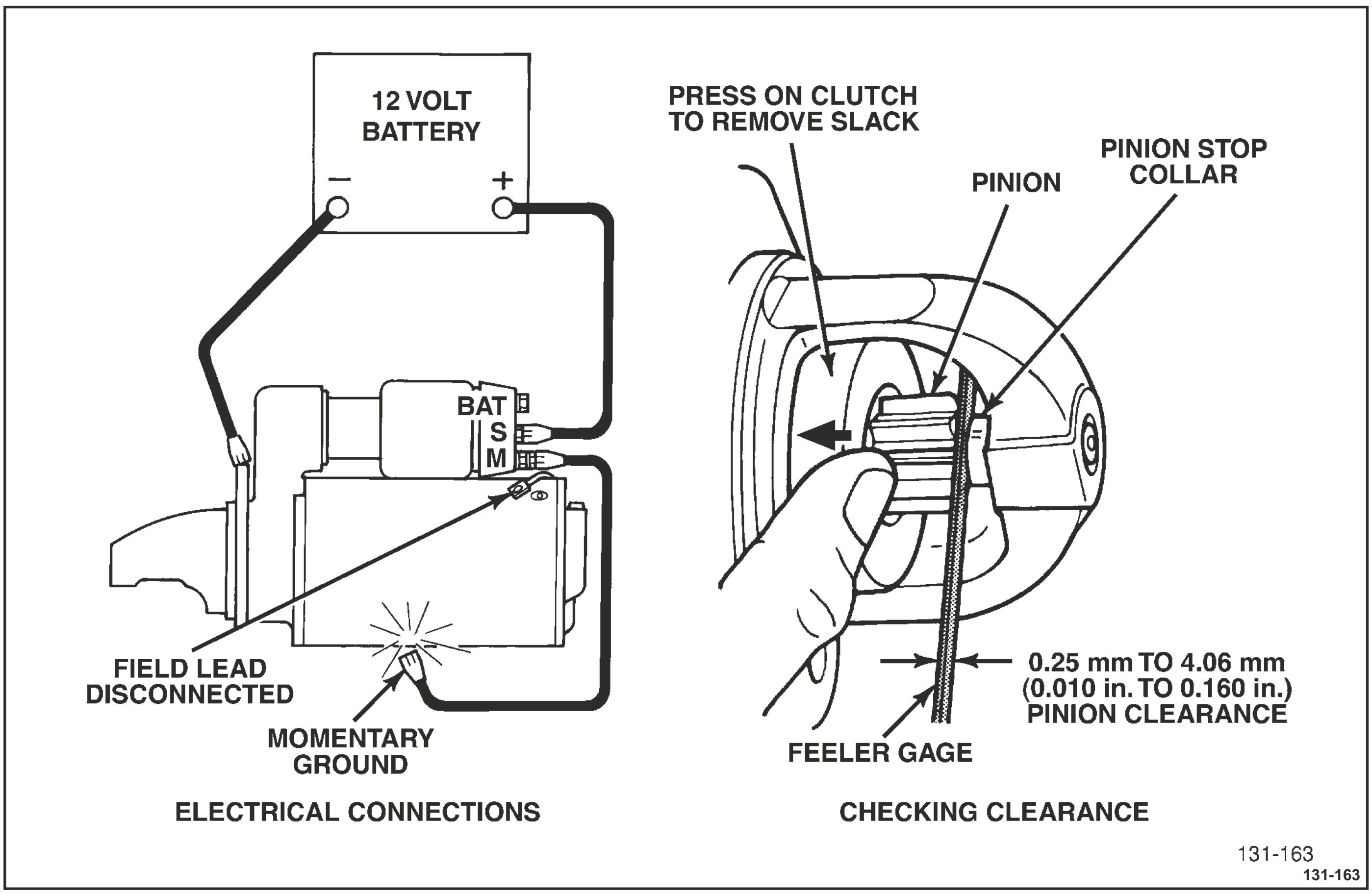


Figure 4-22 *Checking Pinion Clearance*

Tighten

- Through-bolts to 8.5 N•m (75 lb. in.).

Measure

- Pinion clearance, refer to “Checking Pinion Clearance” in this Section.

NOTICE: Before attaching field lead, be sure solenoid terminal is secure by tightening nut next to cap. If this nut is not tight, the cap may be damaged during installation of the field lead and cause starter to fail later.

Tighten

- Nut on solenoid field terminal to 8 N•m (71 lb. in.).

11. Solenoid.
12. Field lead to solenoid terminal.

Tighten

- Attaching nut to 8 N•m (71 lb. in.).

SECTION 1C7

IGNITION SYSTEM

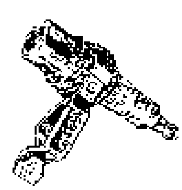
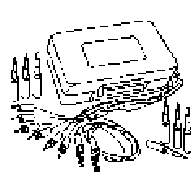
IGNITION SYSTEM SPECIFICATIONS

Application	Specification	
	Metric	English
Firing Order	1-6-5-4-3-2	
Spark Plug Wire Resistance	1,000 ohms per ft	
Spark Plug Torque	15 N·m	11 lb ft
Spark Plug Gap	1.52 mm	0.06 in
Spark Plug Type	R41-932 [AC plug type]	

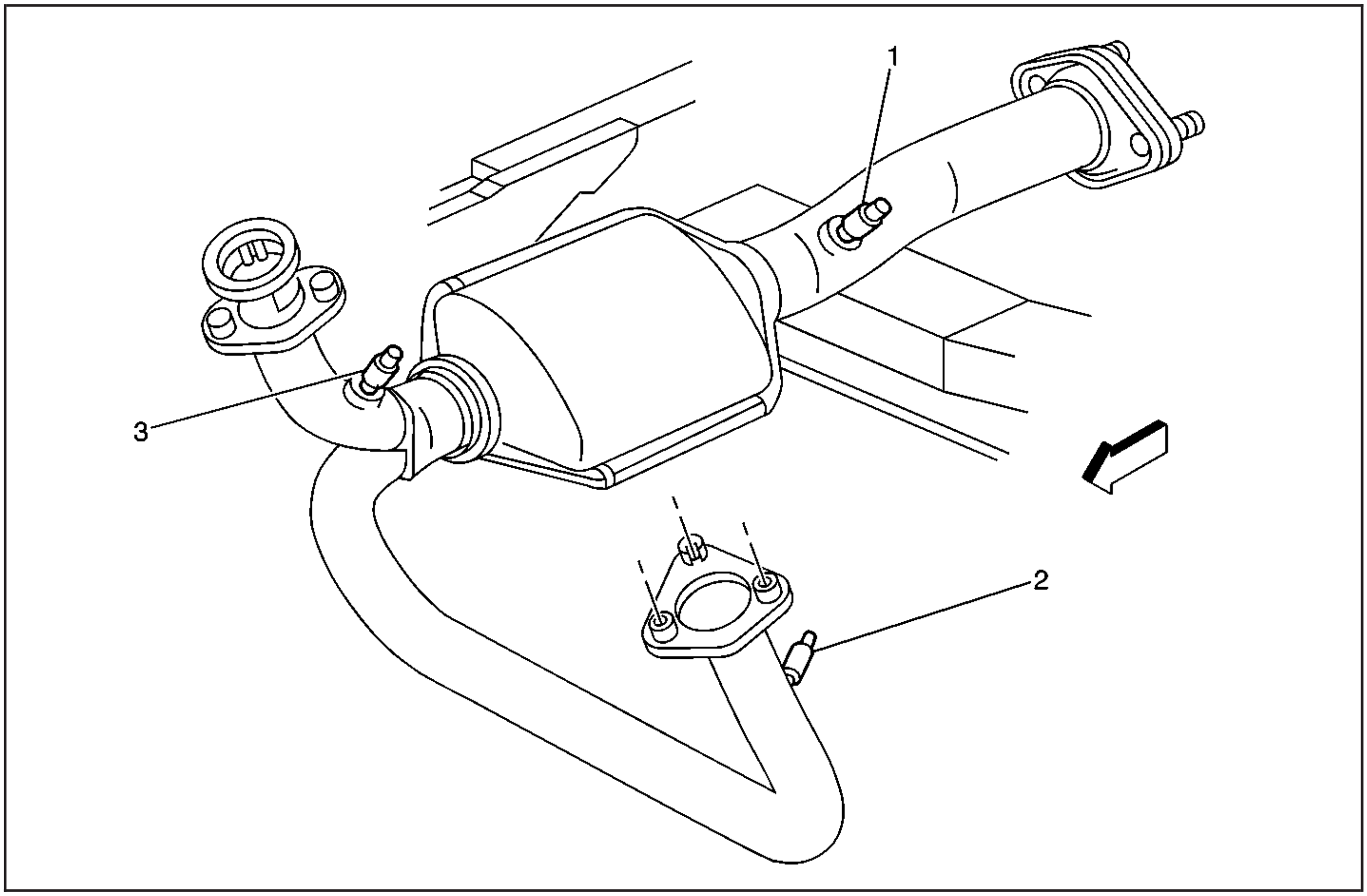
FASTENER TIGHTENING SPECIFICATIONS

Application	Specification	
	Metric	English
Distributor Cap Screws	2.4 N·m	21 lb in
Distributor Mounting Clamp Bolt	25 N·m	18 lb ft
Distributor Rotor Retaining Screws	1.9 N·m	17 lb in
Ignition Coil Bracket Stud	11 N·m	97 lb in
Ignition Coil Mounting Screws	11 N·m	97 lb in
Ignition Module Mounting Screws	3.5 N·m	31 lb in
Spark Plug-New Iron Head	30 N·m	22 lb ft
Spark Plug-Used Head	15 N·m	11 lb ft

SPECIAL TOOLS

Illustration	Tool Number/Description
 8442	J 26792 Spark Tester
 8917	J 35616–A Connector Test Adapter Kit

Heated Oxygen Sensors SIO-ID = 765593

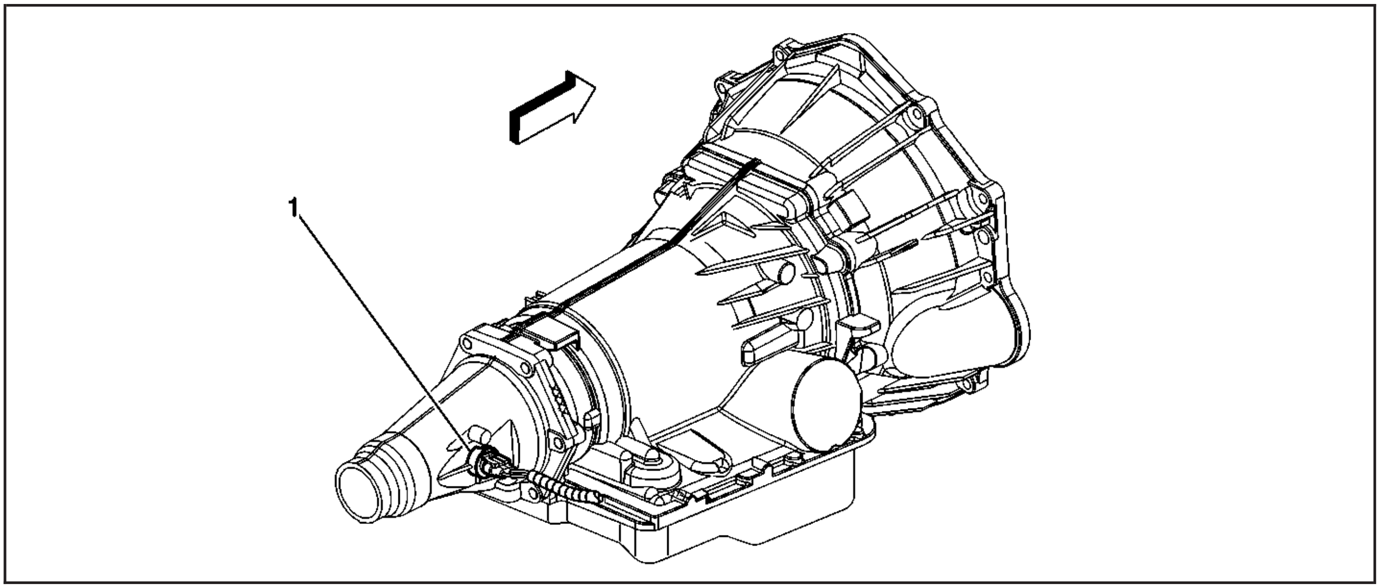


Legend

(1) Heated Oxygen Sensor (HO2S) Bank 1 Sensor 2

(2) Heated Oxygen Sensor (HO2S) Bank 1 Sensor 1

(3) Heated Oxygen Sensor (HO2S) Bank 2 Sensor 1



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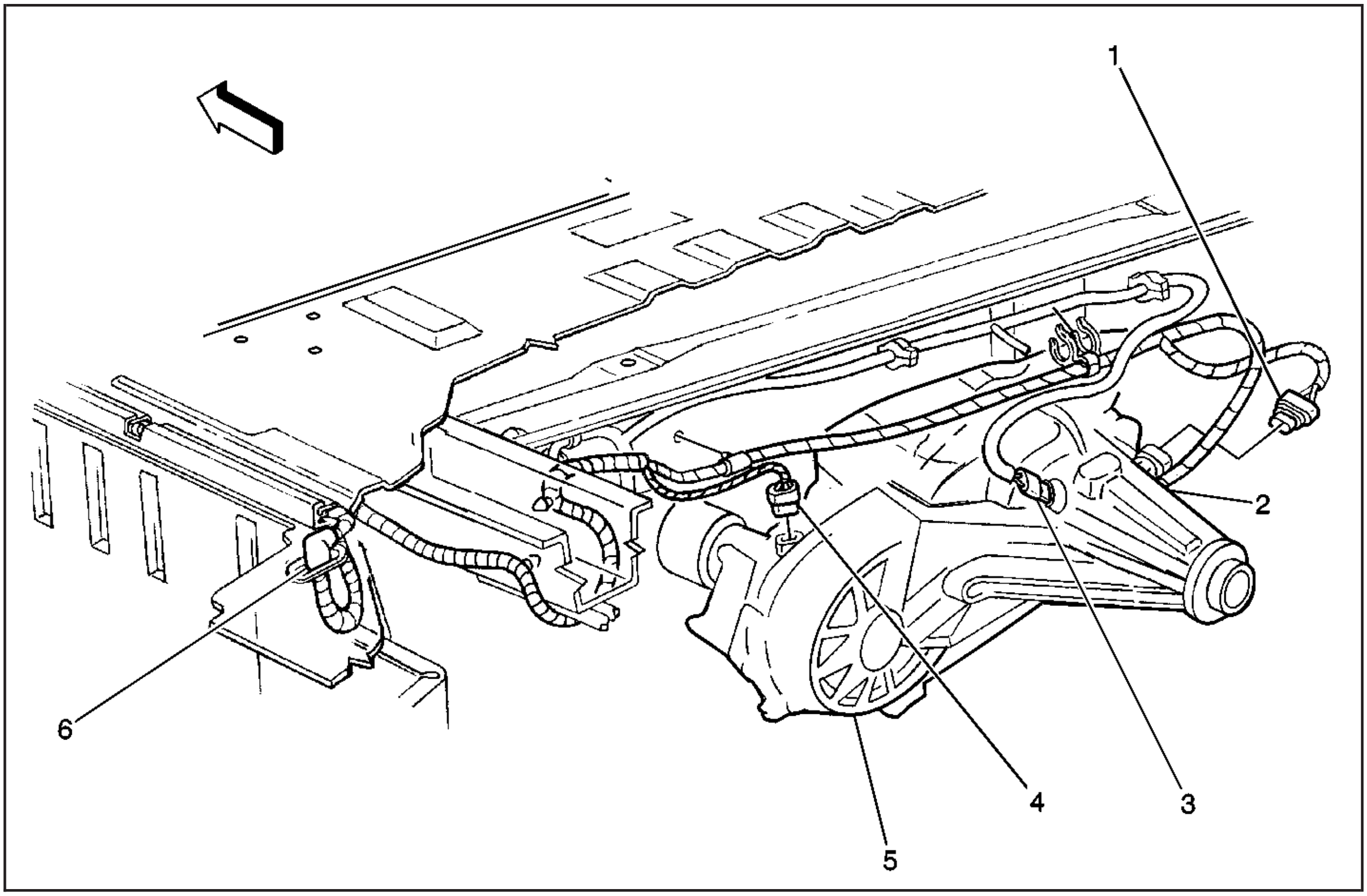
Legend

