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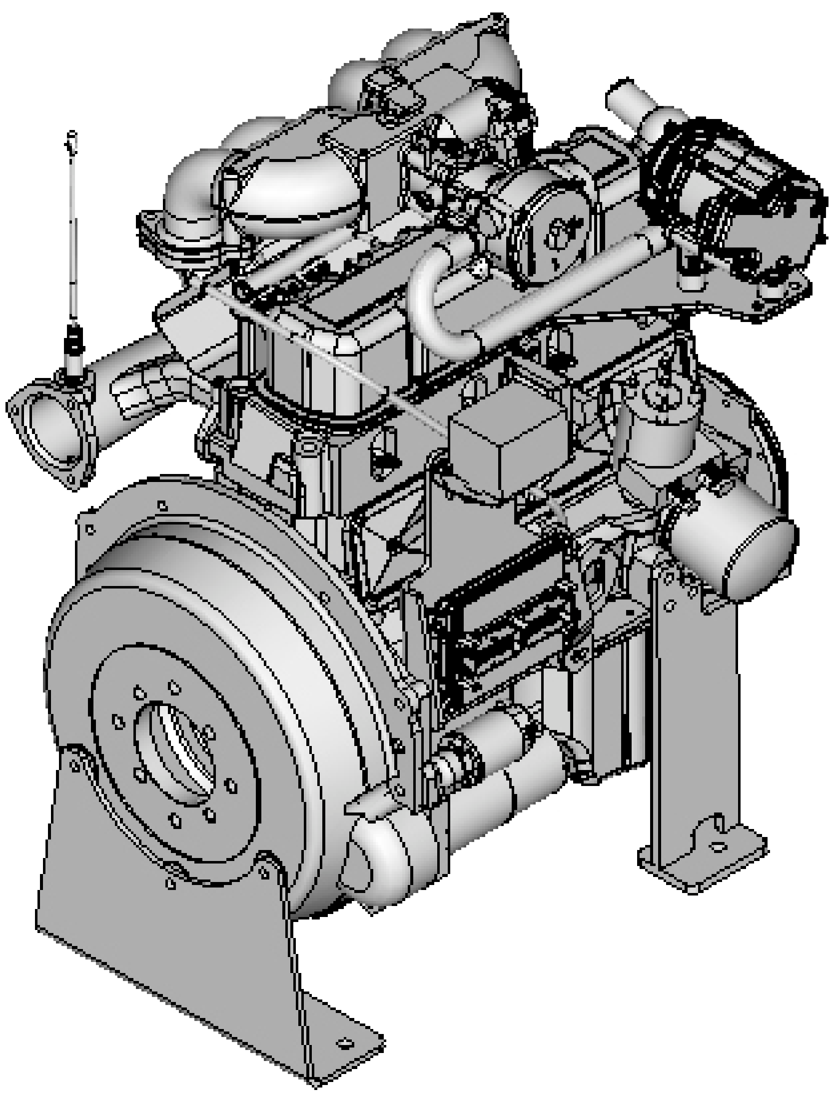
PSI 3.0L PFI CERTIFIED ENGINE SERVICE MANUAL



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PSI 3.0L PFI
MAINTENANCE SECTION

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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 environmental conditions and various temperature variations. This is a recommended guide line only each user must assess there own operational usage and determine an appropriate schedule. In addition the owner may have installed additional equipment to the vehicle may also increase the requirements for service on certain components. Therefore the owner and the service agent should review the operating condition of the equipment and determine if more frequent inspections and maintenance cycles maybe required.

WARNING

MAINTENANCE SHOULD BE PERFORMED BY TRAINED SERVICE PERSONEL AND PERFORMED TO PROCEDURES DEFINED IN THIS SECTION

MAINTENANCE OF THE BELTS

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 additional pumps or devices. It is important to note, the drive belts is an integral part of the cooling and charging systems and should be inspected at a minimum prescribe in the regular maintenance schedule. Where environmental and operational are more severe more frequent maintenance is required.

When inspecting the belts check for:

- Cracks or breaks
- Chunking of the belt
- Splits
- Material hanging from the belt
- Glazing and hardening
- Damaged or improperly aligned pulleys
- Improperly performing tensioner

V-BELT SYSTEMS

Check the belt tensioner by pressing down on the midway point of the longest stretch between pulleys. The belt should not depress beyond 13mm (1/2 inch). If the depression is more than allowable adjust the tension.

NOTE: Do not over tighten the belt as doing so could cause premature failures in other belt driven components.

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

WARNING

ALCOHOL OR METHANOL BASED ANTIFREEZE OR PLAIN WATER ARE NOT RECOMMENDED FOR USE IN COOLING SYSTEM AT ANYTIME

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 THE PRESSURE TO VENT. WEAR PROTECTIVE CLOTHING AND EYEWEAR TO PREVENT INJURY

It is important to remember that the cooling system of the engine be maintained properly to insure the longevity of the engine. Maintenance of the cooling system is critical to not only the cooling system but the fuel system as well. The LPG vaporizer is connected into the cooling system. Low coolant levels and restricted or radiators plugged with debris 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 recommended maintenance schedule in this section.

Cooling system inspections should be performed as prescribe. 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 fan shroud
- Check the radiator cap to insure the cap is sealing replace if necessary
- Check for coolant leaks at the radiator tank seams and inlet joints, repair if necessary
- Check for leaks at the radiator hose connections tighten hose clamps if necessary
- Check radiator and regulator coolant hoses for swelling separation, cracks or deterioration in the hoses or hardening if any of these conditions exists replace the hose
- Check Coolant level if add a mixture of 50% coolant and 50% water, do not add just water
- Replaced coolant per the recommended maintenance schedule

Checking the Coolant Level

Check the coolant in the recovery tank. Add coolant as required refer to the vehicle operator manual for more information on the coolant reserve tank

NOTE: The engine manufacturer and the fuel system supplier DO NOT recommend the use of “stop leak” additives to temporarily repair leaks. This stop leak can cause slug build up in the regulator coolant line and cause harm to the regulator.

If the radiator requires repair insure that radiator repair does not result in a significant loss of cooling capacity.

The engine manufacturer recommends the cooling system be filled with a 50/50 mixture of antifreeze and water. The use of DexCool “Long Life” type coolant (orange) is required. The use of ethylene glycol based coolant (green) may contribute to premature wear of seals and moving parts in the engine’s cooling system

ENGINE ELECTRICAL SYSTEM MAINTENANCE

The engine electrical system incorporates computers and micro processors to control the engine ignition, fuel control, and emissions. Due to the sensitivity of the computers to good electrical connections periodic inspection of the electrical wiring is necessary. When inspecting the electrical system use the following:

- Check and clean the battery terminal connections and insure the connections are tight
- Check the battery for any cracks or damage to the case
- Check the Positive and Negative battery cables for any corrosion build up, rubbing or chaffing, check connection on the chassis to insure they are tight
- Check the entire engine wire harness for rubbing chaffing, cuts or damaged connections, repair if necessary
- Check all wire harness connectors to insure they are fully seated and locked
- Check ignition coil and spark plug cables for hardening, cracking, chaffing, separation, split boot covers and properly fitted
- Replace spark plugs at the proper intervals as prescribe in the recommended maintenance
- Check to make sure all electrical components are fitted securely
- Check the instrument panel to insure all warning lights are functioning, MIL, oil pressure and temperature gauges are registering

ENGINE CRANKCASE OIL

To achieve proper engine performance and durability, it is important that you use only engine lubricating oils of the correct quality in your engine. Proper quality oils also provide maximum efficiency for crankcase ventilation systems. Use only oils displaying the American Petroleum Institute (API) “Starburst” Certification Mark ‘FOR GASOLINE ENGINES’ on the container.

Gasoline engines that are converted to run on LPG or NG MUST use oils labeled ‘FOR GASOLINE ENGINES.’ Do not use oils that are formulated for Diesel engines.

ENGINE OIL VISCOSITY SELECTION

Multi-Viscosity oils are recommended. SAE 10W-30 is recommended in climates that range from 0°F and above. For climates that consistently fall below 0°F, SAE 5W-30 is recommended.

IMPORTANT:

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

USE OF SUPPLEMENTAL ADDITIVES

Oils recommended by the engine manufacturer already contain a balanced additive treatment. The use of supplemental additives which are added to the engine oil by the owner is not necessary and may be harmful to the engine. The engine manufacturer, fuel system supplier and the engine distributor 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 allow the extension of oil change intervals.

CHECKING/FILLING ENGINE OIL LEVEL

CAUTION

AN OVERFILLED CRANKCASE (OIL LEVEL OVER THE SPECIFIED FULL MARK) CAN CAUSE OIL LEAK A FLUCTUATION OR DROP IN THE OIL PRESSURE AND ROCKER ARM "CLATTER" IN THE ENGINE.

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

1. Stop the 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

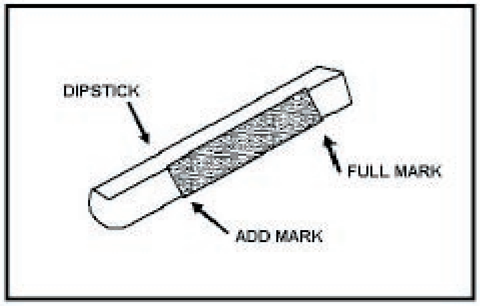


Figure 2

Engine Oil Dip Stick

6. If the oil level is below the “ADD” mark, proceed to Step 7 an 8 and reinstall the dipstick into the dipstick tube
7. Remove the oil filter cap from the valve rocker arm cover
8. Add the required amount of oil to bring the level up to but not over “FULL” mark on the dipstick
9. Reinstall the oil fill cap to the valve rocker cover and wipe away any excess oil

CHANGING THE ENGINE OIL

IMPORTANT:

When changing the oil, always change the oil filter. Change oil when the engine is warm from operation as the oils will flow freely and carry away more impurities.

To change the oil use the following steps

1. Start the engine and run until it reaches normal operating temperature
2. Stop the engine
3. Remove the drain plug and allow the oil to drain
4. Remove and discard the oil filter and its sealing ring

5. Coat the sealing ring on the filter with clean engine oil and wipe the sealing surface on the filter mounting surface to remove any dust, dirt and debris. Tighten the filter securely (follow the filter manufacturers instructions). Do not over tighten.

6. Check the sealing ring on drain plug for any damage, replace if necessary, wipe the plug with a clean rag, and wipe the sealing surface on the pan and reinstall the pan plug. Do not over tighten

7. Fill the crankcase with oil

8. Start the engine and check for oil leaks

9. Stop the engine and check the oil level to insure the oil level is at “FULL”

10. Dispose of the oil and filter in a safe manner.

FUEL SYSTEM INSPECTION AND MAINTENANCE

The propane fuel system installed on this industrial engine has been designed to meet the emission standards applicable for the engine size for model year. To insure that the engine continues to meet the regulatory requirements follow the recommended maintenance schedule contained within this section.

INSPECTION AND MAINTENANCE OF THE FUEL STORAGE CYLINDER

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

When refueling or exchanging a cylinder check the quick fill valve for thread damage. Insure that the O-ring seal is in place check the O-ring for cracks, separation or chunking; replace the O-ring if necessary before refueling. Check the service line quick coupler for any thread damage. Check the coupler O-ring for cracks, separation or chunking; replace the O-ring if necessary before refueling.

IMPORTANT: When refueling the cylinder, clean both the fill hose and the tank connector with a clean cloth to remove any dust, dirt or debris to prevent contamination of the fuel system.

FUEL FILTER MAINTENANCE

The emissions certified fuel system utilizes inline fuel filters to remove dirt and debris from both the gasoline and propane fuel systems. These filters require periodic maintenance refer to the recommended maintenance schedule. When inspecting the fuel filters check the following:

- Check for any fuel leaks at the inlet and outlet fittings
- Check to make sure the filter is securely mounted
- Check for any external damage or distortion, if damaged replace the filter element

To replace the filters use the following steps:

1. Move the equipment to a well ventilated area and insure there are no external ignition sources
2. On Propane units start the engine and close the manual valve on the cylinder and run the engine until the engine runs out of fuel.
3. Remove and replace the fuel filter
4. Leak check the connections with a soapy solution or electronic leak detector
5. On Gasoline fuel pumps with integrated fuel filters or screens located in the tank follow the OEM recommended procedures for pump removal
6. On externally mounted filters close the manual valve at the gasoline tank to prevent fuel from draining from the tank.
7. Drain any excess fuel into an approved container and replace the filter
8. After replacing the filter start the engine and leak check all connections

WARNING

ALWAYS WEAR PROTECTIVE EYEWEAR AND GLOVES WHEN PERFORMING MAINTENANCE ON THE PROPANE OR GASOLINE FUEL SYSTEMS TO PREVENT SERIOUS INJURY. ALWAYS PERFORM MAINTENANCE PROCEDURES IN A WELL VENTILATED AREA AND INSURE THAT THERE ARE NO EXTERNAL SOURCE OF IGNITION

PROPANE ELECTRONIC PRESSURE REGULATOR (EPR) MAINTENANCE

The emission certified propane fuel system utilizes a specifically designed pressure regulator which reduces the high pressure propane fuel to a lower pressure fuel which can be consumed in the engine. The EPR is made up of two separate components a pressure regulator and an electronic control unit or voice coil. The regulator is a two stage pressure regulator. The first stage or primary stage reduces the tank pressure to a pressure of 6-34 kPa (1-5 PSI). The second stage portion of the regulator is controlled by the voice coil portion of the regulator and regulates the amount of fuel to be delivered to the mixer.

The regulator portion of the EPR can be serviced with parts supplied by the OEM, refer to servicing the pressure regulator in the *Fuel System R&R* section of this manual.

When inspecting the EPR check for the following items:

- Check for any fuel leaks at the inlet and outlet fittings
- Check for any fuel leaks at the connecting seams of the regulator body

- Check the inlet and outlet coolant fittings at the regulator body
- Check the inlet and outlet coolant lines for hardening, cracking, chaffing or splits. If any of these conditions exist replace the coolant lines
- Check the inlet and outlet coolant line hose clamps at each connection, tighten if necessary
- Check the CAN connection on the electronic control section to insure it is seated and locked
- Check to make sure the EPR assembly is securely mounted to the rubber isolators
- Check the rubber isolators for cracking, hardening or separation

GASOLINE FUEL PRESSURE & TEMPERATURE MANIFOLD

The emission certified gasoline system utilizes a pressure and temperature manifold assembly device which allows the fuel pressure to be maintained at the injectors and returns any unused fuel back into the tank. This device prevents large amounts of fuel from being returned to the tank which would cause the fuel to be agitated. Excessively agitating fuel causes large amounts of vapor to be built up in the fuel tank. Therefore the gasoline pressure and temperature manifold assembly is critical to preventing heavy vapor build up in the tank.

When inspecting the gasoline pressure and temperature manifold assembly check the following items:

- Check for any fuel leaks at the inlet and outlet fitting on the regulator
- Check the inlet and outlet hoses or fuel lines for any rubbing chaffing or external damage
- Check the electrical connection at the sensor to insure the connector is seated and locked
- Check to make sure the assembly is securely mounted

DRAINING OIL BUILD UP FROM THE PROPANE REGULATOR

During the course of normal operation oils or “heavy ends” may build inside the primary and secondary chambers of the propane pressure regulator. These oils and heavy ends may be a result of poor fuel quality, contamination of the fuel supply chain, or regional variation in the make up of the fuel. If the build up of the oil is significant this can effect the operation of the fuel control system. The recommended maintenance schedule recommends periodic draining of the oil from the regulator. More frequent draining may be required if the fuel supply has been contaminated.

Use the following procedure to drain the regulator:
IMPORTANT: For best results warm the engine to operating temperature before draining as this will allow the oils to be liquid and flow freely from the regulator.

1. Move the equipment to a well ventilated area and insure there are no external ignition sources.
2. Start the engine and bring to operationing temperature.
3. With the engine running close the manual tank valve and run the engine out of fuel.