(1) Vehicle Speed Sensor (VSS)



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Legend

(1) Propshaft Speed Sensor – Rear Connector
(2) Transfer Case Encoder Motor Connector
(3) Vehicle Speed Sensor (VSS) Connector
(4) Propshaft Speed Sensor – Front Connector
(5) Transfer Case
(6) P301

DTC P0140 (cont'd)

Step	Action	Values	Yes	No
10	Remove the jumper from the previous step. Is the ENG 1 fuse open?	—	Go to *Step 13*	Go to *Step 11*
11	1. Turn ON the ignition, with the engine OFF. 2. Probe the HO2S ignition 1 voltage circuit with a test lamp that is connected to a good ground. Does the test lamp illuminate?	—	Go to *Step 12*	Go to *Step 18*
12	1. Connect a test lamp between the affected HO2S ignition 1 voltage circuit and the HO2S heater ground circuit. 2. Turn ON the ignition, with the engine OFF. Does the test lamp illuminate?	—	Go to *Step 16*	Go to *Step 19*
13	1. Disconnect all HO2S pigtail connectors. 2. Test the HO2S ignition 1 voltage circuit for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. 3. Replace the ENG 1 fuse. Did you find and correct a short to ground in the ignition 1 voltage circuit?	—	Go to *Step 22*	Go to *Step 14*
14	**Important:** Perform the following test on HO2S bank 1 sensor 1, HO2S bank 2 sensor 1, and HO2S bank 1 sensor 2. A condition in any sensor will cause this DTC to set. Test the HO2S ignition 1 voltage circuit, sensor side, for a short to the HO2S body. Refer to *Circuit Testing* in Wiring Systems. Did you find the condition?	—	Go to *Step 20*	Go to *Step 15*
15	**Important:** Perform the following test on HO2S bank 1 sensor 1, HO2S bank 2 sensor 1, and HO2S bank 1 sensor 2. A condition in any sensor will cause this DTC to set. Measure the resistance between the HO2S ignition 1 voltage circuit, sensor side, and the HO2S heater ground circuit, sensor side. Refer to *Circuit Testing* in Wiring Systems. Does the resistance of any sensor measure above or below the specified range?	2–50 Ω	Go to *Step 20*	Go to *Testing for Intermittent and Poor Connections*
16	Inspect for poor connections at the harness connector of the affected HO2S. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 22*	Go to *Step 20*
17	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 22*	Go to *Step 21*
18	Repair the open in the ignition 1 voltage circuit. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 22*	—
19	Repair the open in the HO2S heater ground circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 22*	—
20	Replace the affected HO2S refer to *Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 1* or *Heated Oxygen Sensor (HO2S) Replacement Bank 1 Sensor 2* or *Heated Oxygen Sensor (HO2S) Replacement Bank 2 Sensor 1*. Did you complete the replacement?	—	Go to *Step 22*	—

DTC P0140 (cont'd)

Step	Action	Values	Yes	No
21	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 22*	—
22	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 23*	Go to *Step 2*
23	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

SIL-ID = 698882

Circuit Description

The powertrain control module (PCM) controls the air/fuel metering system in order to provide the best possible combination of driveability, fuel economy and emission control. Fuel delivery is controlled differently during open and closed loop. During Open Loop the PCM determines fuel delivery based on sensor signals, without oxygen sensor input. During Closed Loop, the oxygen sensor inputs are added and used by the PCM to calculate short and long term fuel trim (fuel delivery adjustments). If the oxygen sensors indicate a lean condition, fuel trim values will be above 0 percent. If the oxygen sensors indicate a rich condition, fuel trim values will be below 0 percent. Short Term fuel trim values change rapidly in response to the heated oxygen sensor (HO2S) voltage signals. Long Term fuel trim makes coarse adjustments in order to maintain Air/Fuel Ratio of 14.7:1. If the PCM detects an excessively lean condition, this DTC will set.

Conditions for Running the DTC

- DTCs P0101, P0103, P0108, P0135, P0137, P0141, P0200, P0300, P0410, P0420, P0430, P0440, P0442, P0443, P0446, P0449, P0506, P0507 or P1441 are not set.
- The engine coolant temperature (ECT) is between 75–115°C (167–239°F).
- The intake air temperature (IAT) is between −20 to +90°C (4–194°F).
- The manifold absolute pressure (MAP) is between 26–90 kPa (3.7–13 psi).
- The vehicle speed is less than 137 km/h (85 mph).
- The engine speed is between 400–3,000 RPM.
- The barometric pressure (BARO) is more than 74 kPa (10.7 psi).
- The mass airflow (MAF) is between 5–90 g/s.
- The fuel level is more than 10 percent.
- The throttle position (TP) is less than 90 percent.

Conditions for Setting the DTC

- The average long term fuel trim cell value is above 23 percent.
- All of the above conditions are present for 6 seconds.

SIO-ID = 727820

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

SIO-ID = 727824

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- The system will go lean if an injector is not suppling enough fuel.
- A lean condition could be present during high fuel demand.
- Using scan tool, review Failure Records. If an intermittent condition is suspected, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

5. If conditions were not corrected, refer to Fuel System Diagnostics for a possible fuel problem.
6. If conditions were not corrected, a worn cam, worn intake or exhaust valves or other engine mechanical failures may be at fault.

DTC P0171 or P0174

Step	Action	Values	Yes	No
1	Did you perform the Diagnostic System Check–Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check - Engine Controls*

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DTC P0171 or P0174 (cont'd)

Step	Action	Values	Yes	No
2	**Important:** If any DTCs are set, other than P0171 or P0174, refer to those DTCs before continuing. 1. Install the scan tool. 2. Start and idle the engine at the normal operating temperature in Closed Loop. 3. Record the Long Term Fuel Trim. 4. Turn OFF the engine. 5. Turn ON ignition, with engine OFF. 6. Review the Freeze Frame Records and/or Failure Records and record displayed data for this DTC. Does the scan tool indicate that the Long Term Fuel Trim is greater than the specified value?	23 %	Go to *Step 3*	Go to *Diagnostic Aids*
3	1. Operate engine at idle. 2. Using the scan tool, observe HO2S parameters. Does the scan tool indicate that the parameter is within the specified range and fluctuating?	200–800 mv	Go to *Step 4*	Go to *Step 5*
4	1. Turn OFF the engine. 2. Visually and physically inspect the following items: • Vacuum hoses for splits, kinks, and proper connections Refer to *Emission Hose Routing Diagram* • Ensure that the vehicle has sufficient fuel in tank. If fuel pressure is too low this DTC may set Refer to *Fuel System Diagnosis* • Fuel contamination, Refer to *Alcohol/Contaminants-in-Fuel Diagnosis (Without Special Tool)* or *Alcohol/Contaminants-in-Fuel Diagnosis (With Special Tool)* Did you find and correct the condition?	—	Go to *Step 7*	Go to *Step 6*
5	Turn OFF the engine. • Check the HO2S for proper installation. • Check to ensure electrical connectors and wires are secure and not contacting the exhaust system. • Check for a short between the signal circuit and the low reference circuit. Did you find and correct the condition?	—	Go to *Step 7*	Go to *Fuel System Diagnosis*
6	Operate engine at idle. • Check for missing, loose, or leaking exhaust components forward of the HO2S. • Check for vacuum leaks at the intake manifold, throttle body and injector O-rings. • Check the air induction system and air intake ducts for leaks. • Check the secondary air injection (AIR) system for leaks, improper air delivery, or the shut-off valve not closing. • Check the crankcase ventilation system for leaks. Refer to *Crankcase Ventilation System Inspection/Diagnosis*. Did you find and correct the condition?	—	Go to *Step 7*	Go to *Symptoms - Engine Mechanical* in Engine Mechanical – 4.3L

DTC P0171 or P0174 (cont'd)

Step	Action	Values	Yes	No
7	**Important:** After repairs, use scan tool Fuel Trim Reset function in order to reset the Long Term Fuel. 1. Use a scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run, and then pass?	—	Go to *Step 8*	Go to *Step 2*
8	Use a scan tool in order to observe the stored information in Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0172 or P0175

SIE-ID = 693637

Circuit Description

The powertrain control module (PCM) controls the air/fuel metering system in order to provide the best possible combination of driveability, fuel economy and emission control. Fuel delivery is controlled differently during open and closed loop. During open loop the PCM determines fuel delivery based on sensor signals, without oxygen sensor input. During closed loop, the oxygen sensor inputs are added and used by the PCM to calculate short and long term fuel trim (fuel delivery adjustments). If the oxygen sensors indicate a lean condition, fuel trim values will be above 0 percent. If the oxygen sensors indicate a rich condition, fuel trim values will be below 0 percent. Short Term fuel trim values change rapidly in response to the heated oxygen sensor (HO2S) voltage signals. Long Term fuel trim makes coarse adjustments in order to maintain Air/Fuel Ratio of 14.7:1. The fuel trim diagnostic will conduct a test to determine if a rich failure actually exists or if excessive vapor from the evaporative emission (EVAP) canister is causing a rich condition. If the PCM detects an excessively rich condition, this DTC will set. If the PCM detects excessive vapor then a pass is logged.

Conditions for Running the DTC

- DTCs P0101, P0103, P0108, P0135, P0137, P0141, P0200, P0300, P0410, P0420, P0430, P0440, P0442, P0443, P0446, P0449, P0506, P0507 or P1441 are not set.
- The engine coolant temperature (ECT) is between 75–115°C (167–239°F).
- The intake air temperature (IAT) is between –20 to 90°C (4–194°F).
- The manifold absolute pressure (MAP) is between 26–90 kPa (3.7–13 psi).
- The vehicle speed is less than 137 km/h (85 mph).
- The engine speed is between 400–3,000 RPM.
- The barometric pressure (BARO) is more than 74 kPa (10.7 psi).
- The mass airflow (MAF) is between 5–90 g/s.
- The fuel level is more than 10 percent.
- The throttle position (TP) is less than 90 percent

Conditions for Setting the DTC

- The average long term fuel trim value is below –13 percent.
- All of the above conditions are present for 40 seconds.

Diagnostic Aids

- Fuel contamination, such as water and alcohol will effect fuel trim.
- A malfunctioning Mass Air Flow sensor can cause a rich condition and set this DTC. Refer to *DTC P0101*.
- Using scan tool, review Failure Records. If intermittent condition is suspected, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

5. If conditions were not corrected, refer to Fuel System Diagnostic for possible fuel problem.
6. An EVAP canister that is saturated will cause a rich condition. Fuel in the vacuum line to the fuel pressure regulator indicates a leaking regulator. If conditions were not corrected, a worn cam, worn intake or exhaust valves or other engine mechanical failure may be at fault.

DTC P0172 or P0175

Step	Action	Values	Yes	No
1	Did you perform the Diagnostic System Check–Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check - Engine Controls*
2	**Important:** If any DTCs are set, other than P0172, refer to those DTCs before continuing. 1. Install scan tool. 2. Start and idle the engine at the normal operating temperature in closed loop. 3. Record the Long Term Fuel Trim data. 4. Turn OFF the engine. 5. Turn ON ignition, with the engine OFF. 6. Review the Freeze Frame Records and/or Failure Records and record displayed data for this DTC. Does the scan tool indicate that the Long Term Fuel Trim is less than the specified value?	–13%	Go to *Step 3*	Go to Diagnostic Aids

DTC P0172 or P0175 (cont'd)

Step	Action	Values	Yes	No
3	1. Operate engine at idle. 2. Using the scan tool observe HO2S parameters. Does the scan tool indicate that the values are within the specified range and fluctuating?	200–800 mv	Go to *Step 4*	Go to *Step 5*
4	1. Turn OFF the engine. 2. Visually and physically inspect the following items: • Inlet screen of the MAF sensor for blockage. • Vacuum hoses for splits, kinks, and proper connections. Refer to *Emission Hose Routing Diagram*. • The air intake duct for being collapsed or restricted. • The air filter for being dirty or restricted. • Check for objects blocking throttle body. Did you find and correct the condition?	—	Go to *Step 7*	Go to *Step 6*
5	1. Turn OFF the engine. 2. Check the HO2S for proper installation. 3. Check to ensure electrical connectors and wires are secured and not contacting the exhaust system. Did you find and correct the condition?	—	Go to *Step 7*	Go to *Fuel System Diagnosis*
6	Inspect for the following: • Check for excessive fuel in the crankcase. • Inspect the Evaporative Emissions Control System. • Test fuel pressure regulator for proper operation. Refer to *Fuel System Diagnosis*. • Check to ensure that all injectors are functioning properly. Refer to *Fuel Injector Coil Test*. • Perform the Fuel Injector Balance Test. Refer to *Fuel Injector Balance Test with Special Tool*. Did you find and correct the condition?	—	Go to *Step 7*	Go to *Symptoms - Engine Mechanical* in Engine Mechanical –4.3L
7	**Important:** After repairs, use scan tool Fuel Trim Reset function in order to reset the Long Term Fuel. 1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 8*	Go to *Step 2*
8	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic System Check - Engine Controls*	System OK

DTC P0200

SIE-ID = 789930

Circuit Description

The powertrain control module (PCM) enables the appropriate fuel injector on the intake stroke for each cylinder. An ignition voltage is supplied to the fuel injectors. The PCM controls each fuel injector by grounding the control circuit via a solid state device called a driver. The PCM monitors the status of each driver. If the PCM detects an incorrect voltage for the commanded state of the driver, a fuel injector control diagnostic trouble code (DTC) sets.