4. Switch the Key to the Off position once the engine stops.

5. Disconnect the electrical connection to the LPG fuel temperature sesnor in the auxilliary fuel port of the EPR.

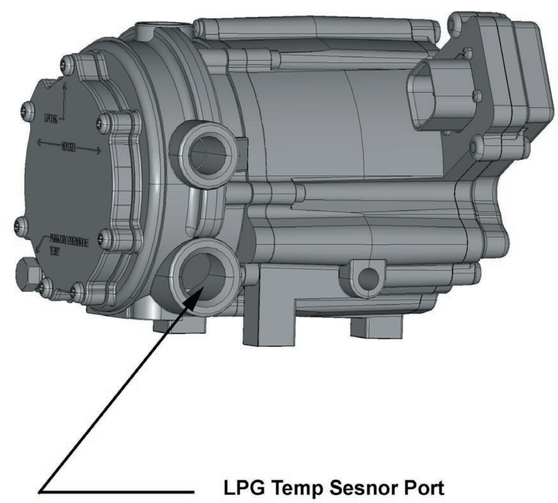
6. Remove the retainer clip for the LPG fuel temperature sensor and remove the sesnor from the regulator body. Note: Have a small container ready to collect oil that will drain freely from the regulator at this point.

7. Once all of the oil has been drained, reinstall the LPG fuel temperature sensor and recooonectthe electrical connector.

8. Re-open the fuel tank manual valve.

9. Start the engine and verify all connections.

10. Dispose of any oil in a safe and proper fashion.



LPG Temp Sesnor Port

Remove Sensor to Drain Oil

AIR FUEL MIXER AND THROTTLE CONTROL DEVICE INSPECTION

The air fuel mixer component fitted to the emission certified engines have been specifically designed and calibrated to meet the regulatory requirements applicable for the engine.

The mixer can be serviced using parts supplied by the OEM, refer to servicing the mixer in the *Fuel System R&R* section of this manual.

When inspecting the mixer check for the following items:

- Check for any leaks at the inlet fitting

- Check the air inlet connection to insure the clamp is tight and sealed
- Check the vapor hose from the regulator to the mixer for kinks, collapsing, cracks, splitting, chaffing or loose connections, replace of any of these conditions are present
- Check the mixer mounting at the throttle control device to insure there are no vacuum leaks
- Check to make sure the mixer is securely attached
- Check the air cleaner element and replace if necessary

THROTTLE CONTROL INSPECTION

The throttle control device utilized on this industrial engine is an Electronic Throttle Control (ETC) device. The ETC receives electrical signals and sends signals to the ECM. Therefore it is important that the electrical connector be securely in place and locked.

In addition to controlling engine speed and load correction the ETC acts as the connecting mechanism between the mixer and the manifold. Any vacuum leaks below the mixer can cause loss of fuel control when operating on propane. Always insure that the throttle connecting screws are securely fastened.

When inspecting the throttle body check for the following items:

- Check the throttle body connections to the mixer and manifold or adaptors is securely attached
- Check for any vacuum leaks below the mixer
- Check the ETC electrical connections and insure they are fully seated and locked

GASOLINE FUEL RAIL AND INJECTORS

The dual fuel system utilizes both a propane fuel system and a base gasoline fuel system to operate. The emission certified engine gasoline fuel system utilizes a port injection fuel system and a common rail for fuel delivery.

When inspecting the gasoline injectors and fuel rails check for the following items

- Check the fuel supply hoses for cracking, chaffing, loose connections, or any external damage and replace if any of these conditions exists
- Check the fuel rail to insure the rail is securely attached
- Check the injector for any leaks at the inlet or outlet points on the injector
- Check the each injector electrical connector to make sure the connector is fully seated and locked

EXHAUST SYSTEM AND CATALYTIC CONVERTOR INSPECTION AND MAINTENANCE

The exhaust system on this emission certified engine contains a Heated Exhaust Gas Sensor (HEGO) before the catalyst as well as after the catalyst. The pre catalyst sensor is used to provide fuel correction information to the ECM. The Post Catalyst sensor provides input to the ECM as the effectiveness of the fuel control system.

It is important to insure that the HEGO sensors are properly operating. As well visual inspection of the catalyst can provide insight as to over fueling condition within the fuel system.

When inspecting the exhaust system check for the following:

- Check the exhaust manifold connection to insure they are tight and no exhaust leaks are present
- Check the exhaust pipe to manifold to insure the bolts are tight and the connection is sealed
- Check the exhaust pipe for any external damage, holes or crushed pipes which may cause exhaust gas flow restriction. Exhaust gas restriction generally cause the manifold and or exhaust pipes to turn blue.
- Check to make sure the exhaust pipe is securely attached at all hangers and supports
- Check the Catalyst to insure that the catalyst is securely attached at all hangers and supports
- Check both the HEGO sensor electrical connections to insure they are fully seated and locked
- Check for any HEGO wiring damage which may have been caused by heat or external interference
- Check the tail pipe for any damage and that the opening is not crushed or restricting flow

Recommended Maintenance Schedule

GASOLINE AND LPG CERTIFIED ENGINE MAINTENANCE REQUIREMENTS										
	Install Date	Interval Hours								
		Daily	200	400	800	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 150 hours or 120 days of operation**									
Check LPG/Gas 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
Engine Coolant Section										
Clean debris from radiator core	**Every 100 hours or 60 days of operation**									
Change coolant					X					
Inspect coolant hoses for cracks, swelling or deterioration						X				X
Engine Ignition System										
Inspect Battery case for damage						X				X
Check all electrical connectors						X				X
Replace Spark Plug Wires										X
Replace Distributor Cap & Rotor					X					
Replace spark plug wires					X					
Fuel System Maintenance										
Replace fuel filter (Gas & LPG)				X						X
Inspect lock off for leaks & closing										X
Check LPG/Gas regulator pressure										X
Leak check LPG/Gas fuel lines										X
Inspect/Drain EPR-LPR for oil build up	**Every 150 hours or 120 days of operation**									
Inspect LPR for coolant leaks	**Annually or every 2000 hours**									
Check air induction for leaks										X
Check manifold for vacuum leaks										X
Replace PCV Valve					X					
Check injector & rails for leaks										X
Inspect air cleaner	**Every 200 hours, or every 100 hours in dusty environment**									
Replace filter element	**Every 400 hours, or every 200 hours in dusty environment**									
Engine Exhaust System										
Inspect exhaust manifold for leaks										X
Inspect exhaust piping for leaks										X
Inspect catalyst inlet and outlet										X
Check HEGO sensors connections										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.										

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3.0L

NOTICE: Always use the correct fastener in the proper location. When you replace a fastener, use ONLY the exact part number of that application.

General Motors will call out those fasteners that require a replacement after removal. General Motors will also call out the fasteners that require thread lockers or thread sealant.

UNLESS OTHERWISE SPECIFIED, Do Not use supplemental coatings (paints, greases or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coating adversely affect the fastener torque and the joint clamping force, and may damage the fastener.

When you install fasteners, use the correct tightening sequence and specifications.

Following these instructions can help you avoid damage to parts and systems.

Engine Mechanical - 3.0L

Specifications

Application	N•m	Lb Ft	Lb In
Camshaft Retainer Bolts	9		80
Coolant Temperature Sensor	20	15	
Connecting Rod Cap Nuts	61	45	
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Cylinder Head Bolts	135	100	
Distributor Hold Down Bolt	33	24	
Flywheel Bolts	100	74	
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Oil Pump Cover	8		71
Oil Pump to Block	13		115
Oil Pump Pickup	7		62
Pushrod Cover Bolts	9		80
Rocker Arm Cover Bolts	7		62
Spark Plugs	20	15	
Thermostat Housing Bolt	38	28	
Water Outlet Housing Bolts	28	21	
Water Pump Bolts	20	15	

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

Application	Metric	English
General Data		
Engine Type	L4	
Displacement	3.0L	181 CID
Bore	101.60 mm	4.000 in
Stroke	91.44 mm	3.60 in
Compression Ratio	9.25:1	
Firing Order	1-3-4-2	
Spark Plug Gap	0.9 mm	0.035 in
Spark Plug Platinum Gap	1.28 mm	0.050 in
Lubrication System		
Oil Pressure (Minimum - Hot)	41.4 kPa at 1,000 engine rpm 124.1 kPa at 2,000 engine rpm 165.5 kPa at 4,000 engine rpm	6.0 psig at 1,000 engine rpm 18.0 psig at 2,000 engine rpm 24.0 psig at 4,000 engine rpm
Oil Capacity (With Oil Filter Change)	3.81	4.00 qts
Oil Pump Type	Gear Driven	
Cylinder Block		
Bore Diameter	101.5746-101.6508 mm	3.9990-4.0020 in
Bore Out-of-Round Production	0.0254 mm (Maximum)	0.001 in (Maximum)
Bore Out-of-Round Service Limit	0.0508 mm (Maximum)	0.002 in (Maximum)
Bore Taper Thrust Side Production	0.0127 mm (Maximum)	0.0005 in (Maximum)
Bore Taper Thrust Side Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Bore Taper Relief Side Production	0.0127 mm (Maximum)	0.0005 in (Maximum)
Bore Taper Relief Side Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Runout - Rear Face of Block to Crankshaft Center Line	0.05 mm (Maximum)	0.002 in (Maximum)
Piston		
Piston-To-Bore Clearance Production	0.0635-0.0889 mm	0.0025-0.0035 in
Piston-To-Bore Clearance Service Limit	0.0889 mm	0.0035 in (Maximum)
Piston Rings		
Piston Compression Ring Groove Clearance Production Top	0.03048-0.07366 mm	0.0012-0.0029 in
Piston Compression Ring Groove Clearance Production 2nd	0.03048-0.07366 mm	0.0012-0.0029 in
Piston Compression Ring Groove Clearance Service Limit	0.09906 mm (Maximum)	0.0039 in (Maximum)
Piston Compression Ring Gap Top Production *	0.254-0.508 mm	0.01-0.02 in
Piston Compression Ring Gap 2nd Production *	0.4318-0.635 mm	0.017-0.025 in
Piston Compression Ring Gap Top Service Limit *	0.88 mm (Maximum)	0.035 In (Maximum)
Piston Compression Ring Gap 2nd Service Limit *	0.88 mm (Maximum)	0.035 in (Maximum)
Piston Oil Ring Groove Clearance Production	0.0254-0.1524 mm	0.001-0.006 in
Piston Oil Ring Groove Clearance Service Limit	0.1778 mm (Maximum)	0.007 in (Maximum)
Piston Oil Ring Gap Production *	0.25-0.76 mm	0.01-0.03 in
Piston Oil Ring Gap Service Limit *	1.016 mm (Maximum)	0.04 in (Maximum)
Piston Pin		
Diameter	23.545-23.548 mm	0.9270-0.927 in
Clearance in Piston Production	0.00762-0.01651 mm	0.0003-0.00065 in
Clearance in Piston Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Fit in Connecting Rod	0.02032-0.050292 mm (Interference)	0.0008-0.00198 in (Interference)

* Measured in cylinder bore

Crankshaft		
Crankshaft Journal Diameter (All)	58.3666-58.4047 mm	2.2979-2.2994 in
Crankshaft Journal Taper Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Crankshaft Journal Taper Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Crankshaft Journal Out-of-Round Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Crankshaft Journal Out-of-Round Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Crankshaft Bearing Clearance Production #1 - #4	0.0254-0.06096 mm	0.001-0.0024 in
Crankshaft Bearing Clearance Production #5	0.0406-0.0889 mm	0.0016-0.0035 in
Crankshaft Bearing Clearance Service Limit #1 - #4	0.0254-0.0635 mm	0.001-0.0025 in
Crankshaft Bearing Clearance Service Limit #5	0.0381-0.0889 mm	0.0015-0.0035 in
Crankshaft End Play	0.05-0.1524 mm	0.002-0.006 in
Crankshaft Sprocket Runout	0.07 mm (Maximum)	0.003 in (Maximum)
Connecting Rod		
Connecting Rod Journal Diameter	53.2892-53.3273 mm	2.0980-2.0995 in
Connecting Rod Journal Taper Production	0.00762 mm (Maximum)	0.0003 in (Maximum)
Connecting Rod Journal Taper Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Connecting Rod Journal Out-of-Round Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Connecting Rod Journal Out-of-Round Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Rod Bearing Clearance Production	0.04318-0.06858 mm	0.0017-0.0027 in
Rod Bearing Clearance Service Limit	0.0762 mm (Maximum)	0.003 in (Maximum)
Rod Side Clearance	0.1524-0.4318 mm	0.006-0.017 in
Camshaft		
Journal Diameter (Industrial)	47.452-47.478 mm	1.8682-1.8692 in
Journal Diameter (Marine)	47.440-47.490 mm	1.8677-1.8697 in
End Play	0.0762-0.2032 mm	0.003-0.008 in
Camshaft Sprocket Runout	0.1 mm (Maximum)	0.004 in (Maximum)
Timing Sprocket Teeth Backlash	0.10-0.15 mm	0.004-0.006 in
Lobe Lift Intake (Industrial)	5.516-5.791 mm	0.2172-0.2280
Lobe Lift Exhaust (Industrial)	5.516-5.791 mm	0.2172-0.2280
Lobe Lift Intake (Marine)	6.400-6.45 mm	0.2520-0.2539
Lobe Lift Exhaust (Marine)	6.400-6.45 mm	0.2520-0.2539
Lobe Lift Service Limit	±0.0254 mm	±0.001 in
Valve System		
Valve Lifter	Hydraulic	
Valve Rocker Arm Ratio	1.75:1	
Valve Lash	Half to One Turn Down From Zero Lash	
Face Angle	45 Degrees	
Seat Angle	46 Degrees	
Seat Runout	0.05 mm (Maximum)	0.002 in (Maximum)
Seat Width Intake	1.27-1.778 mm	0.050-0.070 in
Seat Width Exhaust	1.524-2.032 mm	0.060-0.080 in
Stem Clearance Intake Production	0.0254-0.06858 mm	0.001-0.0027 in
Stem Clearance Exhaust Production	0.01778-0.06858 mm	0.0007-0.0027 in
Stem Clearance Intake Service Limit	0.09398 mm (Maximum)	0.0037 in (Maximum)
Stem Clearance Exhaust Service Limit	0.1193 mm (Maximum)	0.0047 in (Maximum)
Valve Spring Free Length	52.299 mm	2.059 in
Valve Spring Pressure Closed	444-490 N at 40.89 mm	100-110 lb at 1.61 in
Valve Spring Pressure Open	925-987 N at 30.99 mm	208-222 lb at 1.22 in
Valve Spring Installed Height Intake	41.91 mm	1.65 in
Valve Spring Installed Height Exhaust	41.91 mm	1.65 in
Valve Lift Intake	11.25 mm	0.443 in
Valve Lift Exhaust	11.25 mm	0.443 in
Cylinder Head Warpage		
Cylinder Head Deck (measured within a 152.4 mm (6.0 in) area)	0.0762 mm	0.003 in
Cylinder Head Deck (measuring the overall length of the cylinder head)	0.1778 mm	0.007 in

Step	Action	Value	Yes	No
1	1. With the engine running, try to determine if the noise is timed to the crankshaft speed or the camshaft speed. 2. Using a timing light, two knocks per flash is the crankshaft or one knock per flash is the camshaft. Is the noise timed to the crankshaft speed?	—	Go to Step 2	Go to Step 3
2	1. Remove the rod bearings and inspect the bearings and the journals for wear. 2. If the parts are OK, remove the crankshaft and inspect the main bearings and journals for wear. 3. Replace the parts as necessary. Does the engine continue to knock?	—	Go to Step 3	System OK
3	Check to see if the noise is timed to the camshaft speed. Is the noise timed to the camshaft speed?	—	Go to Step 5	Go to Step 4
4	1. Inspect for loose accessory attachments, the flywheel. 2. Tighten or adjust as necessary. Does the engine continue to knock?	—	Go to Step 5	System OK
5	1. Remove the pushrod cover. • Refer to *Pushrod Cover Removal.* 2. Rotate the engine and measure the lifter movement in the bore. 3. Compare the measurement with the specifications in *Engine Mechanical Specifications.* Is the camshaft within specifications?	—	Go to Step 7	Go to Step 6
6	Replace the camshaft. Refer to *Camshaft Removal and Installation.* Does the engine continue to knock?	—	Go to Step 7	System OK
7	1. Remove the rocker arms, the pushrods and the lifters. 2. Inspect the parts for excessive wear or damage. 3. Replace the parts as necessary. Are the repairs complete?	—	System OK	—

Engine Compression Test

Perform the following steps in order to conduct a compression test:

1. Conduct the following steps in order to check cylinder compression:
   1.1. Engine should be at room temperature.
   1.2. Disconnect the two electrical connectors from the distributor.
   1.3. Remove the spark plugs.
   1.4. Throttle plates should be wide open.
   1.5. Battery should be at or near full charge.
2. For each cylinder, crank engine through four compression strokes.
3. The lowest cylinder reading should not be less than 70% of the highest.
4. No cylinder reading should be less than 689 kPa (100 psi).

Important: The results of a compression test will fall into the following categories:

1. Normal — Compression builds up quickly and evenly to specified compression on each cylinder.
2. Piston Rings — Compression low on first stroke. Tends to build up on the following strokes but does not reach normal. Improves considerably with addition of oil.
3. Valves — Compression low on first stroke. Does not tend to build up on the following strokes. Does not improve much with addition of oil. Use approximately three squirts from a plunger-type oiler.

Engine Noise Diagnosis

There are four steps to diagnosing engine noise. You must determine the following conditions:

- Type of noise.
- The exact operating condition under which the noise exists.
- Determine the rate and location of the noise.
- Compare the sounds in other engines to make sure you are not trying to correct a normal condition.

Identify the type of noise. For example, a light rattle or low rumble.

Remember, engine noises are generally synchronized to either engine speed (caused by the crankshaft, pistons or connecting rods) or one-half engine speed (valve train noise). Try to determine the rate at which the noise is occurring.

Knocks Cold and Continues for 2 to 3 Minutes

- Engine flywheel contacting the splash shield. Reposition the splash shield.
- Loose or broken crankshaft balancer or drive pulleys. Tighten or replace as necessary.
- Excessive piston to bore clearance. Replace the piston.
- Cold engine knock usually disappears when the specific cylinder secondary ignition circuit is grounded out. Cold engine piston knock which disappears in 1.5 minutes should be considered acceptable.

Knocks on Start-Up but Only Lasts a Few Seconds

- Improper oil viscosity. Install recommended oil viscosity for expected temperatures.
- Excessive piston to bore clearance.
- Excessive piston pin to piston clearance.
- Excessive crankshaft end clearance.
- Excessive crankshaft bearing clearance.

Knocks at Idle Hot

- Detonation or spark knock. Check operation of ignition controls or knock sensor circuit.
- Loose flywheel bolts.
- Exhaust leak at manifold. Tighten the exhaust manifold bolts and/or replace the gasket.
- Excessive connecting rod bearing clearance. Replace the bearings as necessary.
- Excessive piston pin clearance.
- Excessive crankshaft thrust bearing clearance.
- Bent connecting rod.

Valve Train Diagnosis

A light tapping at one-half engine speed or any varying frequency, can indicate a valve train problem. These tapping noises increase with engine speed.

Before attempting to judge the valve train noises, thoroughly warm up the engine. By doing this you will bring all engine components to a normal state of expansion. Also, run the engine at various speeds and listen for engine noise. The causes of the valve train noise include the following conditions:

- Incorrectly adjusted valve lash.
- Low oil pressure.
- Loose valve rocker arm attachments.
- Worn valve rocker arm and/or pushrod.
- Broken valve spring.
- Sticking valves.
- Lifters worn, dirty or faulty.
- Camshaft lobes worn.
- Worn valve guides.
- Worn or damaged valve keys.
- Bent pushrods.

Oil Consumption Diagnosis

Excessive oil consumption (not due to leaks) is the use of 1.9L (2 qts.) or more of engine oil within 50 hours of use. The causes of excessive oil consumption include the following conditions:

- External oil leaks. Tighten bolts and/or replace gaskets and oil seals as necessary.
- Incorrect oil level or improper reading of oil level indicator. With the engine at a level surface, allow adequate drain down time and check for the correct oil level.
- Improper oil viscosity. Use a recommended SAE viscosity for the prevailing temperatures.
- Continuous high speed operation and/or severe usage.
- Crankcase ventilation system restrictions or malfunctioning components. Possible improper PCV valve.
- Valve guides and/or valve stem oil seals worn, or

the seal omitted. Ream guides and install oversize service valves and/or new valve stem oil seals.

- Piston rings broken, improperly installed, worn or not seated properly. Allow adequate time for rings to seat. Replace broken or worn rings as necessary.
- Piston improperly installed or mis-fitted.

Low or No Oil Pressure Diagnosis and Testing

- Low oil level. Fill to full mark on oil level indicator.
- Incorrect or malfunctioning oil pressure switch.
- Incorrect or malfunctioning oil pressure gauge.
- Improper oil viscosity for the expected temperature.
- Oil pump worn or dirty.
- Malfunctioning oil pump pressure regulator valve.
- Plugged oil filter.
- Oil pump screen loose, plugged or damaged.
- Excessive bearing clearance. Replace as necessary.
- Cracked, porous or restricted oil galleys. Repair or replace the engine block.
- Oil galley plugs missing or incorrectly installed. Install the plugs or repair as necessary.
- Oil diluted by moisture or unburned fuel mixtures.

Oil Leak Diagnosis

Most fluid oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions a fluid leak may be difficult to locate or repair.

Use the following steps in order to find the leak:

1. Identify the fluid, determine whether it is engine oil, transmission fluid or power steering fluid.
2. At what point is the fluid leaking from? After running the engine at normal operating temperature, place a large sheet of paper under the engine. After a few minutes, you should be able to find the approximate location of the leak by the drippings on the paper.
3. Visually check around the suspected component. Check around the gasket mating surfaces for leaks. A mirror is useful for finding leaks in areas that are hard to reach.
4. If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam or spray solvent. Clean the area well, then dry the area. Run the engine for several minutes at normal operating temperature and varying speeds. After running the engine, visually check the suspected area. If you still cannot locate the leak, try using the powder or black light and dye method.

Perform the following steps in order to perform the powder method:

1. Clean the suspected area.
2. Apply an aerosol-type powder (such as foot powder) to the suspected area.
3. Run the engine under normal operating conditions.
4. Visually inspect the suspected area. You should be able to trace the leak path over the white powder surface to the source.

Perform the following steps in order to use the black light and dye method:

Tools Required

J 39400 Leak Detector

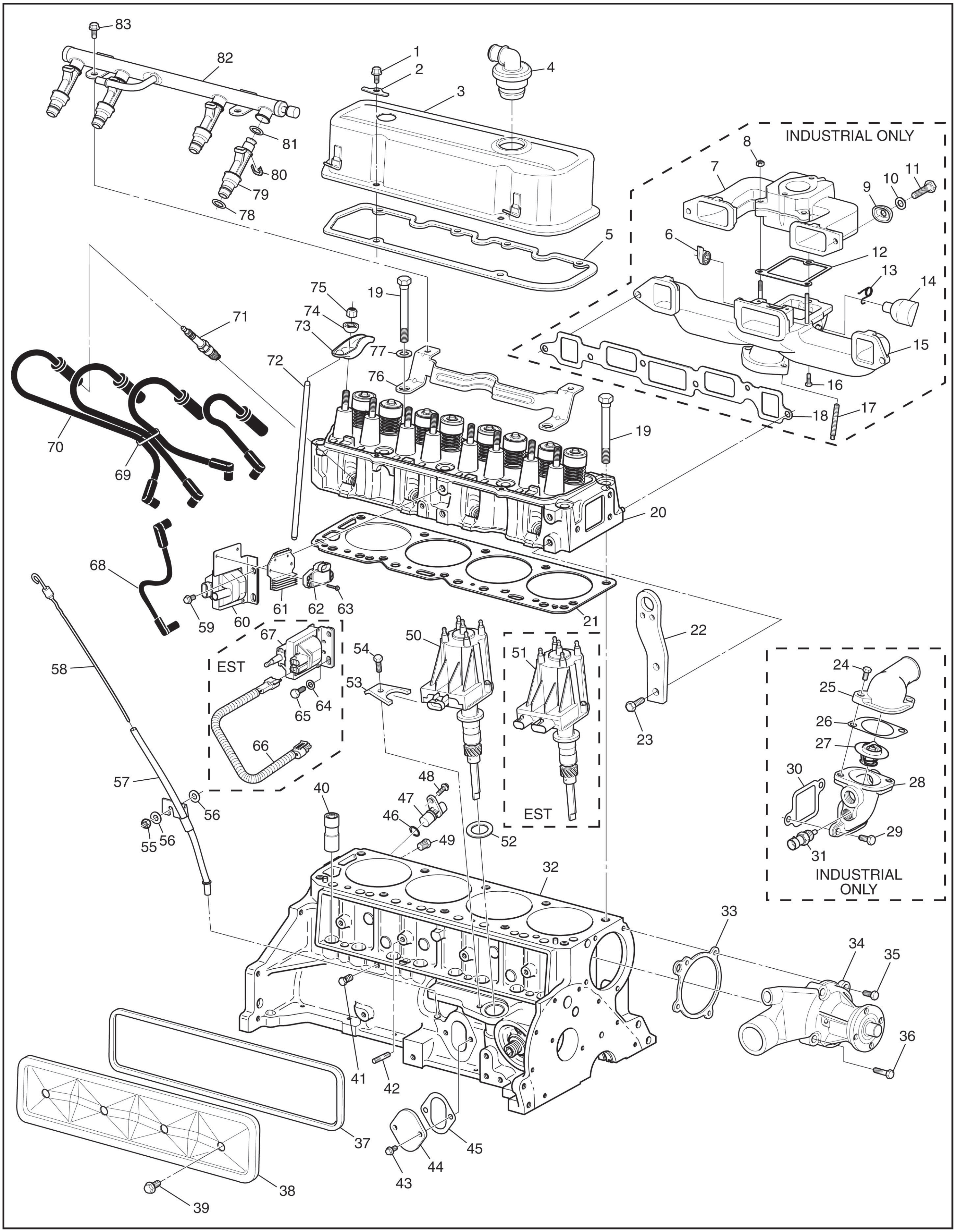
1. Pour specified amount of dye into the leaking component.
2. Run the engine under normal operating conditions as directed by the J 39400.
3. Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

Repairing the Leak

Once the origin of the leak has been pinpointed and traced back to its source, the cause of the leak must be determined in order for it to be repaired properly. If a gasket is replaced, but the sealing surface is damaged, the new gasket will not repair the leak. Before attempting to repair a leak, be sure that the gasket and sealing surfaces are correct.

Perform the following steps in order to check for gasket leaks:

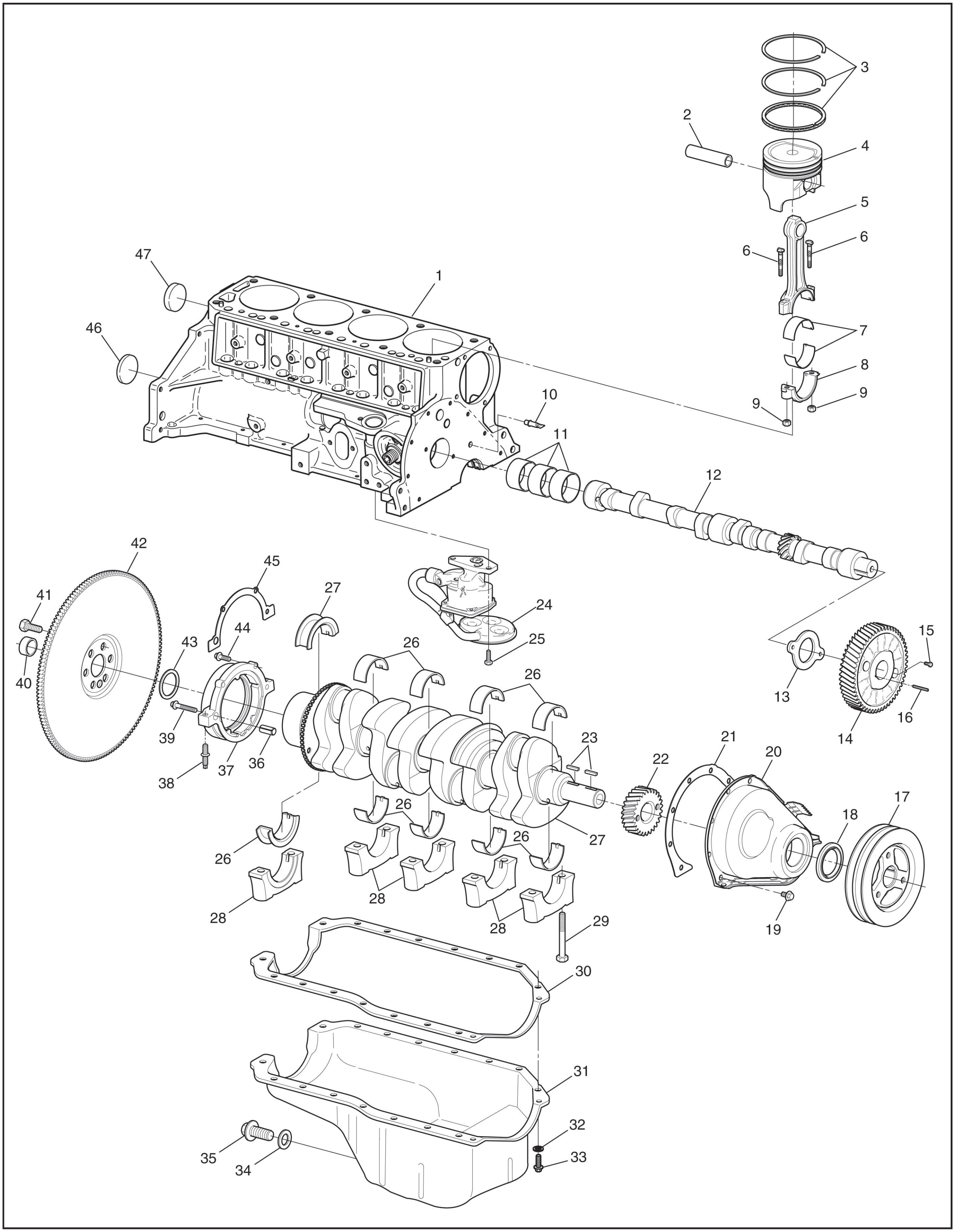
1. Inspect the fluid level/pressure for being too high.
2. Check the crankcase ventilation system for restrictions or malfunctioning components.
3. Inspect for improperly tightened fasteners or dirty/ damaged threads.
4. Look for warped flanges or sealing surfaces.
5. Check for scratches, burrs or other damage to the sealing surface.
6. Look for a damaged or worn gasket.
7. Check for cracking or porosity of the component.
8. Check for use of an improper sealant used (where applicable).