Conditions for Running the DTC

- The engine is running.
- The ignition voltage is between 6–18 volts.

Conditions for Setting the DTC

- The PCM detects an incorrect voltage on the fuel injector control circuit.
- The condition exists for 5 seconds.

SIO-ID = 727820

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

SIO-ID = 727824

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- Performing the Fuel Injector Coil Test may help isolate an intermittent condition. Refer to *Fuel Injector Coil Test*.
- For an intermittent condition, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

4. This step tests for voltage at the fuel injector harness connector. The ECM 1 fuse supplies power to the coil side of the fuel injector harness connector. If the fuse is open, a short to ground on the ignition 1 voltage supply circuit of the fuel injector is indicated.
5. This step verifies that the PCM is able to control the fuel injector. If the test lamp flashes the PCM and the wiring are OK.
6. This step tests if a ground is constantly being applied to the fuel injector.

DTC P0200

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check–Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check - Engine Controls*
2	1. Clear the DTCs with a scan tool. 2. Idle the engine at the normal operating temperature. 3. Monitor the Misfire Current counters with a scan tool. Are any of the counters incrementing?	Go to *Step 4*	Go to *Step 3*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	Go to *Step 4*	Go to Diagnostic Aids

DTC P0200 (cont'd)

Step	Action	Yes	No
4	1. Turn OFF the ignition. 2. Remove the engine cover. Refer to *Engine Cover Replacement* in Interior Trim. 3. Disconnect the fuel injector harness connector. Refer to *Engine Wiring, LH Side (Electrical)* in Wiring Systems. 4. Turn ON the ignition, with the engine OFF. 5. Probe the ignition 1 voltage supply circuit of the appropriate fuel injector with a test lamp that is connected to a good ground. Does the test lamp illuminate?	Go to *Step 5*	Go to *Step 11*
5	1. Connect the *J 34730-375* Fuel Injector Test Lamp between the control circuit and the ignition 1 voltage supply circuit of the appropriate fuel injector. 2. Crank the engine. Does the test lamp flash?	Go to *Step 9*	Go to *Step 6*
6	Does the test lamp remain illuminated at all times?	Go to *Step 8*	Go to *Step 7*
7	Test the control circuit of the fuel injector for an open and for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 10*
8	Test the control circuit of the fuel injector for a short to ground. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 13*
9	Inspect for poor connections at the harness connector of the fuel injector. Refer to *Testing for Intermittent and Poor Connections* and *Repairing Connector Terminals* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 12*
10	Inspect for poor connections at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Repairing Connector Terminals* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 13*
11	Repair the ignition 1 voltage supply circuit of the fuel injector for an open or for a short to ground. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 14*	—
12	Replace the fuel injector. Refer to *Fuel Injector Replacement*. Did you complete the replacement?	Go to *Step 14*	—
13	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	Go to *Step 14*	—
14	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 15*	Go to *Step 2*
15	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0230

SIE-ID = 789976

Circuit Description

The powertrain control module (PCM) provides ignition positive voltage to the coil side of the fuel pump relay. When the ignition switch is first turned ON, the PCM energizes the fuel pump relay, which applies power to the fuel pump. The PCM enables the fuel pump relay as long as the engine is cranking or running, and crankshaft reference pulses are received. If no crankshaft reference pulses are received, the PCM de-energizes the fuel pump relay after 2 seconds. The PCM monitors the voltage on the fuel pump relay control circuit. If the PCM detects an incorrect voltage on the fuel pump relay control circuit, diagnostic trouble code (DTC) P0230 sets.

Conditions for Running the DTC

- The engine speed is more than 400 RPM.
- The ignition voltage is between 6–18 volts.

Conditions for Setting the DTC

- The PCM detects that the commanded state of the driver and the actual state of the control circuit do not match.
- The above conditions are present for a minimum of 2.5 seconds.

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. Listen for a click when the fuel pump relay operates. Command both the ON and OFF states. Repeat the commands as necessary.
4. This step verifies that the PCM is providing voltage to the fuel pump relay.
5. This step tests for an open in the ground circuit to the fuel pump relay.
6. This step determines if voltage is constantly being applied to the control circuit of the fuel pump relay.

DTC P0230

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check–Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check - Engine Controls*
2	1. Turn ON the ignition, with the engine OFF. 2. Command the fuel pump ON and OFF with a scan tool. Does the fuel pump relay turn ON and OFF with each command?	Go to *Step 3*	Go to *Step 4*
3	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame/Failure Records data that you observed. Does the DTC fail this ignition?	Go to *Step 4*	Go to *Intermittent Conditions*

DTC P0230 (cont'd)

Step	Action	Yes	No
4	1. Turn OFF the ignition. 2. Disconnect the fuel pump relay. 3. Turn ON the ignition, with the engine OFF. 4. Probe the control circuit of the fuel pump relay with a test lamp that is connected to a good ground. 5. Command the fuel pump ON and OFF with a scan tool. Does the test lamp turn ON and OFF with each command?	Go to *Step 5*	Go to *Step 6*
5	1. Connect a test lamp between the control circuit of the fuel pump relay and the ground circuit of the relay. 2. Command the fuel pump ON and OFF with a scan tool. Does the test lamp turn ON and OFF with each command?	Go to *Step 9*	Go to *Step 11*
6	Does the test lamp remain illuminated with each command?	Go to *Step 8*	Go to *Step 7*
7	Test the control circuit of the fuel pump relay for a short to ground or for an open. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 10*
8	Test the control circuit of the fuel pump relay for a short to voltage. Refer to *Circuit Testing* and *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 10*
9	Inspect for poor connections at the fuel pump relay. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 12*
10	Inspect for poor connections at the harness connectors of the PCM. Refer to *Testing for Intermittent and Poor Connections* and *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	Go to *Step 14*	Go to *Step 13*
11	Repair the ground circuit of the relay. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	Go to *Step 14*	—
12	Replace the fuel pump relay. Did you complete the replacement?	Go to *Step 14*	—
13	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	Go to *Step 14*	—
14	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 15*	Go to *Step 2*
15	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

n Description

wertrain control module (PCM) uses information
e crankshaft position (CKP) sensor and the
ft position (CMP) sensor in order to determine
n engine misfire is occurring. By monitoring
ns in the crankshaft rotation speed for
linder, the PCM is able to detect individual
events. A misfire rate that is high enough can
hree-way catalytic converter (TWC) damage.
lfunction indicator lamp (MIL) will flash ON and
hen the conditions for catalytic converter
e are present.

tions for Running the DTC

ant: If the start-up engine coolant
ature (ECT) is less than 7°C (20°F), misfire
n is delayed until ECT is more than 21°C
If the start-up ECT is more than 7°C (20°F),
detection begins after a 5 second delay.

Cs P0101, P0102, P0103, P0116, P0117,
118, P0128, P0335, P0336, P0341, P0343,
500, P0502, P0503, P1114, P1115, P1121,
122, P1220, P1258, P1336, or P1345 are
set.

e fuel level is more than 10 percent

e engine speed is between 450–5,000 RPM.

e system voltage is between 11–16 volts.

e throttle position (TP) is steady within 2 percent
100 milliseconds.

tions for Setting the DTC

M detects a deceleration in the crankshaft
hat is characteristic of either an emission type
or of a catalyst-damaging type misfire.

7820

Taken When the DTC Sets

e control module illuminates the malfunction
cator lamp (MIL) on the second consecutive
tion cycle that the diagnostic runs and fails.

e control module records the operating
ditions at the time the diagnostic fails. The
time the diagnostic fails, the control module
res this information in the Failure Records.
he diagnostic reports a failure on the
ond consecutive ignition cycle, the control
dule records the operating conditions at
time of the failure. The control module writes
operating conditions to the Freeze Frame
l updates the Failure Records.

7824

tions for Clearing the MIL/DTC

e control module turns OFF the malfunction
cator lamp (MIL) after 3 consecutive ignition
les that the diagnostic runs and does not fail.

urrent DTC, Last Test Failed, clears when the
gnostic runs and passes.

- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

The misfire index counts the number of misfires. The scan tool can monitor the misfire index. There is a current and a history misfire counter for each cylinder. Use the current misfire counter in order to determine which cylinder is misfiring. Use the history misfire counter for misfires that are not currently present.

Many different conditions could cause an intermittent misfire. Inspect the following conditions:

- Inspect the ignition control (IC) circuit for an intermittent short to ground.
- Ensure that the spark plug wires are securely attached to the spark plugs and the distributor cap.
- Ensure that the coil wire is securely attached to the distributor cap and the coil.
- Inspect the wire routing to ensure that cross-firing is not occurring.
- If the misfire occurs when the weather is damp, the problem could be due to worn plug wires.
- Inspect the fuel for the following conditions:
  - Condition and quality—Dirty or contaminated fuel could cause a misfire condition.
  - The fuel level—If the fuel level is low, the fuel pump may draw air into the fuel rail, causing a stumble and a possible misfire condition. Inspect the fuel trim number in the Freeze Frame in order to determine if this has occurred. This condition would be likely if the short term fuel number was more than +20.
  - Restrictions—A restricted fuel filter can also cause a misfire.
- Inspect for sticking intake or exhaust valves on engines which misfire when the engine is cold.
- Inspect the heated oxygen sensor (HO2S) for abnormal voltage readings.
- Inspect for a vacuum leak as a possible cause of the engine misfire.

An intermittent may be caused by any of the following conditions:

- A poor connection
- Rubbed through wire insulation
- A broken wire inside the insulation

Thoroughly inspect any circuitry that is suspected of causing the intermittent complaint. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. If a repair is necessary, refer to *Wiring Repairs* in Wiring Systems.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

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Step	Action	Values	Yes	No
1	Did you perform the Diagnostic System Check–Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check - Engine Controls*
2	1. Turn ON the ignition, with the engine OFF. 2. Observe the DTC information with a scan tool. Are there any other DTCs set?	—	Go to *Diagnostic Trouble Code (DTC) List*	Go to *Step 3*
3	1. Start the engine. 2. Clear the DTCs with a scan tool. 3. Allow the engine to reach operating temperature. 4. Observe the Misfire Current Counters with a scan tool. Are any of the Misfire Current Counters incrementing?	—	Go to *Step 5*	Go to *Step 4*
4	1. Observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data. Does the DTC fail this ignition cycle?	—	Go to *Step 5*	Go to Diagnostic Aids
5	Is the engine misfiring?	—	Go to *Step 6*	Go to *Symptoms - Engine Mechanical* -4.3L
6	Is there only one Misfire Current Counter incrementing?	—	Go to *Step 7*	Go to *Step 13*
7	1. Turn OFF the ignition. 2. Disconnect the spark plug wire from the spark plug. Refer to *Spark Plug Wire Replacement*. 3. Connect the *J 26792* Spark Tester to the spark plug wire and a good ground. 4. Start and idle the engine. Does the spark tester spark and is the spark consistent?	—	Go to *Step 9*	Go to *Step 8*
8	1. Turn OFF the ignition. 2. Remove the spark plug wire from the cylinder that indicates a misfire. Refer to *Spark Plug Wire Replacement*. 3. Measure the resistance of the spark plug wire with a DMM. Is the resistance less than the specified value?	625 Ω Per 30 CM (Per Foot)	Go to *Step 16*	Go to *Step 15*
9	1. Remove the spark plug from the cylinder that indicates a misfire. Refer to *Spark Plug Replacement*. **Important:** If the spark plug is gas, coolant, or oil fouled, determine the cause of the fouling. Refer to *DTC P0172 or P0175* for spark plugs that are gas fouled. Refer to *Symptoms - Engine Mechanical* -4.3L for spark plugs that are coolant or oil fouled. 2. Inspect the spark plug. Refer to *Spark Plug Inspection*. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 10*

DTC P0300 (cont'd)

Step	Action	Values	Yes	No
10	1. Exchange the suspected spark plug with another cylinder that is operating correctly. 2. Start the engine. 3. Operate the engine within the conditions that the misfire occurred. 4. Monitor the Misfire Current Counters with a scan tool. Did the misfire move with the spark plug?	—	Go to *Step 14*	Go to *Step 11*
11	**Important:** • Ensure that all the injectors operate. High resistance in an injector circuit causes the injector to be inoperative without setting a fuel injector DTC. • Return to this diagnostic after you complete the Fuel Injector Coil Test. Perform the Fuel Injector Coil Test. Refer to *Fuel Injector Coil Test*. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Step 12*
12	Perform the Fuel System Diagnosis. Refer to *Fuel System Diagnosis*. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Symptoms - Engine Mechanical* -4.3L
13	Inspect or test for the following conditions: • Inspect the vacuum hoses for splits, kinks, and the correct connections. • Inspect for vacuum leaks at the throttle body and at the intake manifold. • Inspect the PCM grounds for being clean, tight, and in the correct location. • Inspect for contaminated fuel. Refer to *Alcohol/Contaminants-in-Fuel Diagnosis (Without Special Tool)* or *Alcohol/Contaminants-in-Fuel Diagnosis (With Special Tool)*. • Test for the correct fuel pressure. Refer to *Fuel System Diagnosis*. • Inspect for poor connections at the ignition coil. • Inspect for faulty spark plug wires or coil wire. Refer to *Spark Plug Wire Inspection*. • Inspect for fouled or damaged spark plugs. Refer to *Spark Plug Inspection*. • Inspect the distributor cap and distributor for damage. Refer to *Distributor Inspection*. • Test the ignition coil for the correct output with the *J 26792*. • Inspect the exhaust system for restrictions. Refer to *Restricted Exhaust* in Engine Exhaust. Did you find and correct the condition?	—	Go to *Step 17*	Go to *Symptoms - Engine Mechanical*
14	Replace the spark plugs. Refer to *Spark Plug Replacement*. Did you complete the replacement?	—	Go to *Step 17*	—
15	Replace the spark plug wires. Refer to *Spark Plug Wire Replacement*. Did you complete the replacement?	—	Go to *Step 17*	—
16	Replace the distributor cap. Refer to *Distributor Overhaul*. Did you complete the replacement?	—	Go to *Step 17*	—

DTC P0300 (cont'd)

Step	Action	Values	Yes	No
17	1. Use the scan tool in order to clear the DTCs. 2. Turn the ignition OFF for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC. Does the DTC run and pass?	—	Go to *Step 18*	Go to *Step 2*
18	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	—	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0325

SIE-ID = 693514

Circuit Description

The knock sensor (KS) produces an AC voltage at all engine speeds and loads. The powertrain control module (PCM) then adjusts the spark timing based on the amplitude and frequency of the KS signal. The PCM uses the KS signal to calculate the average voltage. Then the PCM assigns a voltage value. The PCM checks the knock sensor and related wiring by comparing the actual knock signal to the assigned voltage range. A normal KS signal should stay within the assigned voltage range. This DTC will set if the PCM malfunctions in a manner that will not allow proper diagnosis of the KS system.