Block Explode #1

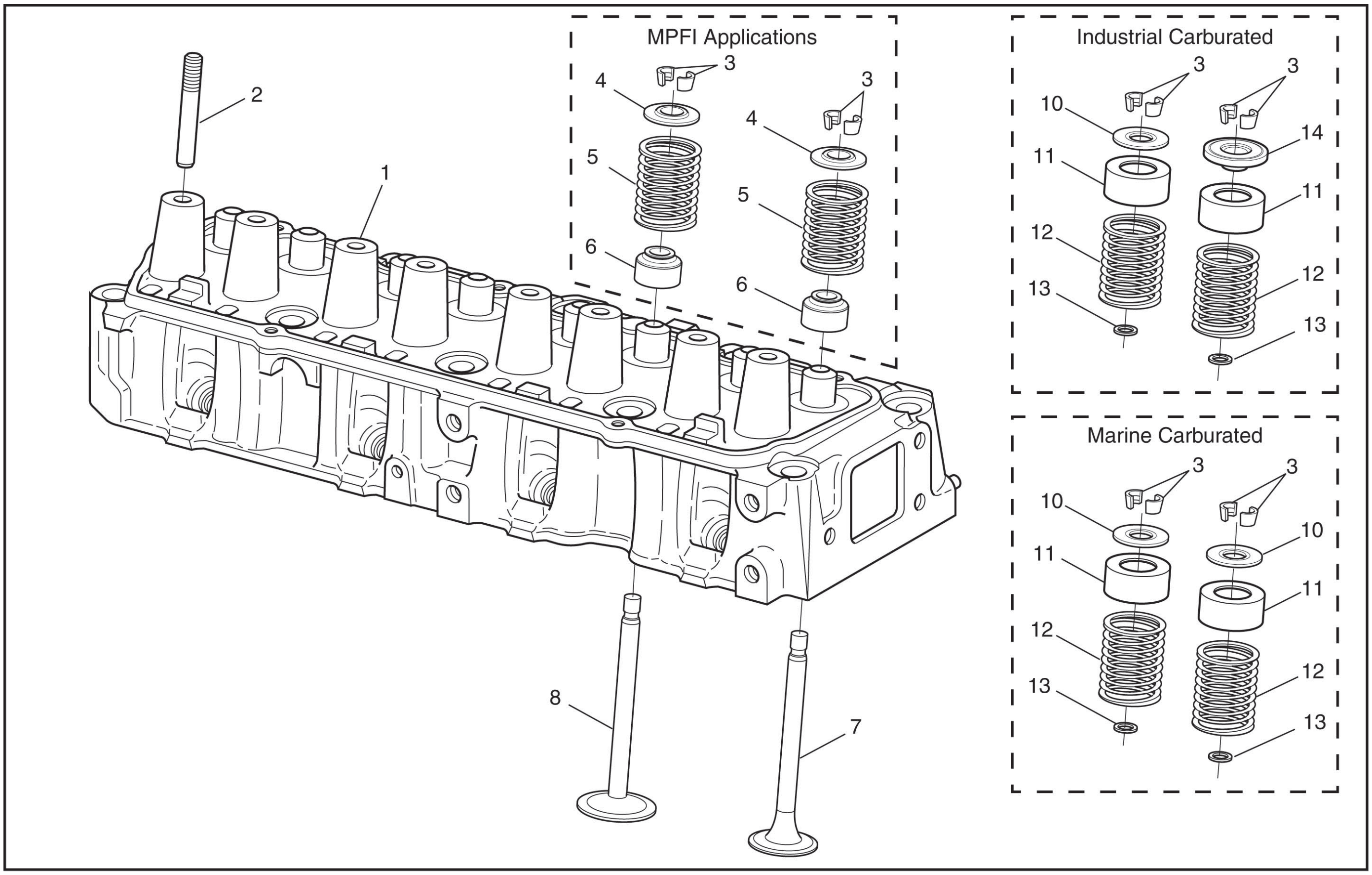
Disassembled View (1 of 4)

1 VALVE ROCKER ARM COVER BOLT
2 VALVE ROCKER ARM COVER REINFORCEMENT
3 VALVE ROCKER ARM COVER
4 OIL FILLER CAP
5 VALVE ROCKER ARM COVER GASKET
6 EFE VALVE THERMOSTAT
7 INTAKE MANIFOLD
8 INTAKE MANIFOLD NUT
9 INTAKE/EXHAUST MANIFOLD CLAMP
10 INTAKE/EXHAUST MANIFOLD WASHER
11 INTAKE/EXHAUST MANIFOLD BOLT
12 INTAKE/EXHAUST MANIFOLD GASKET
13 EFE VALVE SPRING
14 EFE VALVE WEIGHT
15 EXHAUST MANIFOLD
16 INTAKE/EXHAUST MANIFOLD BOLT
17 EXHAUST MANIFOLD STUD
18 INTAKE/EXHAUST MANIFOLD GASKET
19 CYLINDER HEAD BOLT
20 CYLINDER HEAD
21 CYLINDER HEAD GASKET
22 LIFT BRACKET
23 LIFT BRACKET BOLT
24 WATER OUTLET HOUSING BOLTS
25 WATER OUTLET HOUSING
26 WATER OUTLET HOUSING GASKET
27 COOLANT THERMOSTAT
28 THERMOSTAT HOUSING
29 THERMOSTAT HOUSING BOLTS
30 THERMOSTAT HOUSING GASKET
31 COOLANT TEMPERATURE SENSOR
32 ENGINE BLOCK
33 WATER PUMP GASKET
34 WATER PUMP
35 WATER PUMP BOLT
36 WATER PUMP BOLT
37 PUSHROD COVER GASKET
38 PUSHROD COVER
39 PUSHROD COVER BOLT
40 VALVE LIFTER
41 ENGINE BLOCK COOLANT PLUG
42 PUSHROD COVER STUD
43 FUEL PUMP COVER BOLT
44 FUEL PUMP COVER
45 FUEL PUMP COVER GASKET
46 CRANKSHAFT POSITION SENSOR O-RING
47 CRANKSHAFT POSITION SENSOR
48 CRANKSHAFT POSITION SENSOR RETAINING BOLT
49 ENGINE BLOCK COOLANT PLUG
50 DISTRIBUTOR/HIGH VOLTAGE SWITCH (HVS)
51 DISTRIBUTOR (EST)
52 DISTRIBUTOR GASKET
53 DISTRIBUTOR HOLD DOWN
54 DISTRIBUTOR HOLD DOWN BOLT
55 OIL LEVEL INDICATOR TUBE BRACKET RETAINING NUT
56 OIL LEVEL INDICATOR TUBE BRACKET WASHER
57 OIL LEVEL INDICATOR TUBE
58 OIL LEVEL INDICATOR
59 IGNITION COIL BRACKET BOLT
60 IGNITION COIL
61 IGNITION CONTROL MODULE HEAT SINK
62 IGNITION CONTROL MODULE
63 IGNITION CONTROL MODULE BOLTS
64 IGNITION COIL WASHER (EST)
65 IGNITION COIL BOLT (EST)
66 PRIMARY IGNITION COIL HARNESS (EST)
67 IGNITION COIL (EST)
68 IGNITION COIL WIRE
69 SPARK PLUG WIRE RETAINER
70 SPARK PLUG WIRE HARNESS
71 SPARK PLUG
72 VALVE PUSHROD
73 VALVE ROCKER ARM
74 VALVE ROCKER ARM BALL
75 VALVE ROCKER ARM NUT
76 FUEL RAIL BRACKET
77 FUEL RAIL BRACKET WASHER
78 FUEL INJECTOR TO CYLINDER HEAD O-RING
79 FUEL INJECTOR
80 FUEL INJECTOR RETAINING CLIP
81 FUEL INJECTOR TO RAIL O-RING
82 FUEL RAIL
83 FUEL RAIL TO BRACKET BOLTS



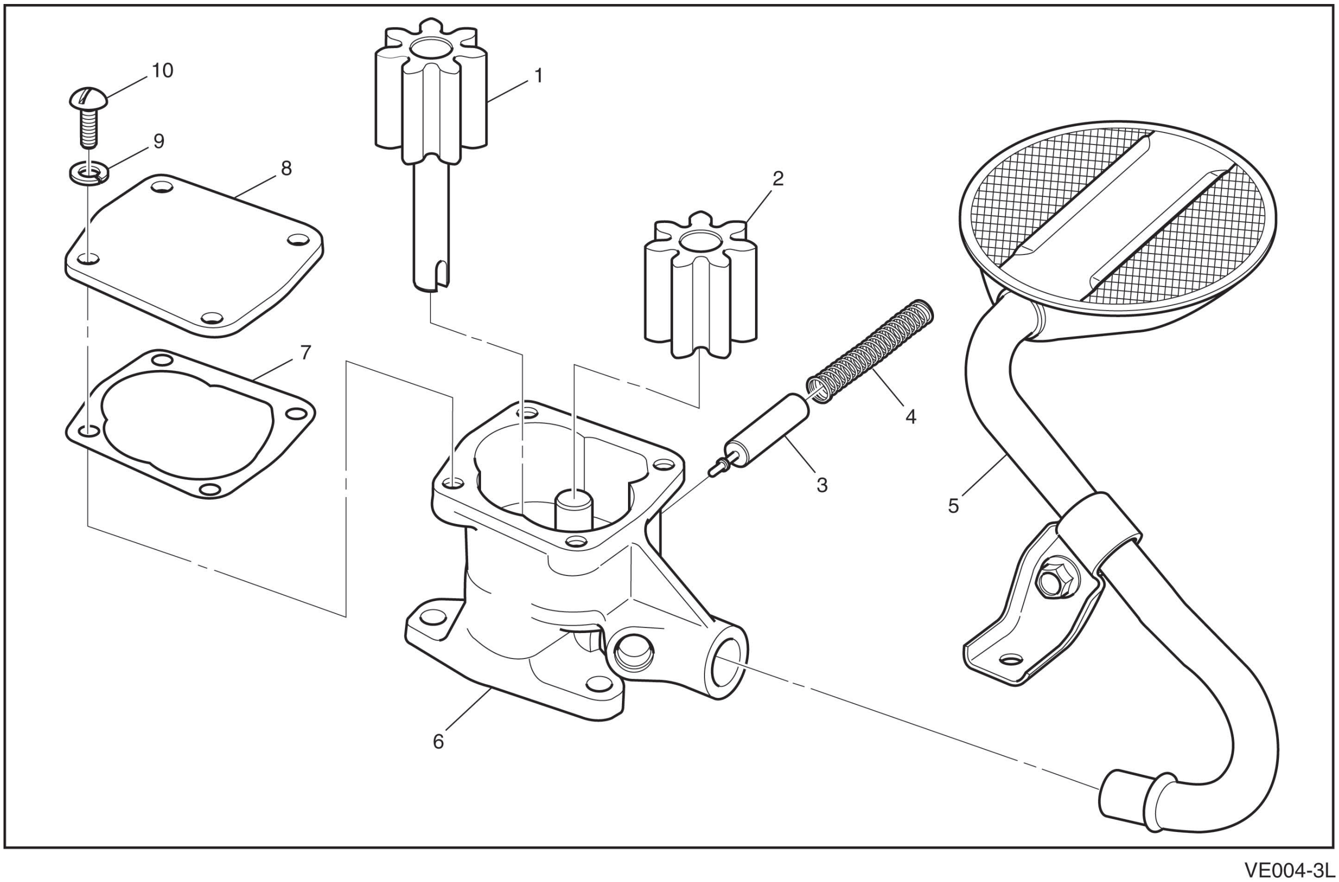
Block Explode #2

1	ENGINE BLOCK
2	PISTON PIN
3	PISTON RING KIT
4	PISTON
5	CONNECTING ROD
6	CONNECTING ROD BOLT
7	CONNECTING ROD BEARING KIT
8	CONNECTING ROD CAP
9	CONNECTING ROD NUT
10	OIL NOZZLE
11	CAMSHAFT BEARINGS
12	CAMSHAFT
13	CAMSHAFT RETAINER
14	CAMSHAFT SPROCKET
15	CAMSHAFT RETAINER BOLT
16	CAMSHAFT WOODRUFF KEY
17	CRANKSHAFT PULLEY
18	ENGINE FRONT COVER SEAL
19	ENGINE FRONT COVER BOLT
20	ENGINE FRONT COVER
21	ENGINE FRONT COVER GASKET
22	CRANKSHAFT SPROCKET
23	CRANKSHAFT KEYWAY
24	OIL PUMP
25	OIL PUMP BOLT
26	CRANKSHAFT BEARING KIT
27	CRANKSHAFT
28	CRANKSHAFT BEARING CAP
29	CRANKSHAFT BEARING CAP BOLT
30	OIL PAN GASKET
31	OIL PAN
32	OIL PAN WASHER
33	OIL PAN BOLT
34	OIL DRAIN PLUG WASHER
35	OIL DRAIN PLUG
36	CRANKSHAFT REAR OIL SEAL HOUSING PIN
37	CRANKSHAFT REAR OIL SEAL HOUSING
38	CRANKSHAFT REAR OIL SEAL HOUSING STUD
39	CRANKSHAFT REAR OIL SEAL HOUSING BOLT
40	CLUTCH PILOT BEARING
41	ENGINE FLYWHEEL BOLT
42	ENGINE FLYWHEEL
43	CRANKSHAFT REAR OIL SEAL
44	CRANKSHAFT REAR OIL SEAL HOUSING BOLT
45	CRANKSHAFT REAR OIL SEAL HOUSING GASKET
46	CAMSHAFT REAR BEARING HOLE PLUG
47	ENGINE BLOCK CORE PLUG



Head Explode

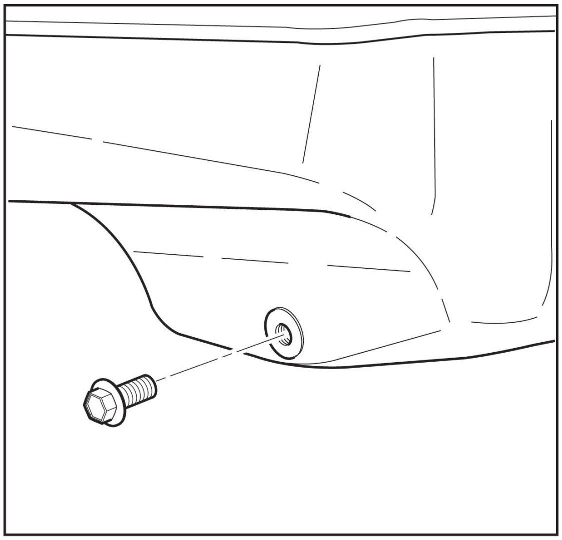
1	CYLINDER HEAD
2	VALVE ROCKER ARM STUD
3	VALVE STEM KEY
4	VALVE SPRING CAP (MPFI)
5	VALVE SPRING (MPFI)
6	VALVE STEM OIL SEAL (MPFI)
7	EXHAUST VALVE
8	INTAKE VALVE
9	VALVE STEM KEY
10	VALVE SPRING CAP
11	VALVE STEM OIL SHIELD
12	VALVE SPRING
13	VALVE STEM OIL SEAL
14	VALVE ROTATOR CAP EXHAUST



OIL PUMP EXPLODE

1	DRIVE GEAR
2	DRIVEN GEAR
3	OIL PRESSURE RELIEF VALVE
4	OIL PRESSURE RELIEF VALVE SPRING
5	OIL PUMP SCREEN
6	OIL PUMP
7	OIL PUMP COVER GASKET
8	OIL PUMP COVER
9	OIL PUMP COVER WASHER
10	OIL PUMP COVER BOLT

Draining Fluids, Oil Filter and Fuel Pump Cover Removal


VE005-3L
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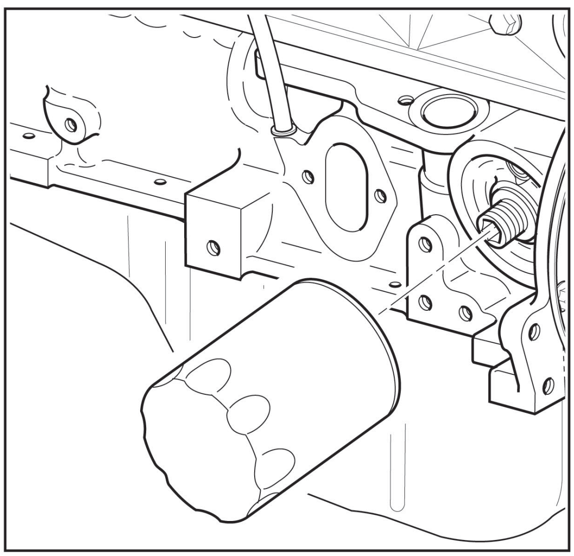
1. Remove the oil pan drain plug and allow the oil to drain.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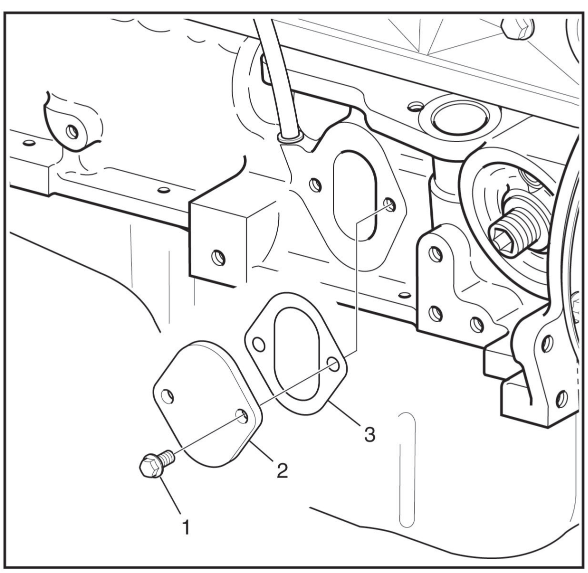
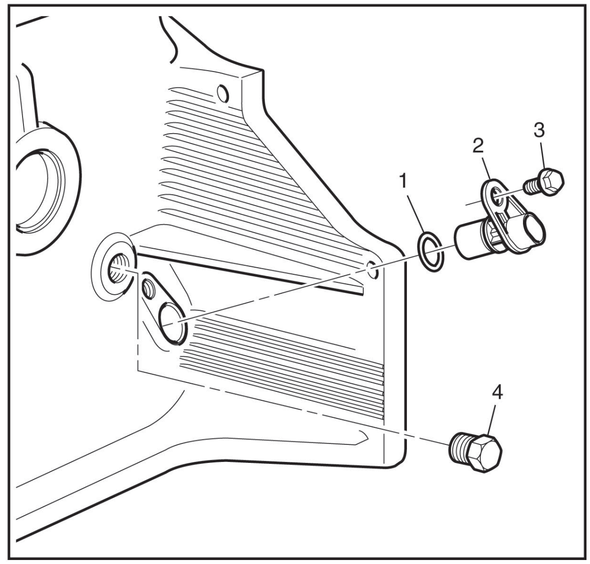
2. Remove the oil filter.



VE133-3L
VE133-3L

3. Remove the fuel pump cover bolts (1), cover (2), and gasket (3).

4. Remove the left rear engine block coolant plug (4) and allow the coolant to drain.
5. Remove the crankshaft position sensor retaining bolt (3).
6. Remove the crankshaft position sensor (2), (MPFI engine only).



VE008-3L
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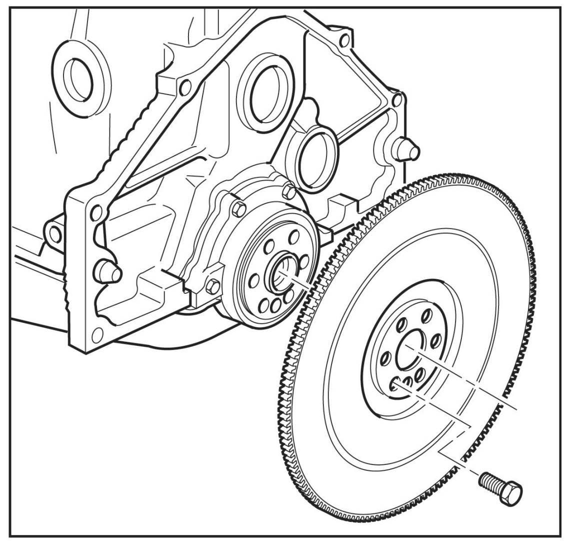
Engine Flywheel Removal

Important: Note the position and direction of the engine flywheel before removal. The flywheel center alignment hole is a tapered fit to the crankshaft. The engine flywheel must be reinstalled to the original position and direction.

1. Remove the engine flywheel bolts.
2. Remove the engine flywheel.



VE009-3L
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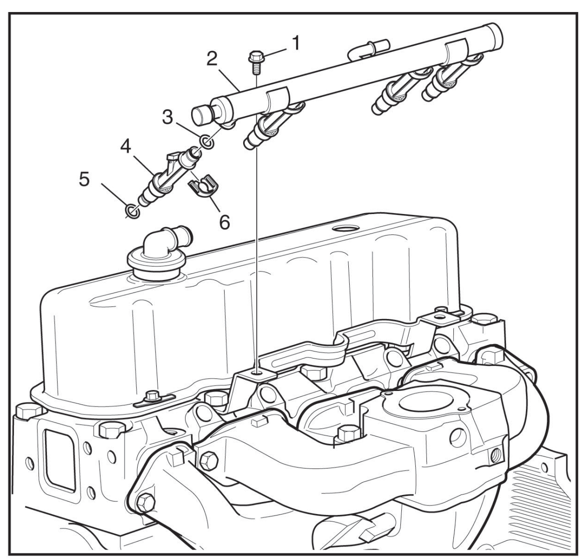
Fuel Rail Removal

1. Remove the fuel rail mounting bolts (1).
2. Remove the fuel rail and injector assembly (2).



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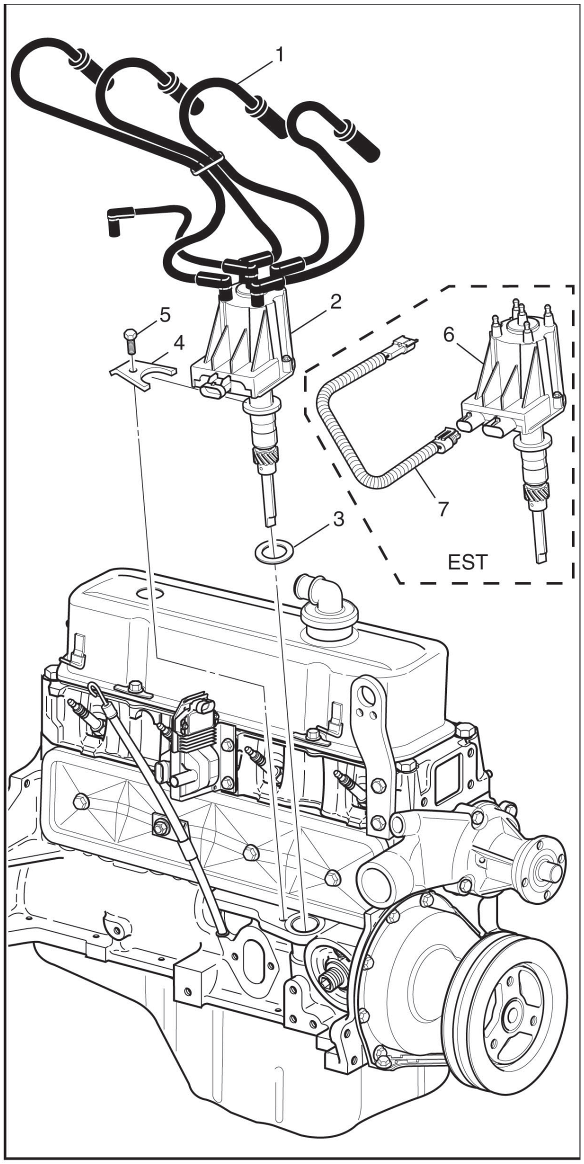
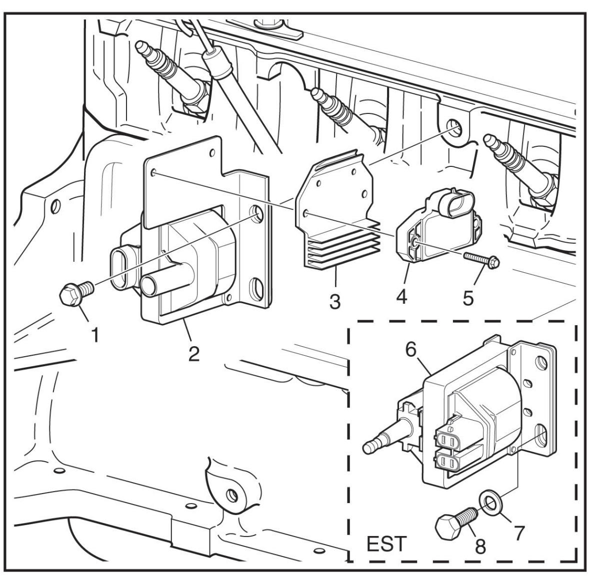
VE130-3L



VE010-3L
VE010-3L

Distributor/High Voltage Switch (HVS) Removal

1. Disconnect the secondary ignition wires (1) from the spark plugs and the ignition coil.
2. Remove the distributor hold down bolt (5).
3. Remove the distributor/high voltage switch (HVS) (2), and gasket (3).
4. distributor (6) and primary ignition harness for EST



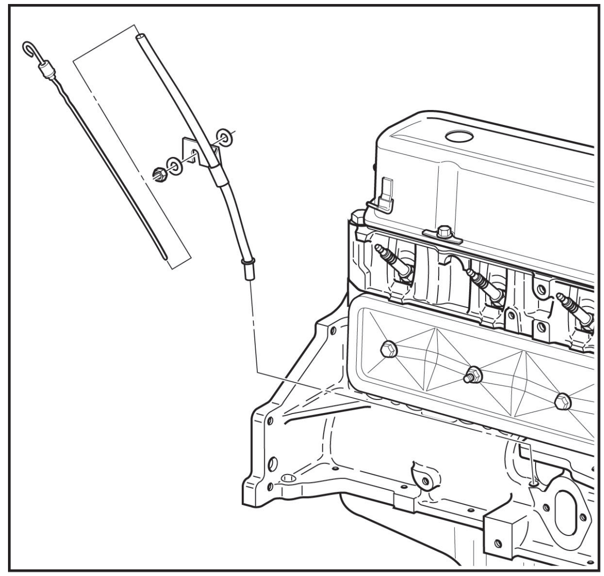
VE011-3L
VE011-3L

Ignition Coil Module Assembly Removal

1. Remove the ignition coil bracket attaching bolts (1).
2. Remove the ignition coil and module assembly (2).
3. Remove the ignition coil bolt (8), washer (7) and ignition coil (6) for EST models.

Oil Level Indicator and Tube Removal

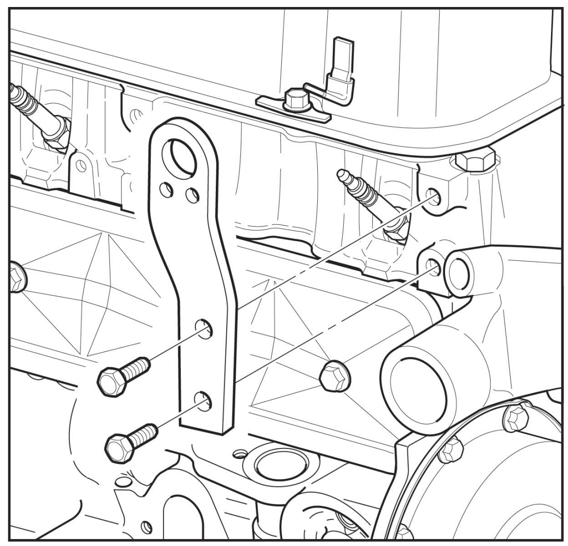
1. Remove the oil level indicator from the tube.
2. Remove the oil level indicator tube retaining nut and washer.
3. Remove the oil level indicator from the block, and the washer from the stud.



VE128-3L

Lift Bracket Removal

1. Remove the lift bracket bolts.
2. Remove the lift bracket.



VE012-3L
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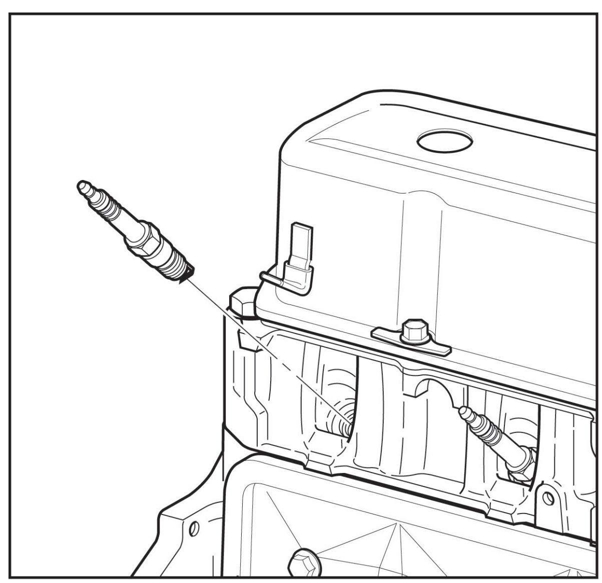
Spark Plug Removal

1. Remove the spark plugs.



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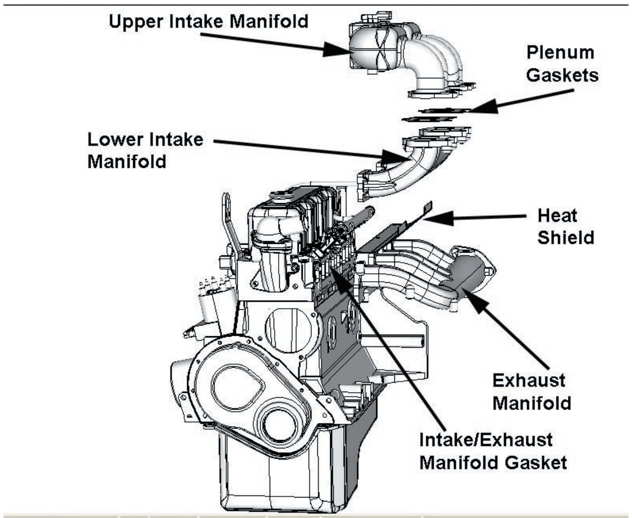
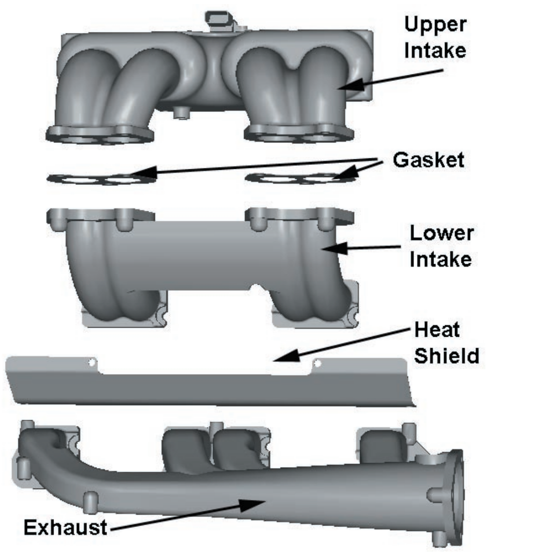


VE014-3L

Intake/Exhaust Manifold Removal (Industrial)

1. Remove the intake/exhaust manifold bolts.
2. Remove the intake/exhaust manifold.
3. Remove the intake/exhaust manifold gaskets.



VE015-3L

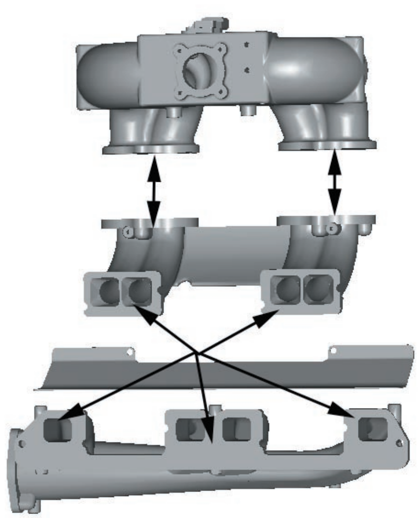
Intake/Exhaust Manifold Disassemble and Assemble (Industrial)

If necessary to replace either the intake or exhaust manifold, separate them as follows:

1. Remove the one attaching bolt and the two nuts at the center of the assembly.
2. Reassemble manifolds using a new gasket.

Tighten

Tighten the bolts to 27-34 N•m (20-25 lb ft).