Conditions for Running the DTC

The engine run time is more than 10 seconds.

Conditions for Setting the DTC

The PCM detects a malfunction in the KS diagnostic circuitry that will not allow proper diagnosis of the KS system.

SIO-ID = 727820

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

SIO-ID = 727824

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- The knock sensor must be torqued correctly to 25 N·m (18 lb ft).
- The mounting between the sensor and engine must be free of burrs, casting flash, and foreign material.
- The knock sensor head is clear from hoses, brackets, and engine electrical wiring.

DTC P0325

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check–Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check - Engine Controls*
2	**Important:** If you can hear an engine knock, repair the engine mechanical problem before proceeding with this diagnostic. 1. Observe the Freeze Frame and Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as close to the Freeze Frame and Failure Records data that you observed. Did the DTC fail this ignition?	Go to *Step 3*	Go to *Intermittent Conditions*
3	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	Go to *Step 4*	—
4	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	Go to *Step 5*	Go to *Step 2*

DTC P0325 (cont'd)

Step	Action	Yes	No
5	Use a scan tool in order to observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System C

SIE-ID = 794425

Circuit Description

The knock sensor (KS) produces an AC voltage at all engine speeds and loads. The powertrain control module (PCM) adjusts the spark timing based on the amplitude and frequency of the KS signal. The PCM uses the KS signal in order to calculate the average voltage. The PCM assigns a voltage value. The PCM checks the KS and the related wiring by comparing the actual KS to the assigned voltage range. A normal KS signal should stay within the assigned voltage range. This DTC will set if the KS signal is outside the assigned voltage range or if the signal is not present.

Conditions for Running the DTC

- DTCs P0116, P0117, P0118, P0121, P0122, P0123, P0125, P1114, P1115, P1121, or P1122 are not set.
- The engine coolant temperature (ECT) is more than 60°C (140°F).
- The engine run time is more than 10 seconds.
- The manifold absolute pressure (MAP) is less than 44 kPa.
- The engine speed is between 2,000–3,000 RPM.
- The system voltage is more than 10 volts.

Conditions for Setting the DTC

The KS is outside the assigned range or not present.

SIO-ID = 727820

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

SIO-ID = 727824

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

Diagnostic Aids

- The KS must be correctly tightened to 25 N·m (18 lb ft).
- The mounting between the sensor and engine must be free of burrs, casting flash, and foreign material.
- The KS head is clear from hoses, brackets, and engine wiring.
- If an intermittent is suspected, refer to *Intermittent Conditions*.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step ensures that the malfunction is present.
3. This step ensures that the KS is capable of detecting detonation and producing a signal.
6. If the KS signal wire is shorted to ground or shorted to voltage, the KS may still produce a signal.
7. If the KS low reference is shorted to ground or shorted to voltage, the KS may still produce a signal.

DTC P0327

Step	Action	Yes	No
Schematic Reference: *Engine Controls Schematics*			
1	Did you perform the Diagnostic System Check–Engine Controls?	Go to *Step 2*	Go to *Diagnostic System Check - Engine Controls*

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DTC P0327 (cont'd)

Step	Action	Yes	No
2	**Important:** If an engine knock can be heard, repair the engine mechanical condition before proceeding with this diagnostic. 1. Use a scan tool in order to observe the Freeze Frame/Failure Records data for this DTC. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text or as closely as possible to the Freeze Frame/Failure Records conditions. Does the DTC fail this ignition?	Go to *Step 3*	Go to *Intermittent Conditions*
3	1. Turn ON the ignition, with the engine OFF. 2. Use a scan tool in order to save the Freeze Frame/Failure Records data stored when the DTC set. 3. Turn OFF the ignition and wait 30 seconds. 4. Disconnect the PCM connector. 5. Use a DMM set to the 400 mv AC hertz scale in order to observe the frequency between the KS signal circuit and the KS low reference circuit while tapping on the block with a non-metallic object. Refer to *Measuring Frequency* in Wiring Systems. Does the DMM display a fluctuating frequency while tapping on the block?	Go to *Step 6*	Go to *Step 4*
4	1. Disconnect the KS. 2. Test for an open in the KS signal circuit and low reference circuit. Refer to *Testing for Continuity* in Wiring Systems. Did you find and correct the condition?	Go to *Step 11*	Go to *Step 5*
5	Inspect for a poor connection at the knock sensor harness connector. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. Did you find and correct the condition?	Go to *Step 11*	Go to *Step 9*
6	Test for a short to ground and for a short to voltage in the KS signal circuit. Refer to *Testing for Short to Ground* and *Testing for a Short to Voltage* in Wiring Systems. Did you find and correct the condition?	Go to *Step 11*	Go to *Step 7*
7	Test for a short to ground and a short to voltage in the KS low reference circuit. Refer to *Testing for Short to Ground* and *Testing for a Short to Voltage* in Wiring Systems. Did you find and correct the condition?	Go to *Step 11*	Go to *Step 8*
8	Inspect for a poor connection at the harness connector of the PCM. Refer to *Testing for Intermittent and Poor Connections* in Wiring Systems. Did you find and correct the condition?	Go to *Step 11*	Go to *Step 10*
9	Replace the KS. Refer to *Knock Sensor (KS) Replacement*. Did you complete the replacement?	Go to *Step 11*	—
10	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	Go to *Step 11*	—
11	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Start the engine. 4. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the diagnostic test run and pass?	Go to *Step 12*	Go to *Step 2*
12	With a scan tool, observe the stored information, Capture Info. Does the scan tool display any DTCs that you have not diagnosed?	Go to *Diagnostic Trouble Code (DTC) List*	System OK

DTC P0335

SIE-ID = 693518

Circuit Description

The crankshaft position (CKP) sensor signal indicates the crankshaft speed and position. The CKP sensor is connected directly to the powertrain control module (PCM), and consists of the following circuits:

- The 12-volt reference circuit
- The low reference circuit
- The CKP sensor signal circuit

Conditions for Running the DTC

- DTCs P0101, P0102, P0103, or P0341 are not set.
- The camshaft position sensor (CMP) is transitioning.
- The mass airflow (MAF) is more than 3 g/s in Crank mode.
- The MAF is more than 5 g/s in Run mode.

Conditions for Setting the DTC

The CKP sensor signal is not detected for more than 3 seconds.

SIO-ID = 727820

Action Taken When the DTC Sets

- The control module illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

SIO-ID = 727824

Conditions for Clearing the MIL/DTC

- The control module turns OFF the malfunction indicator lamp (MIL) after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Clear the MIL and the DTC with a scan tool.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This step determines if the DTC P0336 is an intermittent.
3. This step checks the ignition 1 voltage circuit to the crankshaft position sensor.
4. This step checks the crankshaft position sensor low reference circuit.
5. This step checks the crankshaft position sensor.

DTC P0335

Step	Action	Value(s)	Yes	No
Schematic Reference: *Engine Controls Schematics*				
1	Did you perform the Diagnostic System Check–Engine Controls?	—	Go to *Step 2*	Go to *Diagnostic System Check - Engine Controls*
2	Does the vehicle start and continue to run?	—	Go to *Intermittent Conditions*	Go to *Step 3*
3	1. Disconnect the crankshaft position (CKP) sensor. 2. Turn ON the ignition, leaving the engine OFF. 3. Probe the CKP sensor harness connector 12-volt reference circuit with a test lamp connected to a ground. Does the test lamp illuminate?	—	Go to *Step 4*	Go to *Step 6*
4	Connect a test lamp between the 12-volt reference circuit in the CKP sensor harness connector and the sensor low reference circuit. Does the test lamp illuminated?	—	Go to *Step 5*	Go to *Step 7*

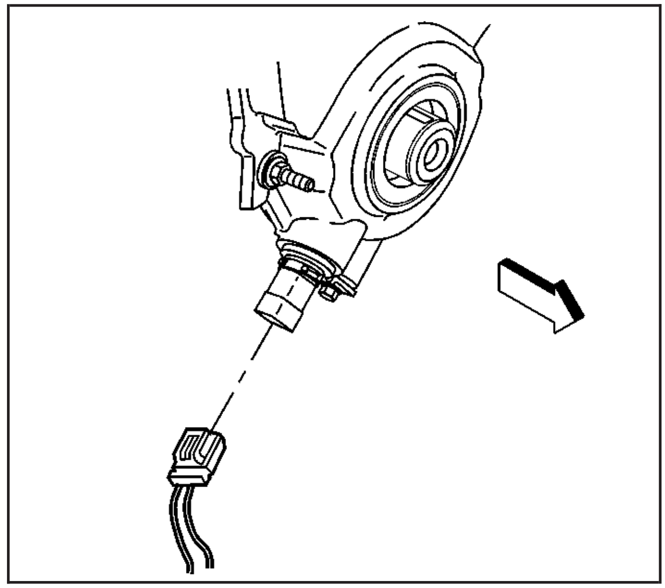
DTC P0335 (cont'd)

Step	Action	Value(s)	Yes	No
5	1. Turn OFF the ignition. 2. Install the gray jumpers from the *J 35616-A* Connector Test Kit between the engine harness connector and the sensor connector of the 12-volt reference circuit and low reference circuit. 3. Connect a DMM set to the duty cycle position between the sensor signal circuit and a ground circuit. Select AC voltage and press the Hz button twice in order to display the duty cycle. 4. Crank the engine. Is the duty cycle within the specified range?	40–60 %	Go to *Step 8*	Go to *Step 9*
6	Repair the open or high resistance in the 12-volt reference circuit. Refer to *Wiring Repairs* in Wiring Systems. Did you complete the repair?	—	Go to *Step 15*	—
7	1. Repair the open or high resistance in the low reference circuit. 2. Repair the circuit as necessary. Refer to *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 13*
8	1. Repair the open, high resistance, and for a short in the sensor signal circuit. 2. Repair the circuit as necessary. Refer to *Wiring Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 11*
9	Check the CKP sensor and the crankshaft reluctor wheel for damage. Refer to *Crankshaft Position (CKP) Sensor Replacement* or *Crankshaft Position (CKP) Reluctor Ring Replacement*. Did you find and correct the condition?	—	Go to *Step 10*	Go to *Step 12*
10	Replace the CKP sensor or the crankshaft reluctor wheel. Refer to *Crankshaft Position (CKP) Sensor Replacement* or *Crankshaft Position (CKP) Reluctor Ring Replacement* in Engine Mechanical. Did you complete the replacement?	—	Go to *Step 15*	—
11	1. Check for a faulty connection at the CKP sensor. 2. Repair the connector as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 13*
12	**Important:** Inspect the CKP sensor mounting surface in order to verify that the surface is clean and free of debris. Replace the CKP sensor. Refer to *Crankshaft Position (CKP) Sensor Replacement*. Did you find and correct the condition?	—	Go to *Step 15*	—
13	1. Check for a faulty connection at the powertrain control module (PCM). 2. Repair the connector as necessary. Refer to *Connector Repairs* in Wiring Systems. Did you find and correct the condition?	—	Go to *Step 15*	Go to *Step 14*
14	Replace the PCM. Refer to *Powertrain Control Module (PCM) Replacement*. Did you complete the replacement?	—	Go to *Step 15*	—
15	1. Use the scan tool in order to clear the DTCs. 2. Turn OFF the ignition for 30 seconds. 3. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text. Does the DTC run and pass?	—	Go to *Step 16*	Go to *Step 2*

Crankshaft Sensor Replacement

Removal Procedure

1. Disconnect the CKP sensor harness connector.



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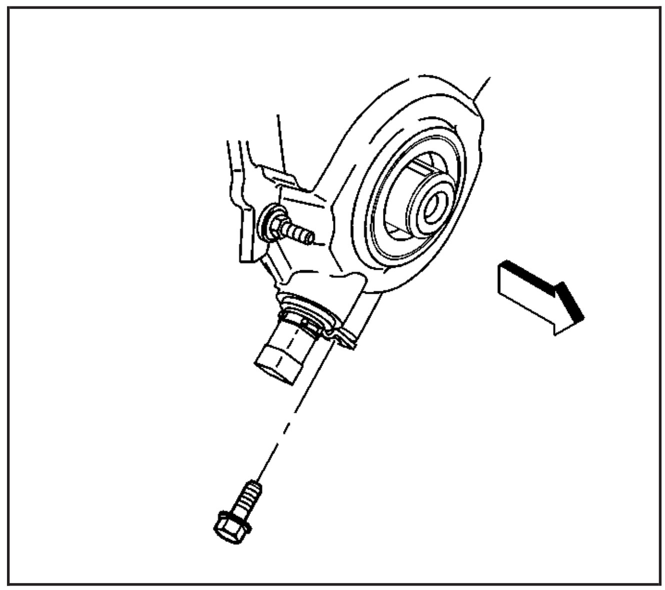
2. Remove the CKP sensor mounting bolt.



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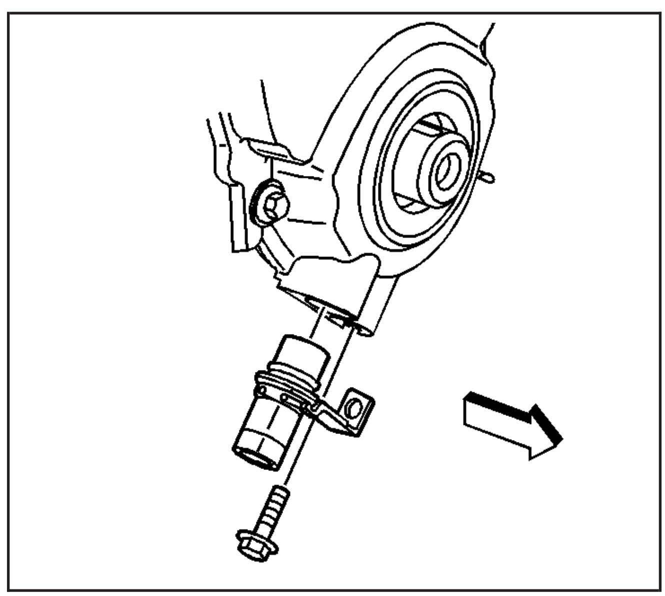
3. Remove the CKP sensor.