VE016-3L

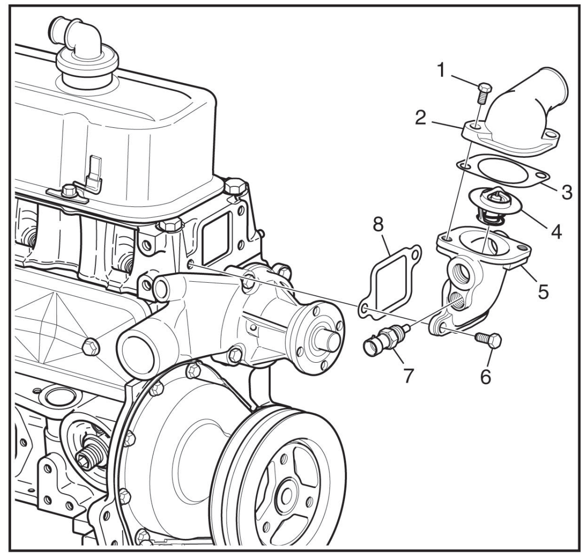
Intake/Exhaust Manifold Clean and Inspect (Industrial)

Clean and inspect the following areas:

- The manifold bolts and studs.
- All manifold sealing surfaces.
- Any old RTV from the manifold.

Water Outlet and Thermostat Removal (Industrial)

1. Remove the two water outlet housing bolts (1).
2. Remove the water outlet housing (2).
3. Remove the thermostat (4) and gasket (3).
4. Discard the water outlet housing gasket.
5. Remove the coolant temperature sensor (7) (MPFI engine only).
6. Remove the thermostat housing bolts (6).
7. Remove the thermostat housing (5) and gasket (8).
8. Discard the thermostat housing gasket.



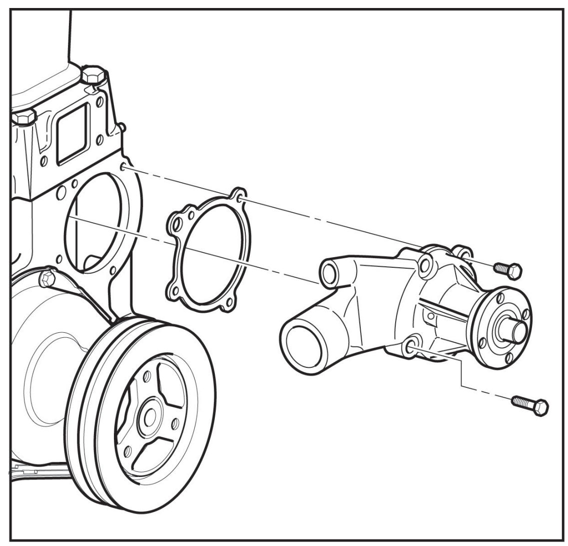
VE129-3L
VE129-3L

Water Pump Removal

Make sure the coolant is drained.

1. Remove the water pump bolts.
2. Remove the water pump and gasket.
3. Discard the water pump gasket.
4. Inspect the water pump for the following:
   - Gasket sealing surfaces for excessive scratches or gouges.
   - Excessive side-to-side play in the hub shaft.
   - Leakage at the water inlet housing or rear cover gaskets areas.
   - Leakage at the water pump vent hole.

     A stain around the vent hole is acceptable. If leakage occurs at the vent hole with the engine running and the cooling system pressurized, replace the pump.



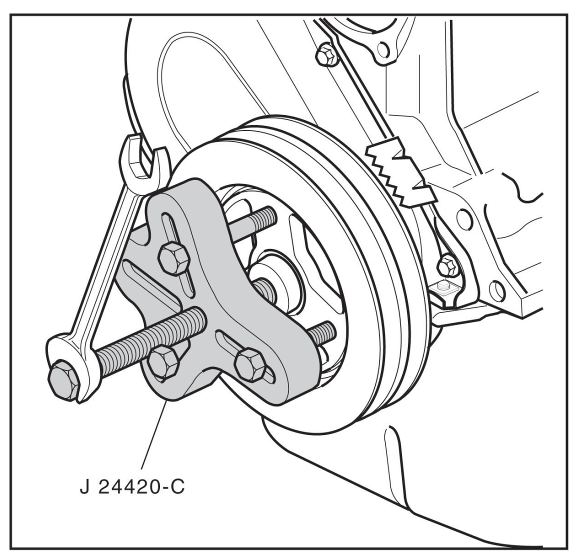
VE017-3L
VE017-3L

Crankshaft Pulley Removal

Tools Required

- J 24420-C Universal Crankshaft Pulley Remover

1. Use the J 24420-C in order to remove the crankshaft pulley.



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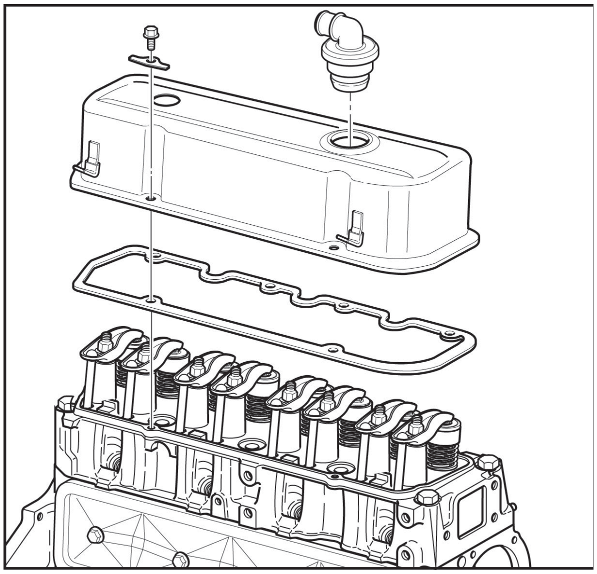
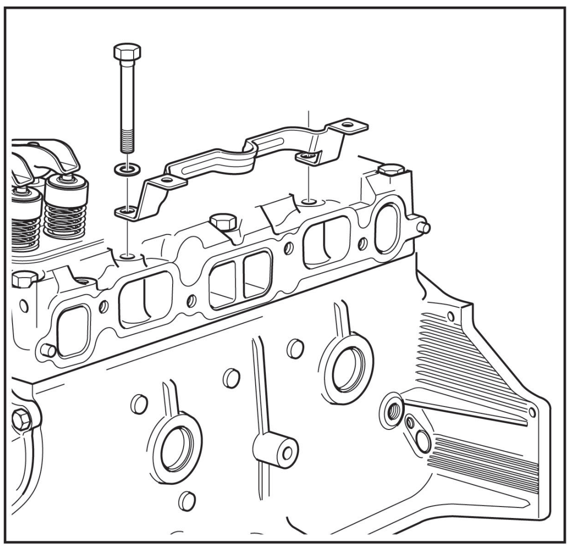


VE019-3L

Valve Rocker Arm Cover Removal

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover.
3. Remove the gasket/sealer.



VE131-3L

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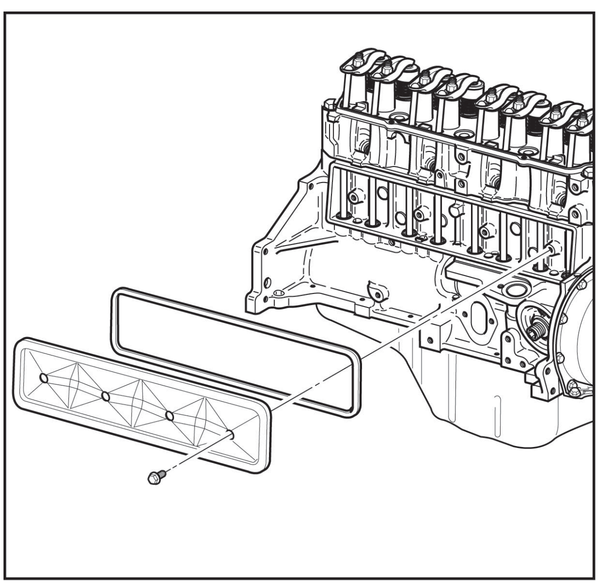
Fuel Rail Bracket Removal

1. Remove two cylinder head bolts and washers retaining the fuel rail bracket.
2.. Remove the fuel rail bracket.



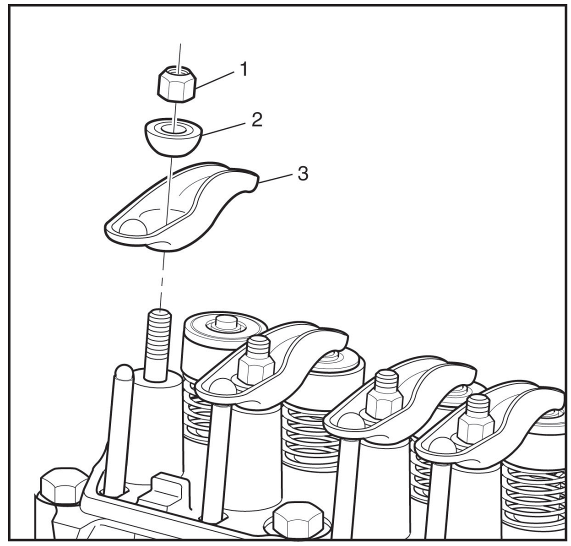
VE020-3L

Pushrod Cover Removal

1. Remove the pushrod cover bolts.
2. Remove the pushrod cover.
3. Remove the gasket/sealer.

Valve Rocker Arm and Pushrod Removal

1. Remove the following components from the cylinder head:
   1.1. The valve rocker arm nuts (1).
   1.2. The valve rocker arm balls (2).



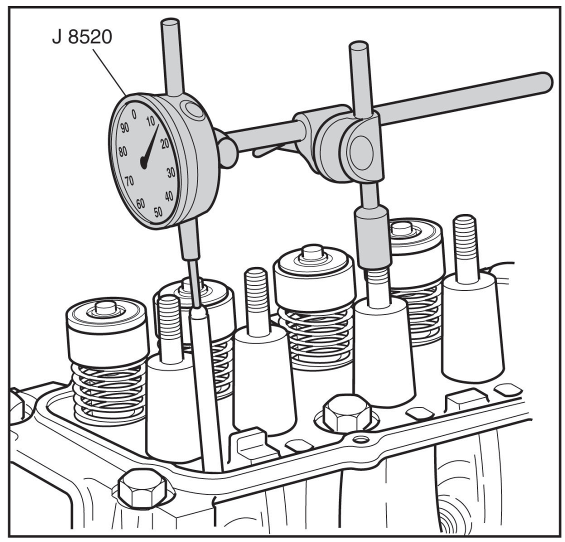
VE021-3L
VE021-3L

Measuring Camshaft Lobe Lift

Tools Required

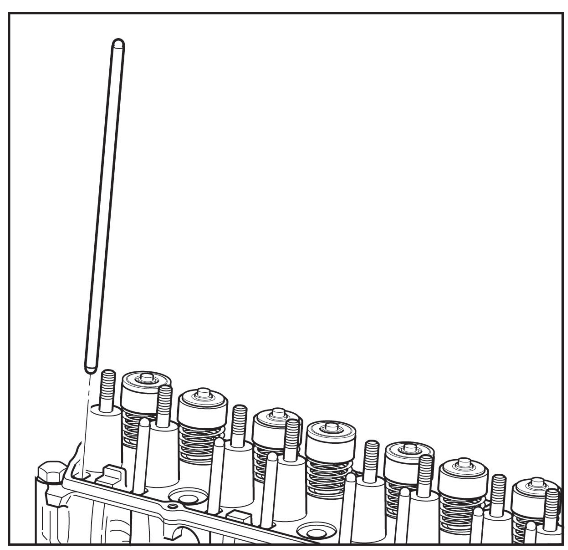
- J 8520 Camshaft Lobe Lift Indicator

1. Position the J 8520 with the ball socket adapter on the valve pushrod. Be sure that the valve pushrod is in the valve lifter socket.
2. Slowly rotate the crankshaft until the valve lifter roller is on the heel of the cam lobe. The valve pushrod will be in its lowest position.
3. Set the J 8520 on zero.
4. Slowly rotate the crankshaft until the valve pushrod is raised fully.
5. Compare the total lift shown on the J 8520 with the specifications. Refer to Engine Mechanical Specifications.
6. Remove the J 8520.



VE022-3L
VE022-3L

2. Remove the valve pushrods.
3. Place the following parts in a rack so that they can be reinstalled in their original locations:
   - The valve rocker arms.
   - The valve rocker arm balls.
   - The valve pushrods.



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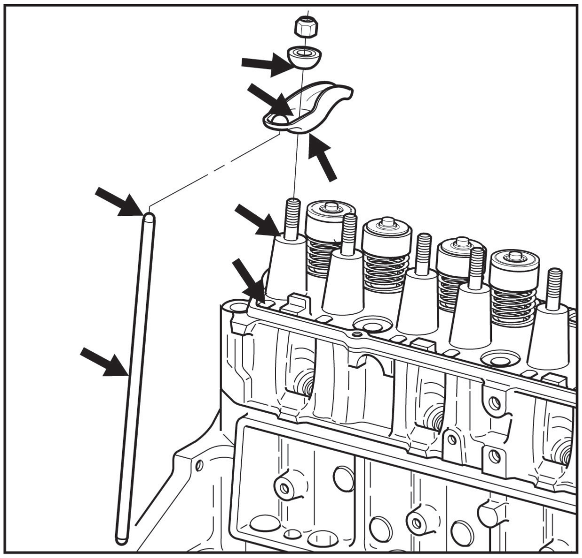
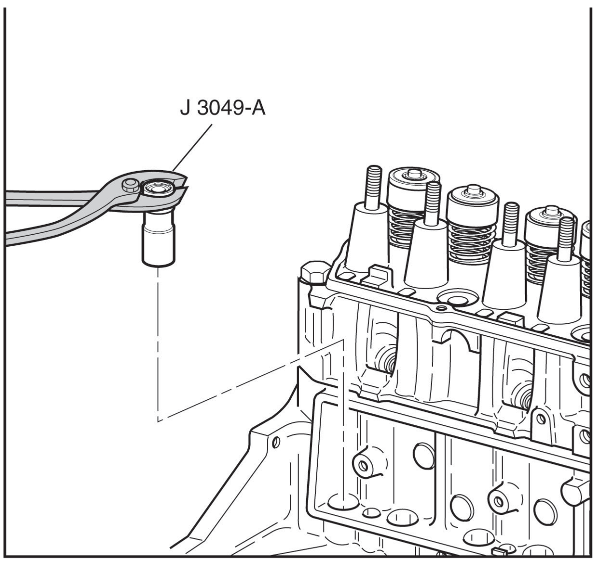


VE024-3L

Valve Train Components Inspect (Cylinder Head)

Inspect the following areas:

- The valve rocker arms and ball at the mating surfaces. These surfaces should be smooth and free of scoring or other damage.
- The valve pushrod sockets and valve stem mating surfaces. These surfaces should be smooth with no scoring or exceptional wear.
- The valve pushrods for bends or scored ends.



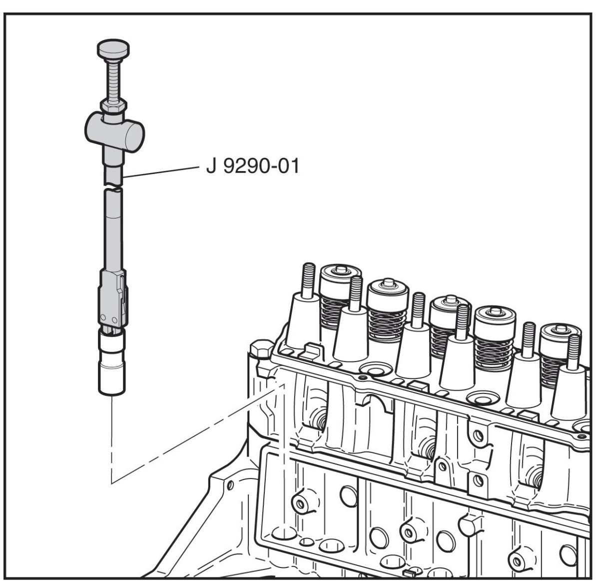
VE025-3L
VE025-3L

Valve Lifter Removal

Tools Required

- J 3049 Valve Lifter Remover (Plier Type)
- J 9290-01 Valve Lifter Remover (Slide Hammer Type)

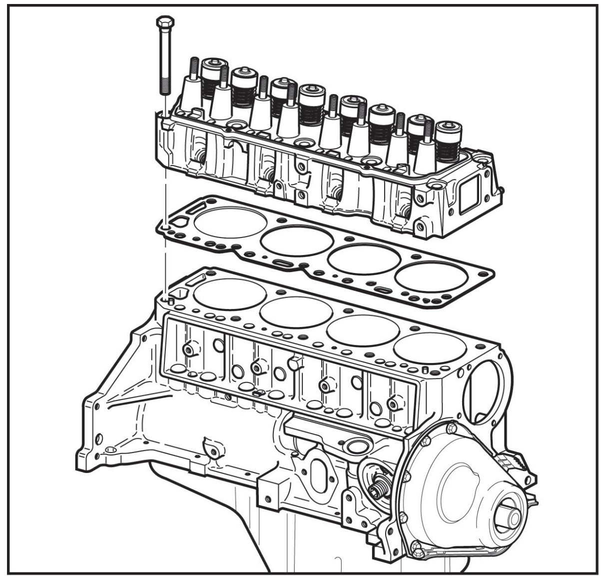
1. Use the J 3049 in order to remove the valve lifters.



VE026-3L

2. If the valve lifters cannot be removed with the J 3049 use the J 9290-01 in order to remove the valve lifters.

Cylinder Head Removal



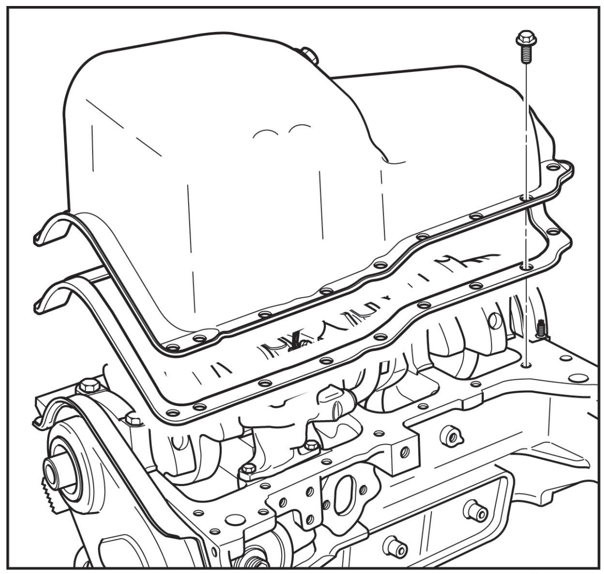
VE027-3L

1. Remove the cylinder head bolts.

Notice: After removal, place the cylinder head on two wood blocks to prevent damage.

2. Remove the cylinder head.
3. Remove the gasket.
4. Discard the gasket

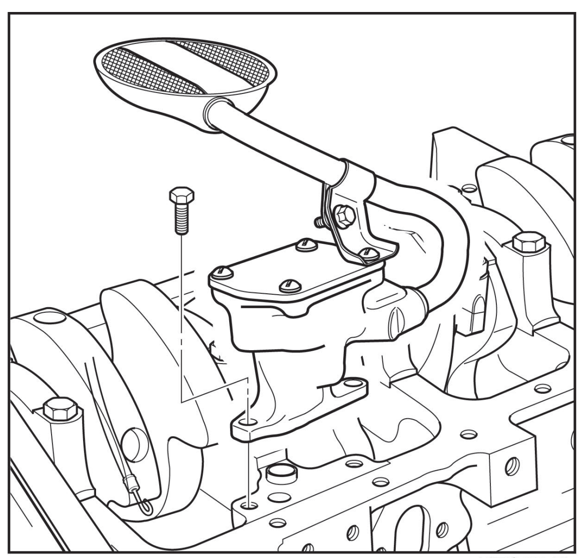
Oil Pan Removal



VE028-3L

1. Remove the oil pan bolts.
2. Remove the oil pan.
3. Remove the gasket.
4. Discard the gasket.

Oil Pump Removal

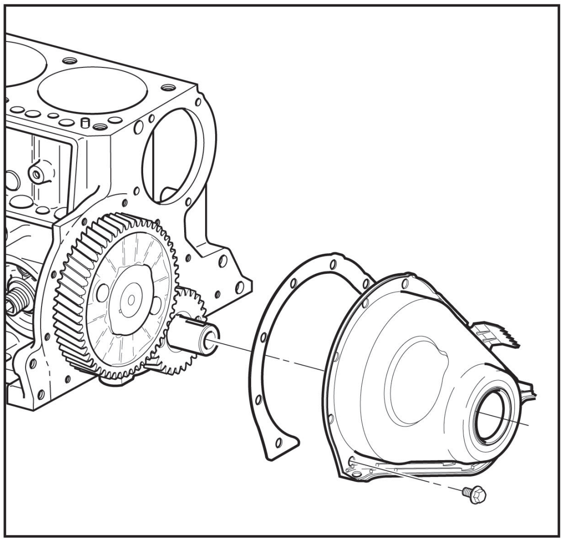


VEO29-3L

VE029-3L

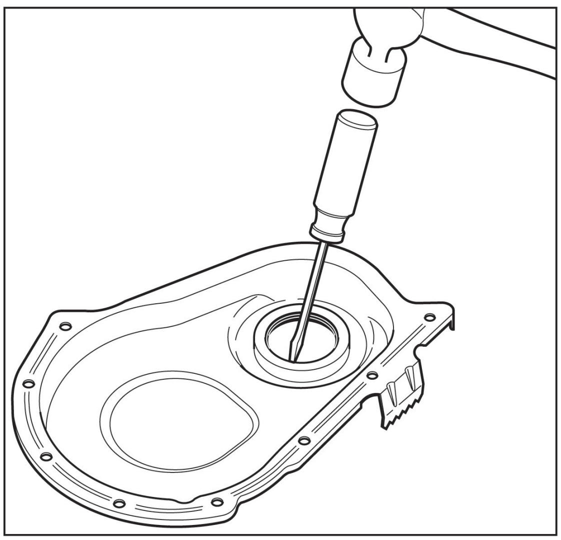
1. Remove the bolts that attach the oil pump to the engine block.
2. Remove the oil pump and gasket.
3. Discard the gasket.

Engine Front Cover Removal



VE030-3L
VE030-3L

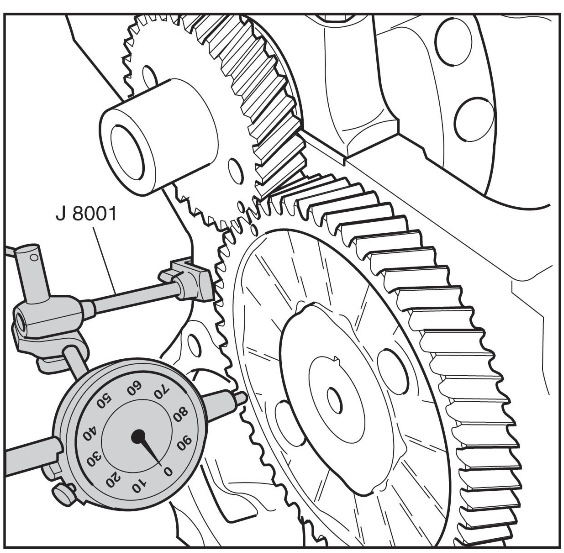
1. Remove the engine front cover bolts.
2. Remove the engine front cover.
3. Remove the gasket.
4. Discard the gasket.



VE031-3L
VE031-3L

5. Remove the oil seal from the front cover.
6. Clean the engine front cover in solvent.
7. Inspect the engine front cover for damage to the gasket surface or the oil seal surface.

Measuring Crankshaft and Camshaft Sprocket Runout



VE032-3L
VE032-3L

Tools Required

- J 8001 Dial Indicator

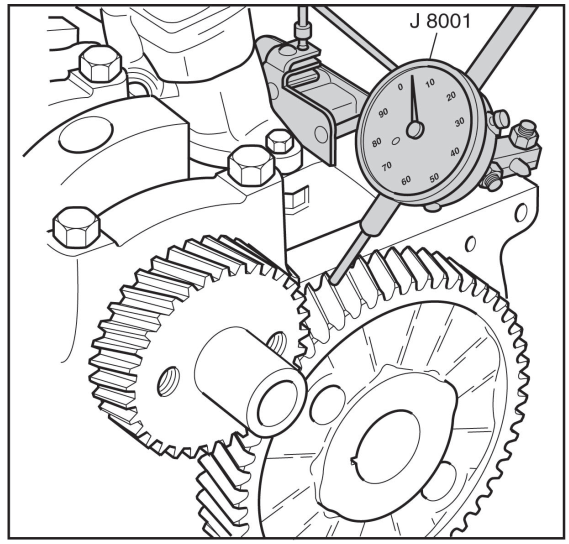
1. Use the J 8001 in order to measure the crankshaft and camshaft sprocket runout. Refer to Engine Mechanical Specifications.
2. If the sprocket runout exceeds specifications, clean and remove any burrs from the shaft or replace the sprocket.

Measuring Timing Sprocket Teeth Backlash

Tools Required

- J 8001 Dial Indicator

1. Use the J 8001 in order to measure the backlash between the timing sprocket teeth.
2. Refer to Engine Mechanical Specifications.



VE033-3L

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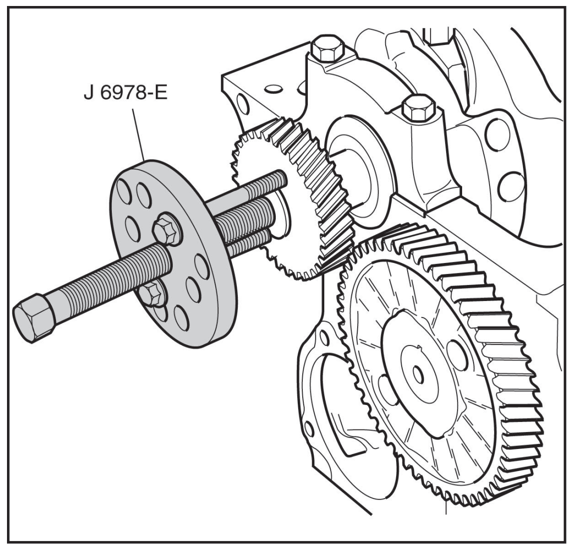
Crankshaft Sprocket Removal

Tools Required

- J 6978-E Crankshaft Sprocket Puller

1. Use the J 6978-E in order to remove the crankshaft sprocket.
2. If necessary, remove the crankshaft keys.



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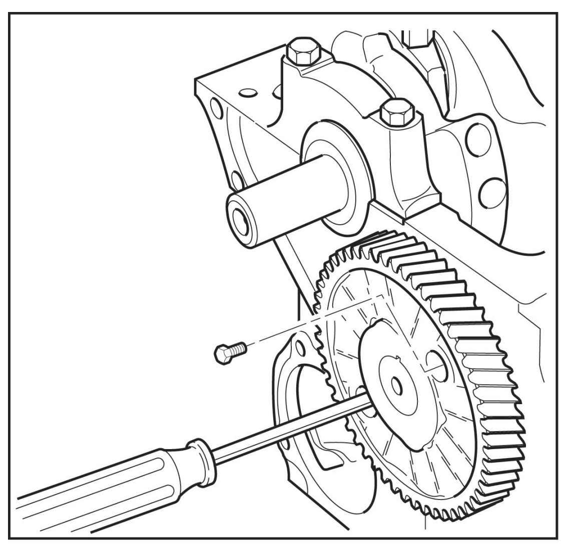
Camshaft Removal

1. Remove the two camshaft retainer bolts, working through the holes in the camshaft sprocket.



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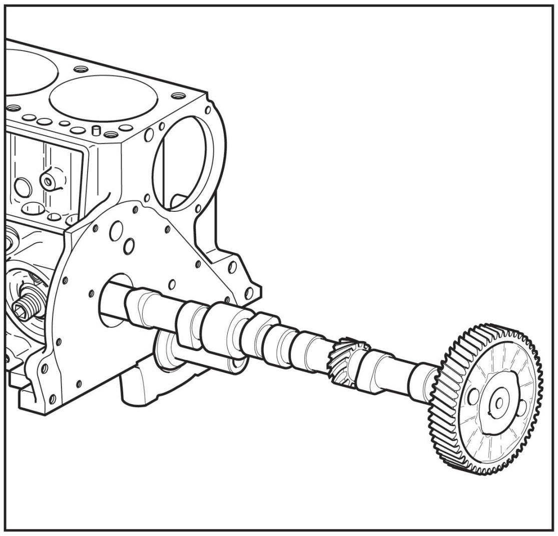
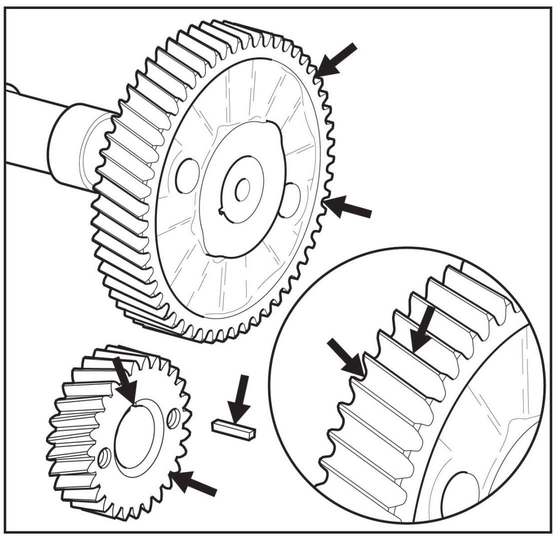


VE125-3L
VE125-3L

Important: All camshaft journals are the same diameter, so care must be used in removing the camshaft to avoid damage to the bearings.

2. Carefully rotate and pull the camshaft out of the bearings.



VE126-3L
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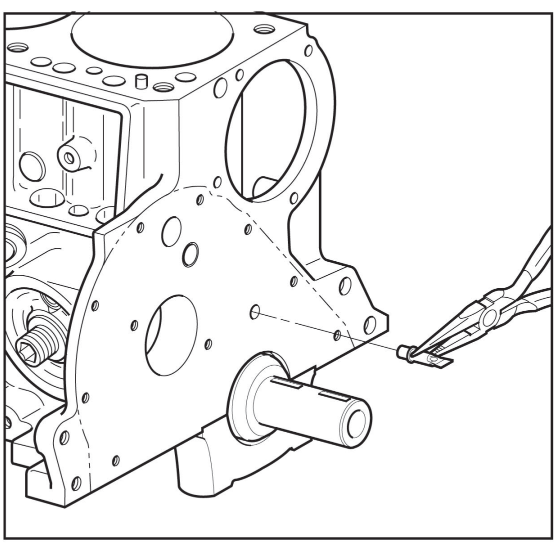
Crankshaft and Camshaft Sprocket Inspect

- The camshaft and crankshaft sprockets for wear.
- One edge of worn teeth or that are no longer concentric.
- The valley between worn teeth.



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Timing Gear Oil Nozzle Removal

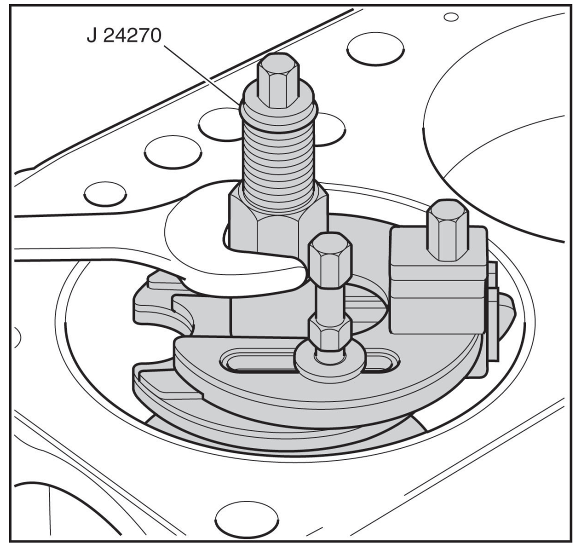
1. Remove the oil nozzle with pliers.