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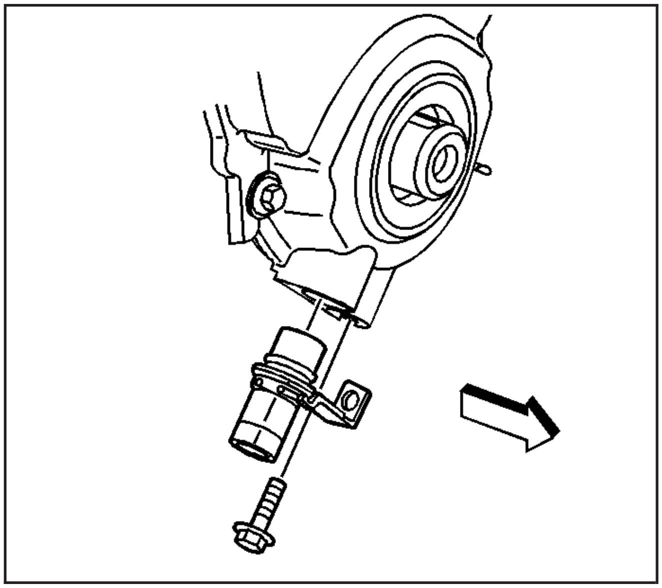


11485

Installation Procedure

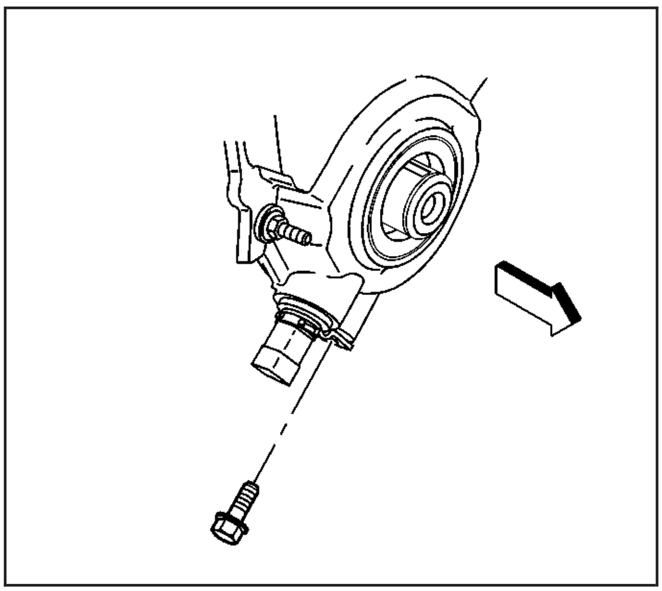
Important: When installing the CKP sensor, make sure the sensor is fully seated before tightening the mounting bolt. A poorly seated CKP sensor may perform erratically and may set false DTCs.

Important: Do not reuse the original O-ring.

1. Replace the CKP sensor O-ring.
2. Lubricate the O-ring with clean engine oil before installing the CKP sensor.

Important: Make sure the CKP sensor mounting surface is clean and free of burrs.

3. Install the CKP sensor.



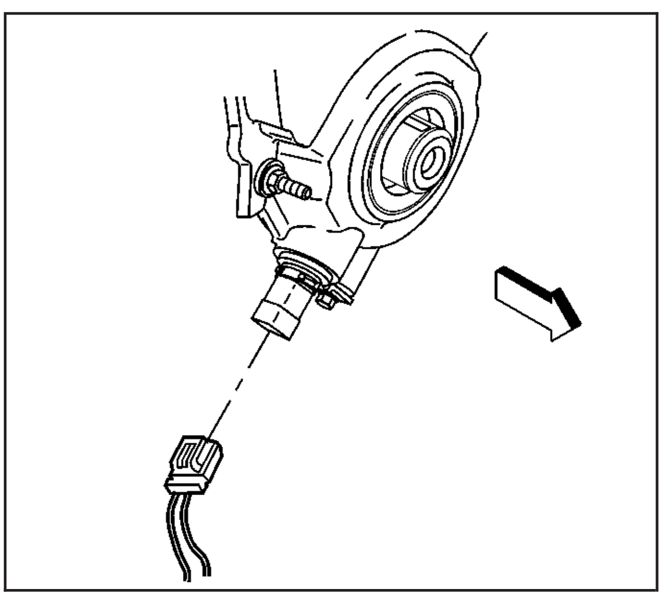
10938

Notice: Refer to Fastener Notice in Cautions and Notices.

4. Install the CKP sensor mounting bolt.

   Tighten

   Tighten the CKP sensor mounting bolt to 9 N·m (80 lb in).



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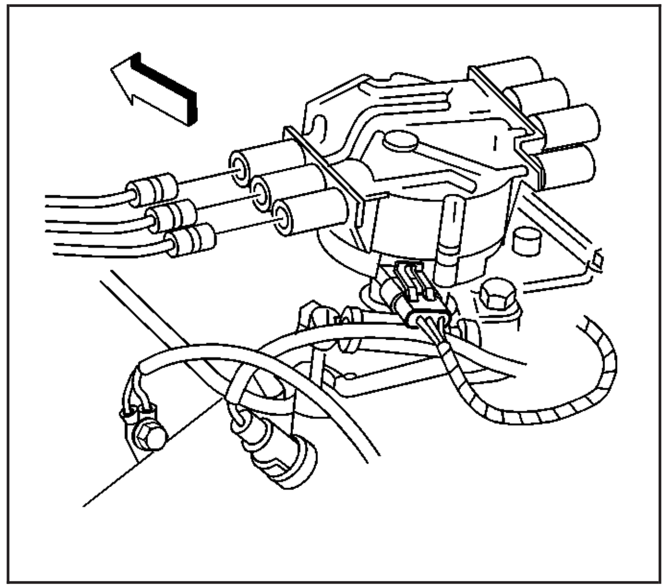
5. Connect the CKP sensor harness connector.

Camshaft Position (CMP) Sensor Replacement

Removal Procedure

1. Disconnect the spark plug wires and ignition coil wire from the distributor. Refer to SparkPlug Wire Replacement.



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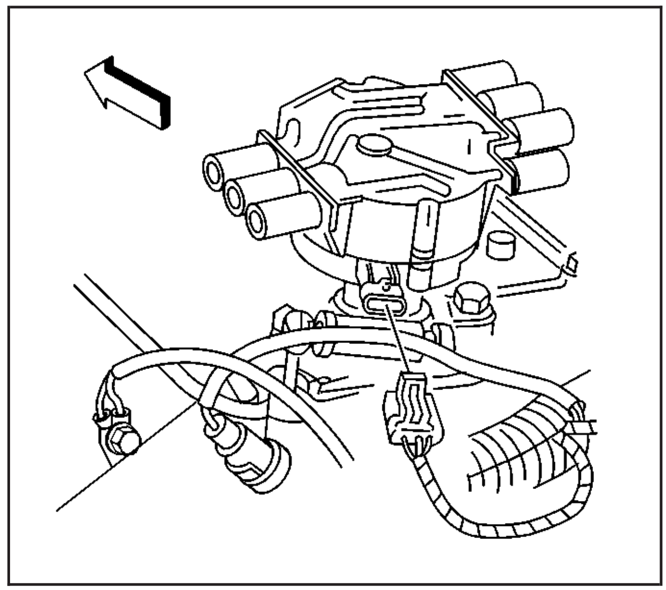
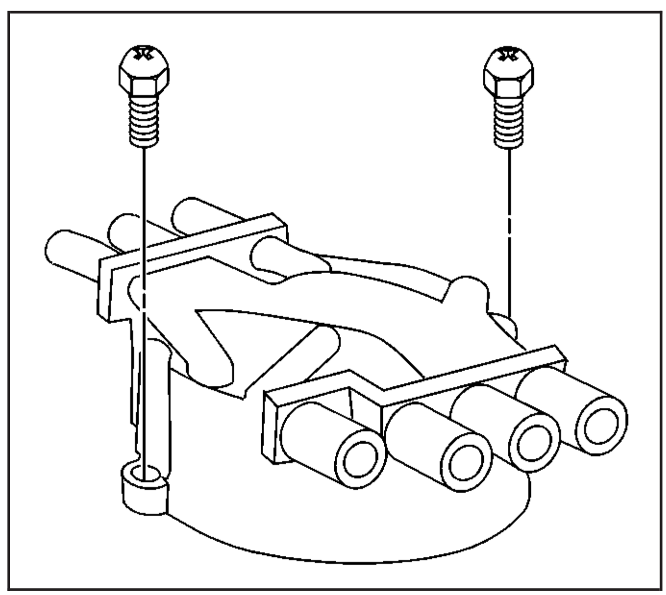
2. Disconnect the camshaft position (CMP) sensor harness connector from the distributor.



302829

3. Remove the distributor cap screws.



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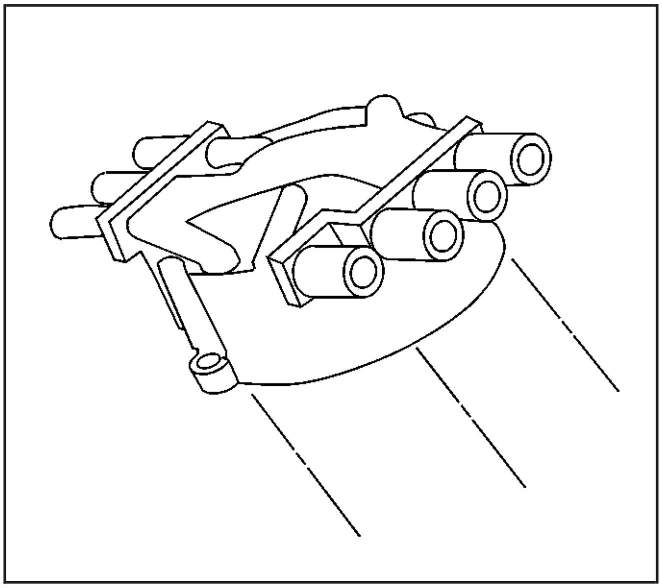

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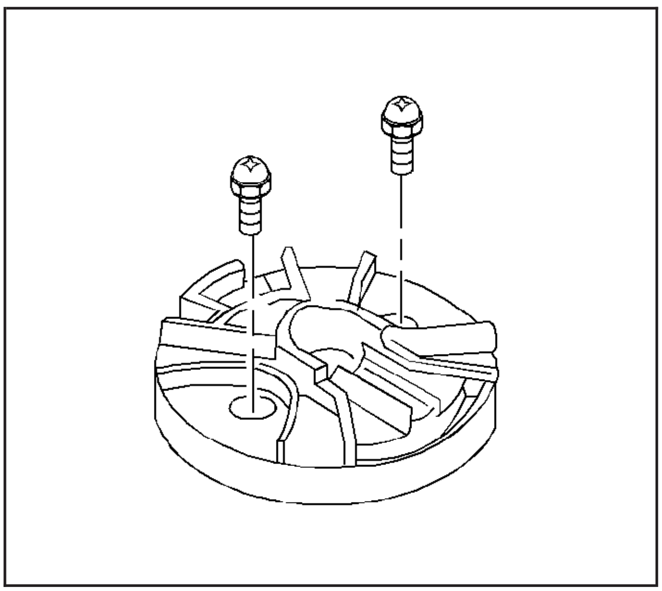
4. Remove the distributor cap.



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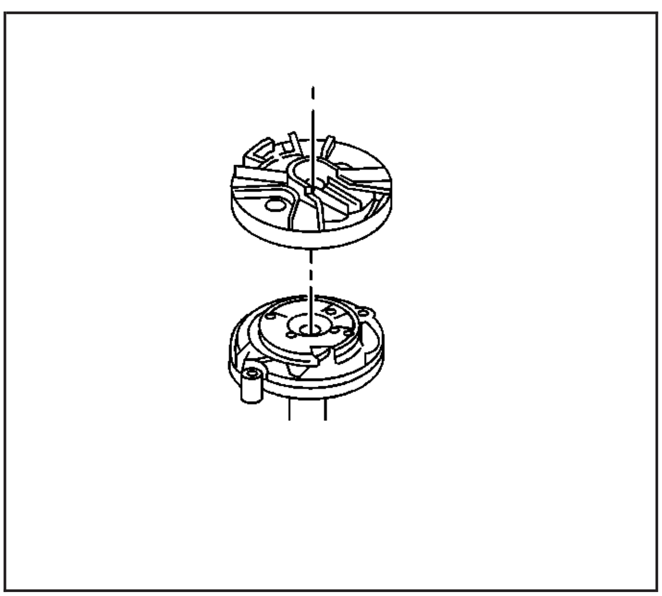
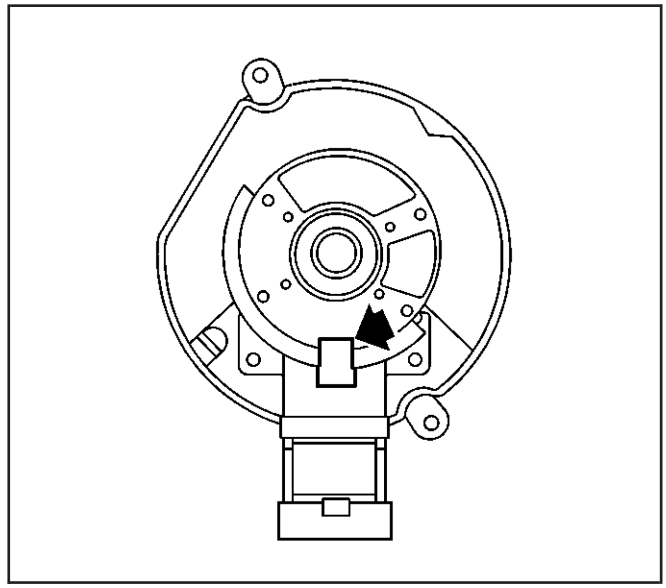
5. Remove the rotor screws.



156748

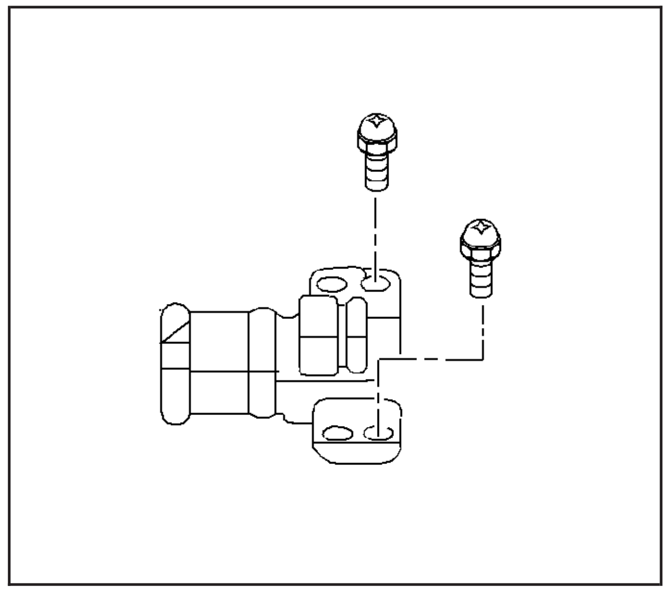
6. Remove the rotor.

7. Align the square slot in the reluctor wheel with the CMP sensor.



156754

8. Remove the CMP screws.



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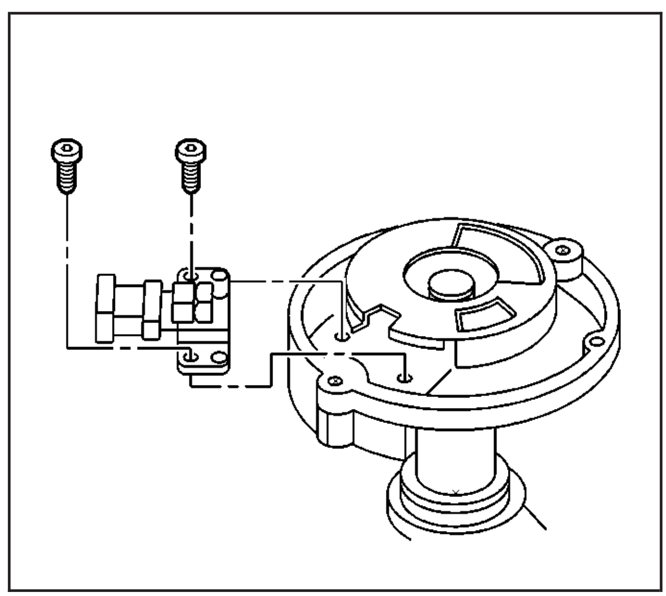
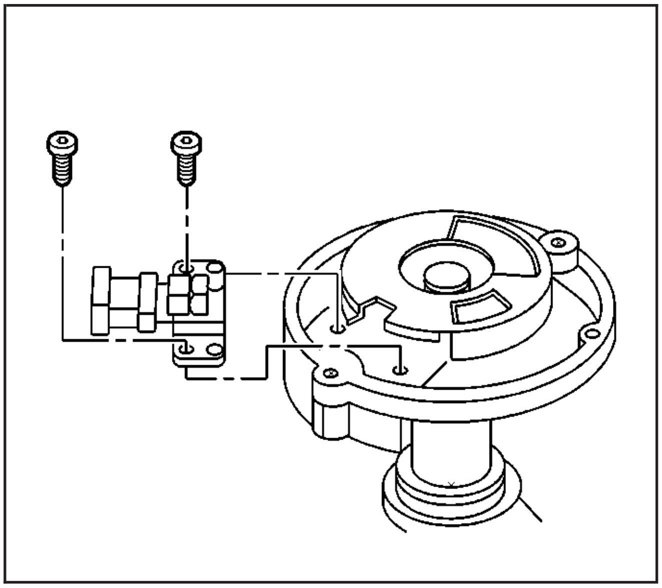
9. Remove the CMP sensor.



301398



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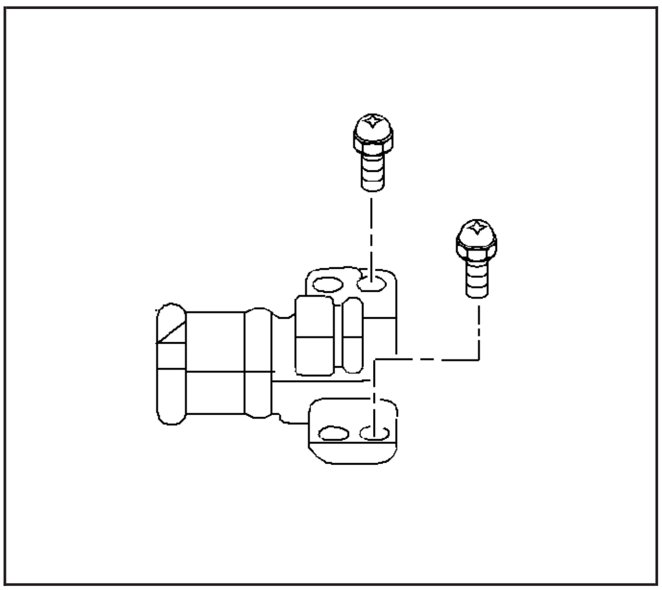
Installation Procedure

Important: Do not use the old cap, CMP sensor, and rotor screws. Use the replacement screws that have been coated with a thread locking compound.

1. Insert the CMP sensor through the reluctor wheel slot.



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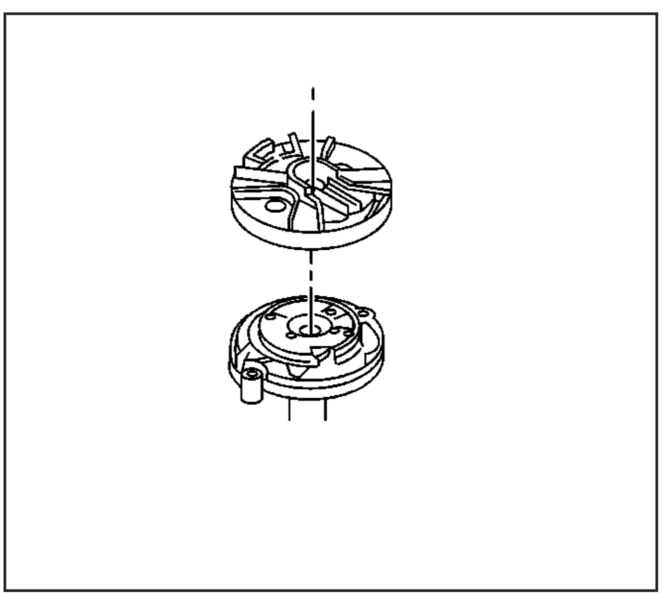
2. Install new CMP mounting screws.

Tighten

Tighten the bolts to 2.2 N·m (19 lb in).



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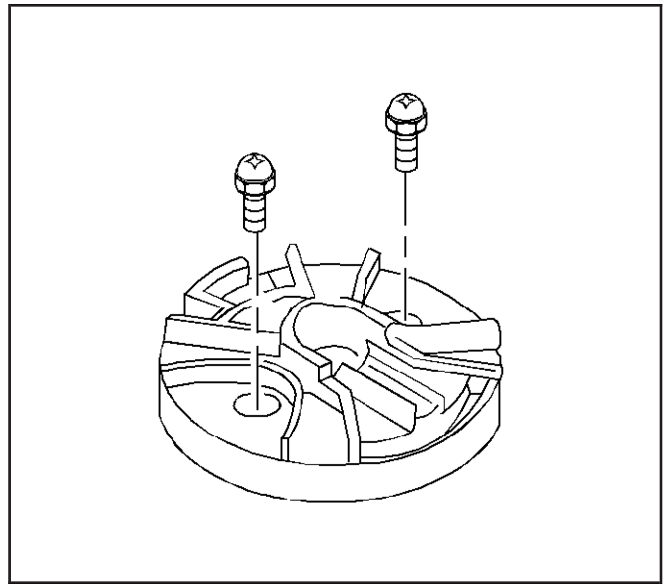
3. Install the rotor onto the reluctor wheel.

4. Install new rotor screws.

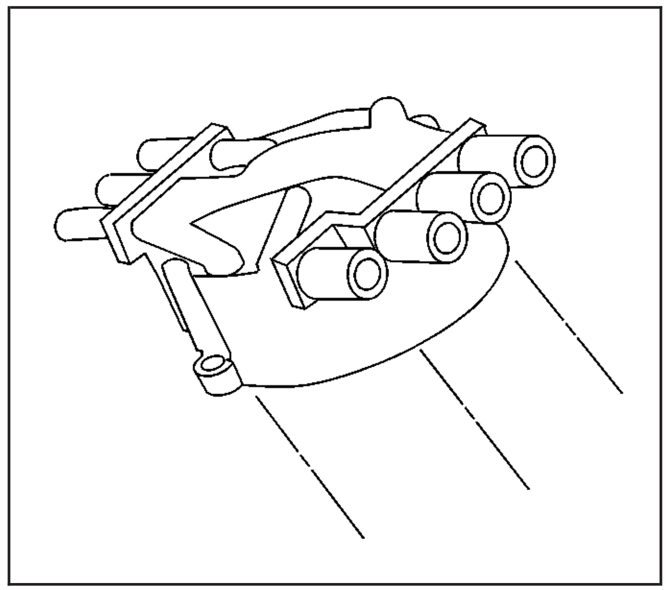
   Tighten

   Tighten the screws to 2 N·m (18 lb in).



4354

5. Install the distributor cap.



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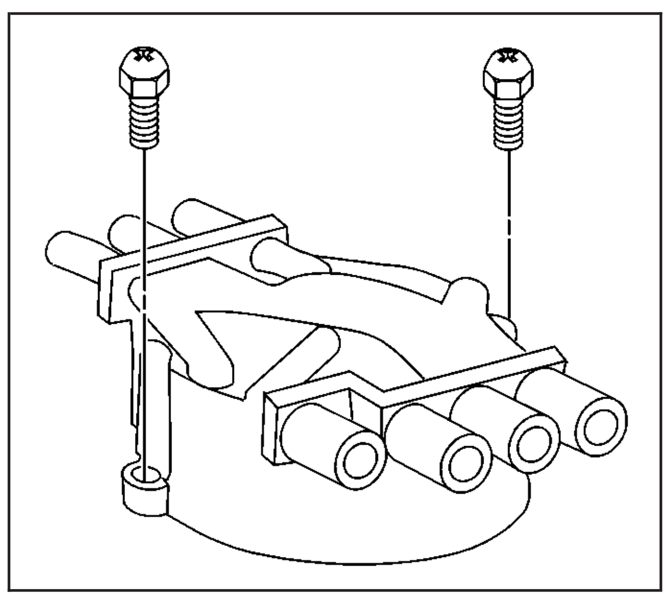
6. Install new distributor cap screws.

   Tighten

   Tighten the screws to 2.4 N·m (21 lb in).



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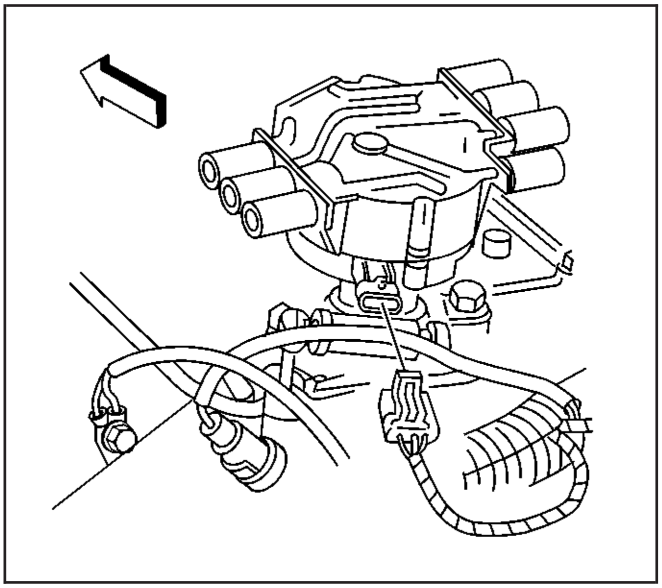

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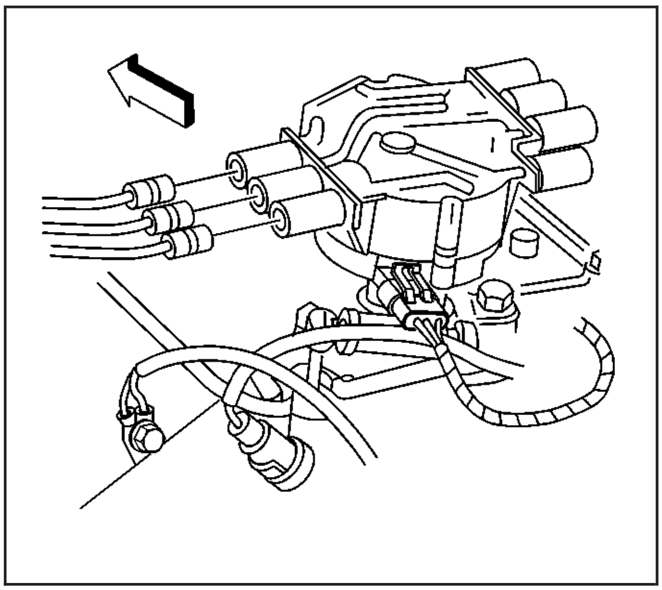
7. Connect the CMP sensor harness connector.



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8. Connect the spark plug wires and ignition coil wire. Refer to Spark Plug Wire Replacement.

SECTION 1E1

FUEL SYSTEM

REPAIR INSTRUCTIONS

PROPANE FUEL SYSTEM PRESSURE RELIEF

CAUTION

THE PROPANE FUEL SYSTEM OPERATES AT PRESSURES UP TO 21.5 BAR (312 PSI). TO MINIMIZE THE RISK OF FIRE AND PERSONAL INJURY, RELIEVE THE PROPANE FUEL SYSTEM PRESSURE (WHERE APPLICABLE) BEFORE SERVICING THE PROPANE FUEL SYSTEM COMPONENTS.

To relieve propane fuel system pressure:

1. Close the manual shut-off valve (MSV) on the propane fuel tank.
2. Start and run the vehicle until the engine stalls.
3. Turn the ignition switch OFF.

IMPORTANT

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

PROPANE FUEL SYSTEM LEAK TEST

CAUTION

NEVER USE AN OPEN FLAME OF ANY TYPE TO CHECK FOR PROPANE FUEL SYSTEM LEAKS.

Always inspect the propane 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.

PROPANE FUEL FILTER REPLACEMENT

(FIGURE 1)

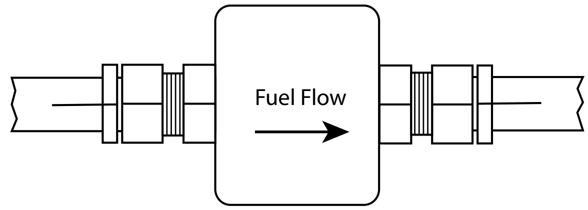

FIGURE 1 INLINE FUEL FILTER

Removal Procedure

1. Relieve the propane fuel system pressure. Refer to *Propane Fuel System Pressure Relief.*
2. Disconnect the negative battery cable.
3. Slowly loosen the fuel inlet fitting to the filter and remove the line.
4. Remove the outlet fitting from the filter
5. Remove the filter from the retaining bracket and discard

Installation Procedure

IMPORTANT:

- Be sure to install the filter in the correct direction of the flow marked with an arrow
- Do Not use Teflon tape on the pipe fittings use only a liquid pipe sealant

6. Install the filter to the retaining device and secure
7. Install the outlet fuel line and tighten to specification

Tighten

27 Nm (20 ft lbs)

8. Reconnect the negative battery cable
9. Open manual shut-off valve.
10. Start the vehicle and leak check the propane fuel system at each serviced fitting Refer to Propane Fuel System Leak Test.

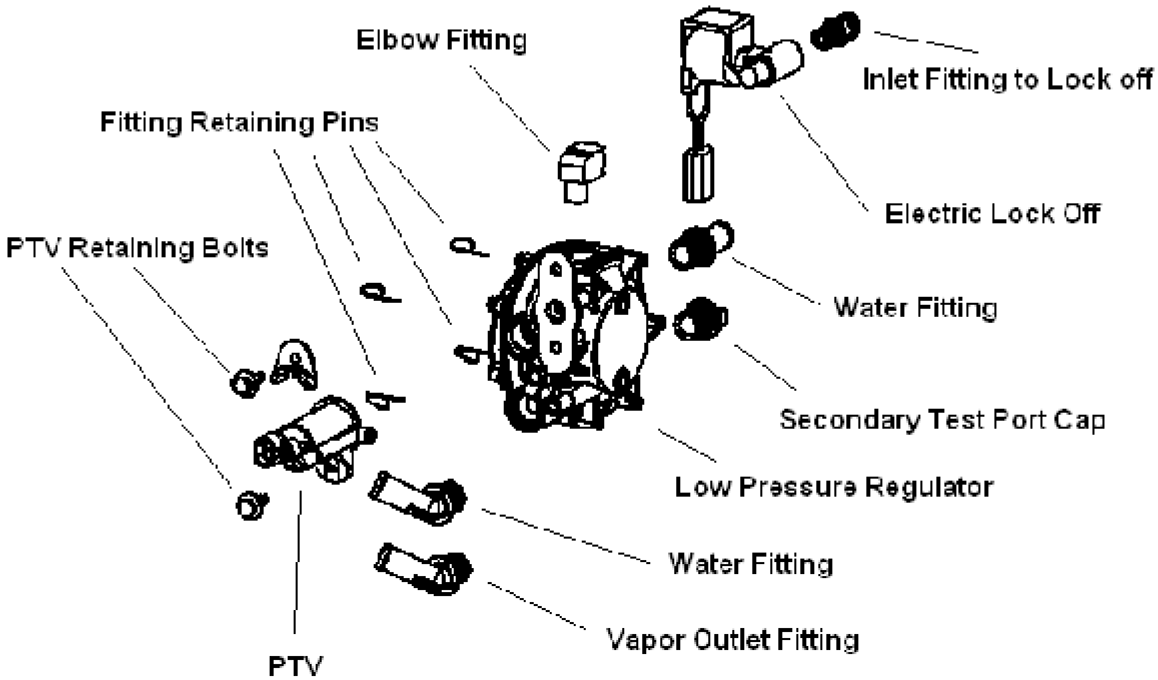

FIGURE 2 LOW PRESSURE REGULATOR AND LOCK OFF ASSEMBLY

LOW PRESSURE LOCK-OFF (LPL) REPLACEMENT

(Figure 2)

Removal Procedure

1. Relieve the propane fuel system pressure. Refer to *Propane Fuel System Pressure Relief.*
2. Disconnect the negative battery cable.
3. Disconnect the LPL electrical connector.
4. Disconnect the LPG fuel inlet line from the LPL inlet fitting.
5. Unscrew the LPL from the LPR inlet fitting.

Installation Procedure

IMPORTANT

- Do not use Teflon tape on any fuel fitting. Use a liquid pipe thread sealant when installing fittings.

1. Apply pipe thread sealant to the LPR inlet fitting.
2. Install the LPL to the LPR. Tighten the LPL finger tight plus 1 to 2 turns and place the LPL in the correct position.
3. Install the fuel inlet line.
4. Tighten the fuel line fitting to the LPL

   Tighten

   27 Nm (20 ft lbs)

5. Connect the LPL electrical connector
6. Connect the negative battery cable
7. Open the tank manual shut off valve
8. Start the vehicle and leak check the propane fuel system at each serviced fitting.

PRESSURE TRIM VALVE (PTV) REPLACEMENT

(Figure 2)

1. Disconnect the PTV electrical connection.
2. Remove the vacuum hose from the PTV
3. Remove and retain the two (2) retaining bolts and plate
4. Remove the PTV

Installation Procedure

IMPORTANT

- Apply a small amount of O-ring lubricant to the PTV O-ring before installation

6. Install the PTV using the two mounting bolts and retaining plate
7. Tighten retaining bolts

   Tighten

   9 N•m (80 lb-in)

8. Connect the PTV vacuum line
9. Connect the PTV electrical connector
10. Start the vehicle.
11. Connect the diagnostic service tool and verify the engine is operating in closed loop and no MIL light is present

LOW PRESSURE REGULATOR (LPR) REPLACEMENT

(Figure 2)

Removal Procedure

1. Relieve the propane fuel system pressure. Refer to *Propane Fuel System Pressure Relief.*
2. Disconnect the negative battery cable.
3. Clamp the coolant hoses to the LPR or drain the radiator.
4. Remove the LPL. Refer to *Low Pressure Lock-off Replacement.*
5. Remove the PTV Refer to *Pressure Trim Valve Replacement*
6. Disconnect the supply and return coolant lines from the LPR.
7. Remove the retaining pin from the water inlet and outlet fittings and retain
8. Remove the coolant inlet and outlet fitting retaining pins and retain.
9. Remove the inlet fitting
10. Remove the outlet fitting and retain
11. Disconnect the FTV supply line
12. Remove the two LPR mounting bolts and retain
13. Lift LPR assembly and remove the two (2) LPR mounting bolts and retain
14. Loosen the fuel vapor hose clamp at the LPR fuel outlet fitting
15. Disconnect the fuel vapor hose from the LPR outlet fitting and remove the LPR.
16. Remove the retaining pin from the vapor outlet fitting and retain
17. Remove and retain the vapor outlet fitting from the LPR
18. Remove the LPR.

Installation Procedure

IMPORTANT

- Do not use Teflon tape on any fuel fitting. Use a liquid pipe thread sealant when installing fittings.
- Lubricate the o-ring of the PTV before installing into the LPR
- Lubricate the o-rings on each of the fitting

1. Install the inlet water fitting and secure with retaining pin
2. Install the outlet water fitting and secure with retaining pin
3. Install vapor outlet fitting and secure with retaining pin
4. Insert the vapor hose to the fuel outlet fitting and place clamp
5. Install the FTV supply line and secure
6. Secure the LPR to the mounting bracket using the two (2) retaining bolts and tighten to specification

   Tighten

   14 Nm (10 ft lbs)

7. Install the water inlet and outlet lines to the fittings and place clamps
8. Install the water inlet and outlet lines to the fittings and place clamps
9. Install LPL. Refer to *Low Pressure Lock-off Replacement.*
10. Install the PTV Refer to *Pressure Trim Valve Replacement*
11. Tighten fuel line fitting

    Tighten

    27 Nm (20 ft lbs)

12. Replace the drained coolant
13. Start the vehicle and leak check the propane fuel system at each serviced fitting.

Figure 3

FUEL TRIM VALVE (FTV) SOLENOID REPLACEMENT

(Figure 3)

Removal Procedure

1. Disconnect the FTV electrical connection.
2. Remove the fuel supply hose from the FTV
3. Remove the two (2) retaining bolts and retain
4. Remove the FTV

Installation Procedure

IMPORTANT

- Apply a small amount of O-ring lubricant to the PTV o-ring before installation

5. Install FTV to throttle body
6. Install the two bolts
7. Tighten retaining bolts

Tighten

9 N•m (80 lb-in)

8. Connect Fuel supply hose
9. Connect electrical connection
10. Start the vehicle.

TEMPERATURE MANIFOLD ABSOLUTE PRESSURE (TMAP)

(Figure 3)

Removal Procedure

1. Disconnect the TMAP electrical connector
2. Remove the two retaining bolts
3. Remove the TMAP

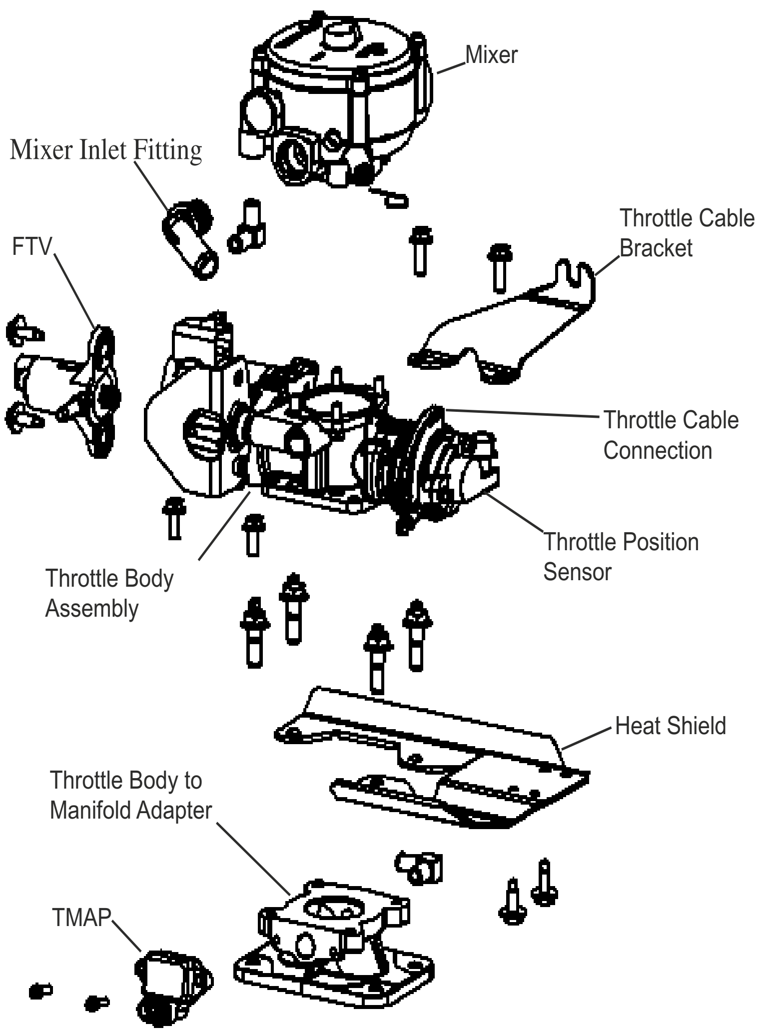

FIGURE 3 MIXER AND THROTTLE BODY ASSEMBLY

Installation Procedure

- Apply a small amount of O-ring lubricant to the PTV o-ring before installation

4. Install the TMAP
5. Install and tighten the two (2) retaining bolts

Tighten

7 N•m (62 lb-in)

6. Start the vehicle

THROTTLE BODY REPLACEMENT

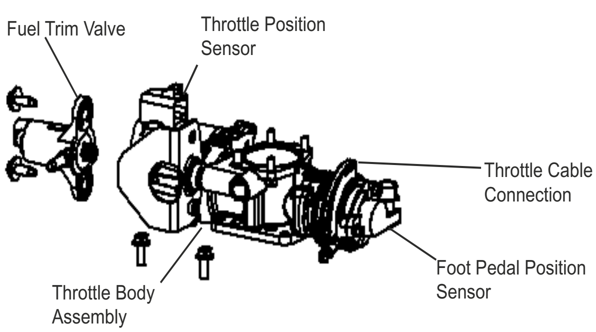

FIGURE 4 THROTTLE BODY ASSEMBLY

Removal Procedure

1. Disconnect the negative battery cable.
. Remove the air intake duct.
3. Disconnect the governor control device electrical connector
4. Disconnect the throttle cable
5. Disconnect the FTV electrical connector
6. Disconnect Both TPS electrical connectors
7. Disconnect the FTV supply line
8. Disconnect the PTV vacuum line
9. Disconnect the balance line to the LPR
10. Release mixer fuel inlet hose clamp and remove hose from mixer inlet
11. Remove the four (4) manifold to adapter retaining bolts from the throttle body adapter and retain bolts
12. Lift assembly from the adapter and cover the throttle body opening with a clean cloth
13. Remove and discard the adapter o-ring
14. Remove the four (4) throttle body to mixer bolts and retain
15. Remove throttle body assembly
16. Remove o-ring gasket and discard

Installation Procedure

IMPORTANT

- Lightly Lubricate the both the o-rings of the throttle control device to adapter
- Cover Throttle body adapter opening to prevent debris from entering engine until reassembly

1. Install o-ring to the top of the throttle body assembly
2. Insert throttle body onto the bottom of the mixer
3. Tighten the four screws to specification

Tighten

9 N•m (80 lb-in)

4. Install Throttle adapter o-ring
5. Install the Throttle body onto the manifold adapter line up the throttle cable bracket and install the four (4) retaining screw
6. Tighten the four screws to specification

Tighten

12 N•m (106 lb-in)

7. Connect the fuel vapor hose and secure clamp
8. Connect the balance line to the LPR
9. Connect the PTV vacuum line
10. Connect both TPS electrical connectors
11. Connect the governor electrical connector
12. Connect the FTV electrical connector
13. Connect the throttle cable
14. Connect the air inlet duct
15. Start engine
16. Install the diagnostic tool and check for DTC codes and no MIL light

MIXER REPLACEMENT

(Figure 3)

Removal Procedure

1. Disconnect the negative battery cable.
2. Remove the air intake duct.
3. Remove the throttle body assembly *Refer to Throttle Body Assembly Replacement*
4. Remove the four (4) screws to the throttle body assem-

bly to mixer

5. Remove and discard the mixer to throttle body assembly o-ring

Installation Procedure

IMPORTANT

- Lightly Lubricate the o-ring of the Mixer to throttle body assembly o-ring before installing
- Cover Throttle body adapter opening to prevent debris from entering engine until reassembly

1. Install Mixer to throttle body assembly o-ring onto the mixer
2. Install the mixer to the throttle body assembly and secure with the 4 retaining screw

Tighten

9 N•m (80 lb-in)

3. Install Throttle body *Refer to Electronic Throttle Control Device Replacement*

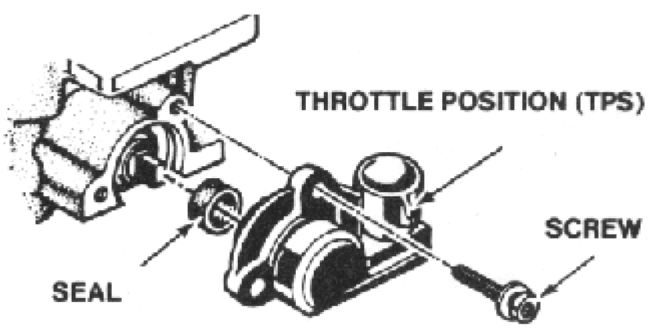

FIGURE 5 THROTTLE POSITION SENSOR

THROTTLE POSITION SENSOR REPLACEMENT

(Figure 5)

1. Disconnect the TPS electrical connect
2. Remove and retain the two (2) screws
3. Remove the TPS shaft seal
4. Remove the TPS

Installation Procedure

5. Install the TPS shaft seal
6. With the throttle valve closed install the TPS
7. Rotate counterclockwise until mounting holes align
8. Install two (2) screws and tighten to specification

Tighten

2 N•m (18 lb-in)

COOLANT HOSE REPLACEMENT

1. Drain coolant
2. Using a hose clamp pliers disconnect both hose clamps on each hose
3. Remove the coolant inlet hose form each fitting
4. Remove the coolant outlet hose

Installation Procedure

IMPORTANT

- Coolant hose are specifically designed, DO NOT use hose material or length other than the OEM specified parts
- DO NOT mix the inlet or outlet hoses when reinstalling

1. Install hose clamps and set back on each hose
2. Reinstall the coolant inlet hose to each fitting
3. Reinstall the coolant outlet hose to each fitting
4. Reset clamps
5. Refill with coolant
6. Start engine and check for coolant leaks

VAPOR HOSE REPLACEMENT

1. Using a hose clamp pliers disconnect both hose clamps
2. Remove the vapor hose form each fitting

Installation Procedure

IMPORTANT

- Vapor supply hose is specifically designed, DO NOT use hose material or length other than the OEM specified parts

3. Install hose clamps and set back on each hose
4. Reinstall the vapor hose to each fitting
5. Reset clamps
6. Start engine and check for leaks

BALANCE LINE HOSE REPLACEMENT

1. Remove the clamp to the fitting at the mixer
2. Remove small hose to check valve
3. Remove and retain check valve
4. Remove the one (1) hose routing retaining bolt and retain
5. Remove clamp at the LPR connection

Installation Procedure

IMPORTANT

- Balance line hoses are specifically designed, DO NOT use hose material or length other than the OEM specified parts
- DO NOT mix the hoses when reinstalling
- Install check valve in correct direction (Arrow on check valve pointing toward mixer)

7. Install hose clamps and set back on each hose
8. Reinstall the LPR hose end to the LPR fitting and set clamp
9. Install Check valve and set clamp (Directional part arrow pointing to mixer)
10. Reinstall the small hose section and set clamps
11. Start engine and check for leaks

PTV HOSE REPLACEMENT

1. Using a hose clamp pliers disconnect the clamps on the hose fitting at the mixer
2. Using a small screw driver push locking clip back on PTV connection
3. Remove the hose and discard

Installation Procedure

IMPORTANT

- PTV hoses are specifically designed, DO NOT use hose material or length other than the OEM specified parts

4. Install hose clamps and set back on the mixer hose end
5. Reinstall hose at the PTV and push lock in place
6. Reinstall hose at the mixer and set clamp
7. Start engine and check for leaks

FTV HOSE REPLACEMENT

1. Using a small screw driver push locking clips back on FTV connection at FTV and LPR
2. Remove the hose and discard

Installation Procedure

IMPORTANT

- FTV hoses are specifically designed, DO NOT use hose material or length other than the OEM specified parts

3. Reinstall hose at the PTV and LPR and push locks in place
4. Start engine and check for leaks

ENGINE CONTROL MODULE REPLACEMENT

1. Disconnect Negative battery cable
2. Remove controller from mounting bracket
3. Push connector lock back to unlock connector
4. Unplug controller and remove

Installation Procedure

IMPORTANT

- Controller is calibrated for each engine verify you have the correct controller

5. Plug connector into controller

6. Push lock into place
7. Mount controller into mounting bracket
8. Reconnect the battery cable
9. Install Diagnostic service tool
10. Start engine
11. Check for any DTC codes and clear
12. Verify engine is in closed loop and no MIL lights are present

HEATED EXHAUST GAS OXYGEN SENSOR REPLACEMENT

1. Disconnect Negative battery cable
2. Disconnect the O-2 sensor electrical connector
3. Using a O-2 Sensor socket remove the O-2 Sensor and discard

Installation Procedure

IMPORTANT

- Before install the O-2 sensor lubricate threads with anti-seize compound GM P/N 5613695 or equivalent. Avoid getting compound on the sensor tip

4. Install O-2 sensor

Tighten

41 N•m (30 lb-ft)

5. Start engine
6. Check for any DTC codes and clear
7. Verify engine is in closed loop and no MIL lights are present

THREE WAY CATALYTIC CONVERTER MUFFLER REPLACEMENT

1. Remove the TWC muffler using the OEM end product processes

Installation Procedure

IMPORTANT

- The Three Way Catalytic converter is specifically designed to meet the emission control of the certified engine. Use only the OEM specified parts

2. Install the TWC muffler using the OEM end product processes
3. Start engine
4. Check for any DTC codes and clear
5. Verify engine is in closed loop and no MIL lights are present

REPAIR INSTRUCTIONS

GASOLINE MPFI FUEL SYSTEM PRESSURE RELIEF

CAUTION

THE FUEL SYSTEM OPERATES AT PRESSURES UP TO 135 KPA (20PSI). TO MINIMIZE THE RISK OF FIRE AND PERSONAL INJURY, RELIEVE THE GASOLINE FUEL SYSTEM PRESSURE (WHERE APPLICABLE) BEFORE SERVICING THE PROPANE FUEL SYSTEM COMPONENTS.

To relieve Gasoline fuel system pressure:

1. Disconnect the electrical connector at the fuel pump.
2. Start and run the vehicle until the engine stalls.
3. Turn the ignition switch OFF.
4. Remove the Cap on the gasoline pressure test port
5. Wrap a shop towel around the fitting and using a small screw driver depress valve and insure there is no pressure left in the system

IMPORTANT

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

GASOLINE FUEL SYSTEM LEAK TEST

CAUTION

NEVER USE AN OPEN FLAME OF ANY TYPE TO CHECK FOR PROPANE FUEL SYSTEM LEAKS.

Always inspect the gasoline fuel system for leaks after performing service. Check for leaks at the fittings of the serviced or replaced component.

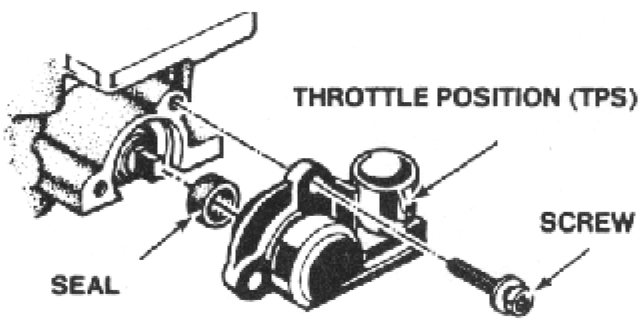

FIGURE 6 THROTTLE POSITION SENSOR

THROTTLE POSITION SENSOR REPLACEMENT

(Figure 6)

1. Disconnect the TPS electrical connect
2. Remove and retain the two (2) screws
3. Remove the TPS shaft seal
4. Remove the TPS

Installation Procedure

5. Install the TPS shaft seal
6. With the throttle valve closed install the TPS
7. Rotate counterclockwise until mounting holes align
8. Install two (2) screws and tighten to specification

Tighten

2 N•m (18 lb-in)

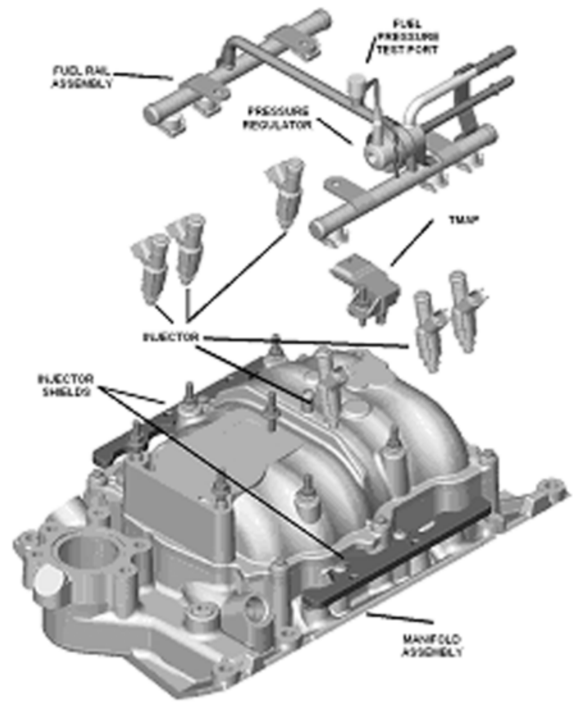

FIGURE 7 INJECTOR RAIL AND MANIFOLD

FUEL RAIL REPLACEMENT

(Figure 7)

1. Disconnect the negative battery cable
2. Disconnect the air duct
3. Remove the throttle body assembly Refer to *Throttle Body Assembly Replacement*
4. Disconnect the fuel supply line to the rail as sembly
5. Disconnect the fuel return line to the rail assembly
6. Disconnect the vacuum line to the Pressure regulator
7. Remove the four (4) fuel rail retaining bolts to the manifold and retain
8. With a screw driver press back on the six (6) injector retaining clips and retain
9. Carefully lift the fuel rail off the injectors

Installation Procedure

IMPORTANT

- Lightly Lubricate the o-ring of the throttle body assembly and the inlet o-ring on each injector
- Cover Throttle body adapter opening and injectors to prevent debris from entering engine or the injectors until reassembly

10. Carefully place the fuel rail over all the injector and press down to set the rails
11. Install the six (6) injector retaining clips
12. Secure the fuel rail to the manifold with the four (4) retaining bolts

Tighten

12 N•m (106 lb-in)

13. Connect the vacuum line to the pressure regulator
14. Connect the fuel return line
15. Connect the fuel supply line
16. Install the throttle body assembly Refer to *Throttle Body Assembly Replacement*
17. Install the air duct
18. Connect the negative battery cable
19. Start engine
20. Install diagnostic tool and check for DTC codes or MIL lights

INJECTOR REPLACEMENT

(Figure 7)

1. Disconnect the negative battery cable
2. Relieve the fuel system pressure. *Refer to Gasoline Fuel System Pressure Relief*
3. Remove the fuel rail assembly *Refer to Fuel Rail Replacement*
4. Disconnect the six (6) injector electrical connections
5. Remove each injector

Installation Procedure

IMPORTANT

- Apply a small amount of o-ring lubricant to the injector o-rings before installation
- Lightly Lubricate the o-ring of the throttle body assembly and the inlet o-ring on each injector
- Cover Throttle body adapter opening and injectors to prevent debris from entering engine or the injectors until reassembly

5. Install the injectors
6. Connect the injector electrical connectors
7. Reinstall the fuel rail assembly *Refer to Fuel Rail Replacement*
8. Start engine and check for leaks
9. Install diagnostic service tool and verify engine is operating closed loop and no MIL light is present

TEMPERATURE MANIFOLD ABSOLUTE PRESSURE REPLACEMENT

(Figure 7)

1. Disconnect the TMAP electrical connection
2. Remove the one (1) retaining bolt and retain
3. Remove the TMAP

Installation Procedure

IMPORTANT

- Apply a small amount of lubricant to the TMAP o-ring

4. Install TMAP
5. Secure using the two (2) retaining bolt

Tighten

6 Nm (54 in lbs)

6. Connect the TMAP electrical connector
7. Start engine
8. Install diagnostic service tool and check for DTC codes and MIL lights

ENGINE CONTROL MODULE REPLACEMENT

1. Disconnect Negative battery cable
2. Remove controller from mounting bracket
3. Push connector lock back to unlock connector
4. Unplug controller and remove

Installation Procedure

IMPORTANT

- Controller is calibrated for each engine verify you have the correct controller

5. Plug connector into controller
6. Push lock into place
7. Mount controller into mounting bracket
8. Reconnect the battery cable
9. Install Diagnostic service tool

10. Start engine
11. Check for any DTC codes and clear
12. Verify engine is in closed loop and no MIL lights are present

HEATED EXHAUST GAS OXYGEN SENSOR REPLACEMENT

1. Disconnect Negative battery cable
2. Disconnect the O-2 sensor electrical connector
3. Using a O-2 Sensor socket remove the O-2 Sensor and discard

Installation Procedure

IMPORTANT

- Before install the O-2 sensor lubricate threads with anti-seize compound GM P/N 5613695 or equivalent. Avoid getting compound on the sensor tip

4. Install O-2 sensor

Tighten

41 N•m (30 lb-ft)

5. Start engine
6. Check for any DTC codes and clear
7. Verify engine is in closed loop and no MIL lights are present

THREE WAY CATALYTIC CONVERTER MUFFLER REPLACEMENT

1. Remove the TWC muffler using the OEM end product processes

Installation Procedure

IMPORTANT

- The Three Way Catalytic converter is specifically designed to meet the emission control of the certified engine. Use only the OEM specified parts

2. Install the TWC muffler using the OEM end product processes
3. Start engine
4. Check for any DTC codes and clear
5. Verify engine is in closed loop and no MIL lights are present

RESTRICTED EXHAUST SYSTEM DIAGNOSIS

EXHAUST SYSTEM DESCRIPTION

The emission certified engine has been designed and calibrated to meet the emission standards in effect for 2004. To help meet the emission requirements the vehicle has been equipped with a Three Way Catalytic (TWC) muffler. The catalyst muffler is a three way catalyst, sound damping and spark arresting unit. Besides controlling the noise created from the combustion process, and preventing sparks from escaping from the exhaust system the most important function is treating the exhaust gases which are created from the combustion process. The three-way catalyst consists of a honeycomb coated with a mixture of platinum, palladium, and rhodium. The hot gases flow through the catalyst sections where an oxidation and reduction reactions take place. These chemical reactions reduce the amount of CO, HC and NOX in the engines exhaust. The Exhaust gas then flows through the outlet.

During normal operation the exhaust system could become damaged. Damage which reduces the flow of the exhaust gas will create increased back pressure in the engine. Reduction in exhaust flow can result from crushed muffler outlets or melted catalyst brick inside the converter.

It may be necessary to measure the back pressure in the exhaust system. To determine if the back pressure in the engine is correct use the following procedure.

Diagnostic Aids

Tools Required:

- J 35314-A

Diagnostic Scan Tool

- IMPCO Fuel System diagnostic tool.

Check at Heated Exhaust Gas Oxygen Sensor (HEGO)

1. Carefully remove the HEGO
2. Install exhaust backpressure test (J35314-a) in place of the HEGO (See Illustration)
3. With the engine idling at normal operating temperature, observe the exhaust system back pressure reading on the gage. Reading should not exceed 8.6 kPa (1.25 psi)
4. Increase engine speed to 2000 RPM and observe gage. Reading should not exceed 20.7 kPa (3 psi)
5. If the back pressure at either speed exceeds specification, a restricted exhaust system is indicated.

6. Inspect the entire exhaust system for a collapsed pipe, heat distress or possible internal muffler failure.
7. If there are no obvious reasons for the excessive back pressure, the catalytic converter is suspected to be restricted and should be replaced using current recommended procedures