Piston, Connecting Rod and Bearing Removal

Tools Required

- J 5239 Connecting Rod Guide Tool
- J 24270 Ridge Reamer

1. Remove the ring ridge as follows:
   1.1. Turn the crankshaft until the piston is at the bottom of the stroke.
   1.2. Place a cloth on top of the piston.
   1.3. Use the J 24270 to remove the cylinder ring ridge.
   1.4. Turn the crankshaft so the piston is at the top of the stroke.
   1.5. Remove the cloth.
   1.6. Remove the cutting debris.

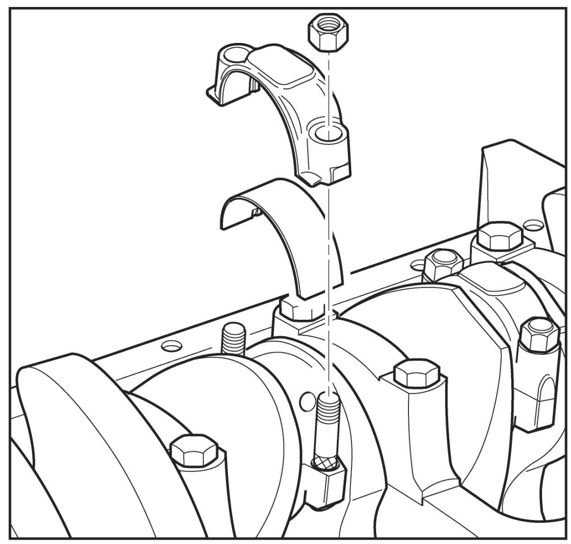


VE036-3L

VE036-3L

Important: Place matchmarks or numbers on the connecting rods and the connecting rod caps. Upon removal of the piston and connecting rod assembly, install the connecting rod caps to the matching connecting rods.

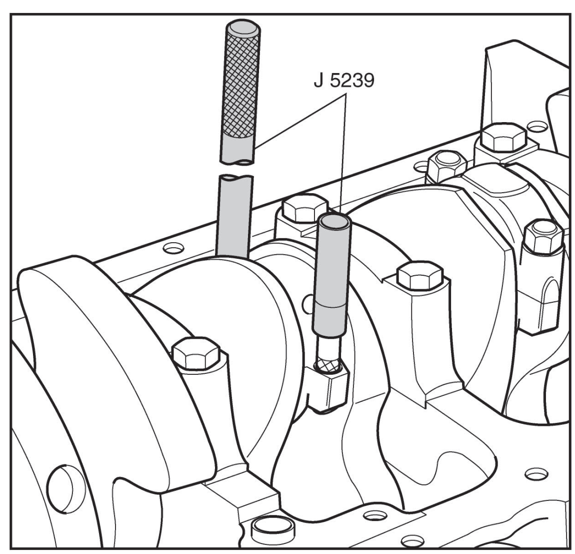
2. Remove the connecting rod nuts.
3. Remove the connecting rod cap.
4. Remove the connecting rod bearings.
   - Keep bearings with the original connecting rod and connecting rod cap.
   - Wipe the oil from the bearings.
   - Wipe the oil from the crankpins.



VE037-3L

VE037-3L

5. Use the J 5239 in order to remove the connecting rod and the piston out of the engine block.
6. Use a hammer and tap lightly on the end of the connecting rod guide tool to remove the piston and connecting rod assembly from the cylinder bore.



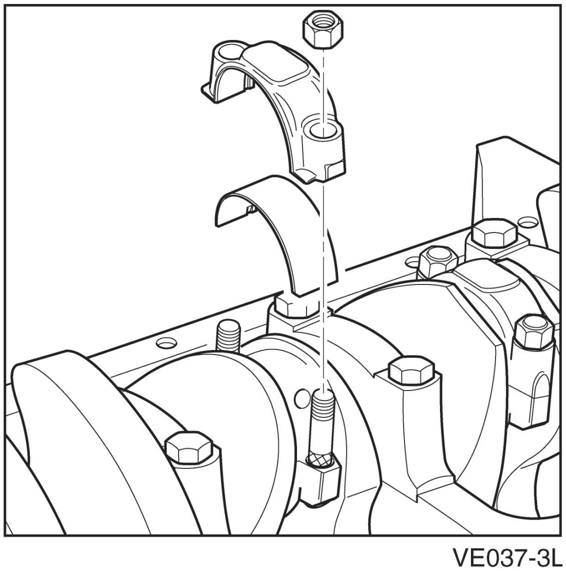
VE038-3L

VE038-3L

Crankshaft and Bearings Clean and Inspect (Connecting Rod Bearing Clearance)

Important: Connecting rod bearings are a precision insert type. Connecting rods are of a powdered metal design and cannot be shimmed or filed for bearing fit. If clearances are found to be excessive, a new bearing and/or connecting rod are required. Do not rotate the crankshaft while gauging plastic is between the crankshaft journal and the bearing surface.

1. Remove the connecting rod nuts.
2. Remove the connecting rod cap and bearing.



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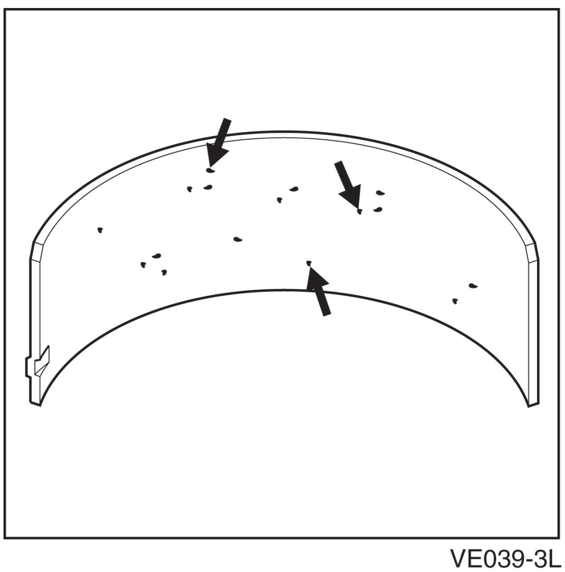
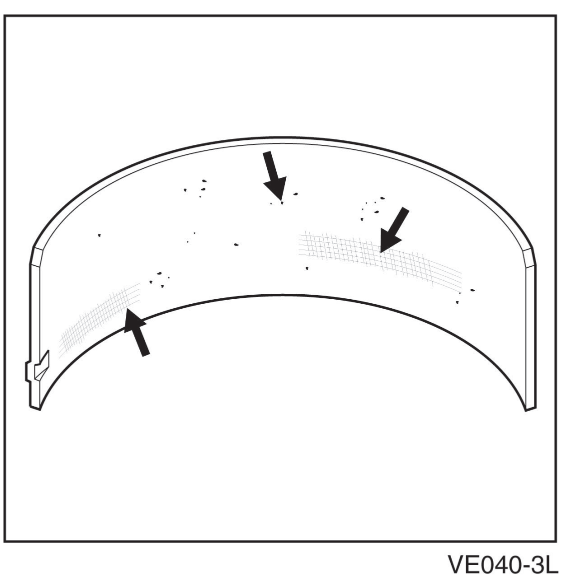
3. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.



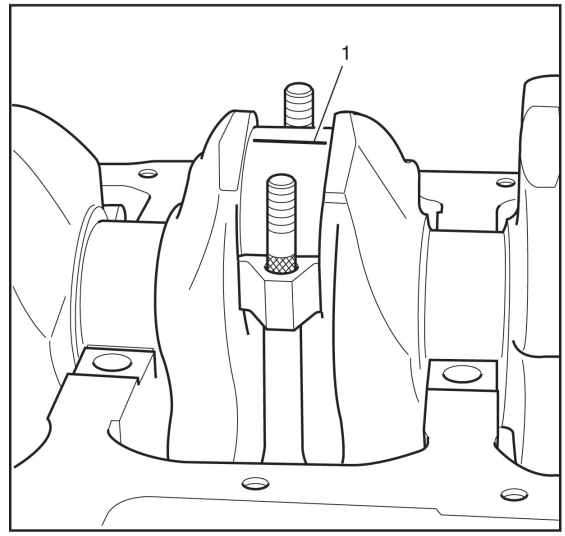
VE039-3L

4. Inspect the crankshaft bearings for excessive scoring or discoloration.
5. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.



VE040-3L

6. Install the gauging plastic (1) onto the connecting rod bearing journal. Install the gauging plastic the full width of the journal.



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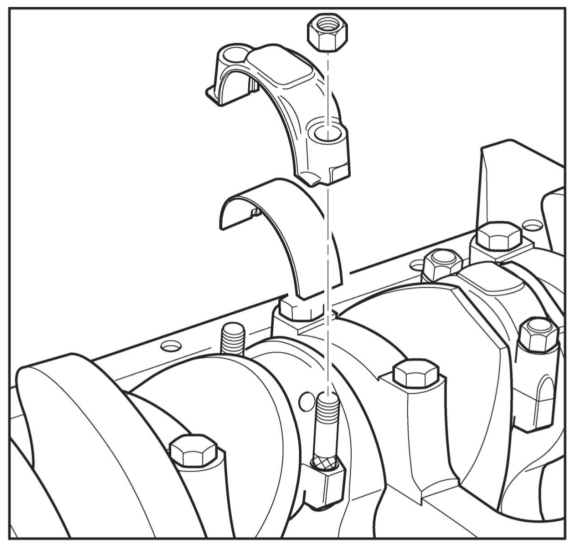
7. Install the connecting rod cap and bearing.

Tighten

Tighten the nuts evenly to 61 N•m (45 lb ft).



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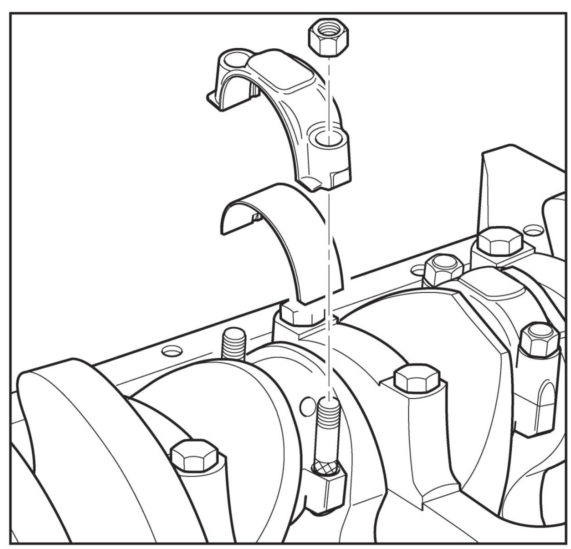
8. Remove the connecting rod nuts.
9. Remove the connecting rod cap and bearing.



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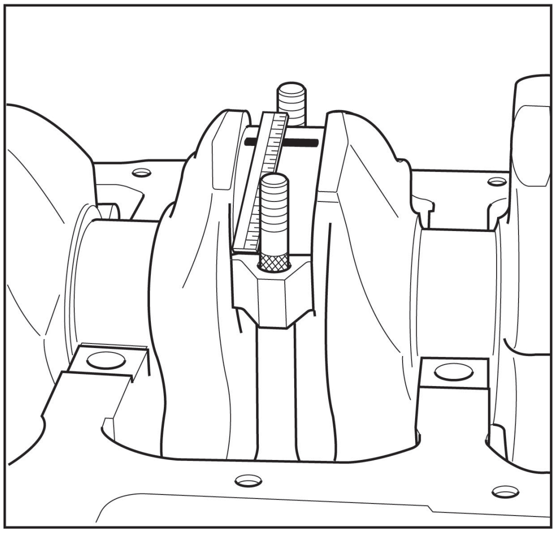

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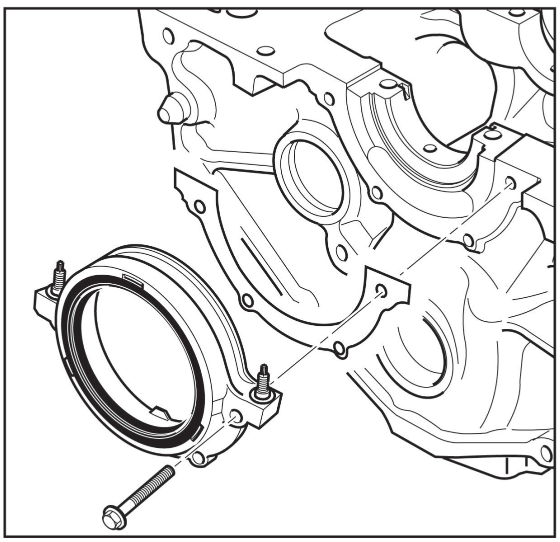
10. Measure the gauging plastic at its widest area using the scale supplied with the plastic gauging kit.
11. Compare the measurements to Engine Mechanical Specifications.



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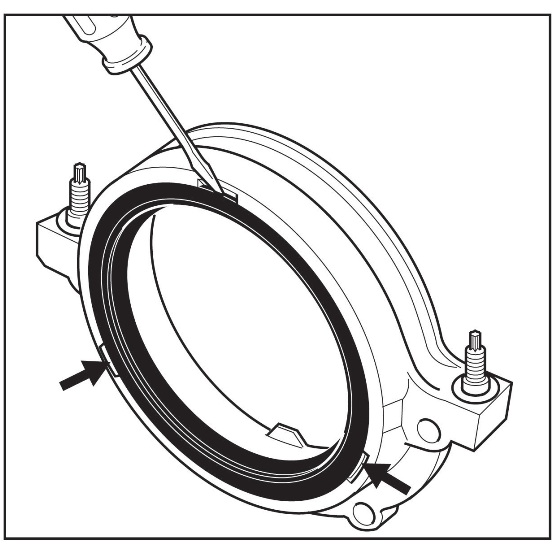
Crankshaft Rear Oil Seal and Housing Removal

1. Remove the crankshaft rear oil seal housing bolts.
2. Remove the crankshaft rear oil seal housing, seal and gasket.



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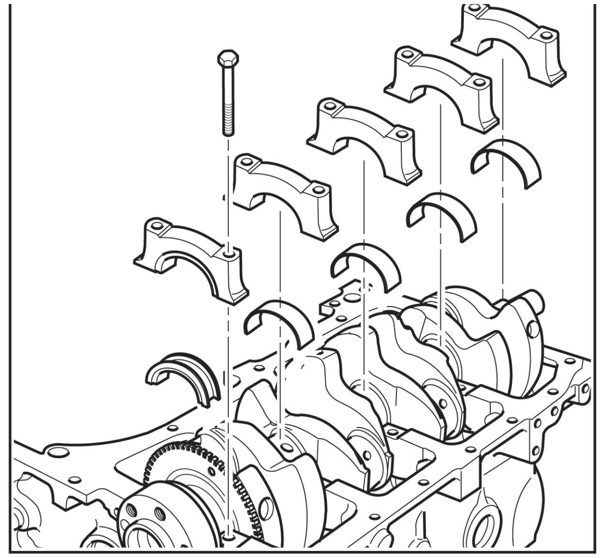
3. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.

Crankshaft , Bearings and Bearing Cap Removal

1. Remove the crankshaft bearing cap bolts.
2. Remove the crankshaft bearing caps.



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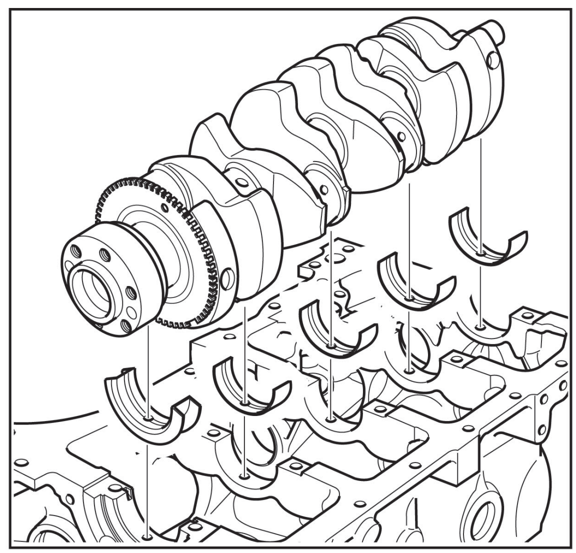
3. Remove the crankshaft.
4. Remove the crankshaft bearings from the bearing caps (lower bearings) and from the engine block (upper bearings).



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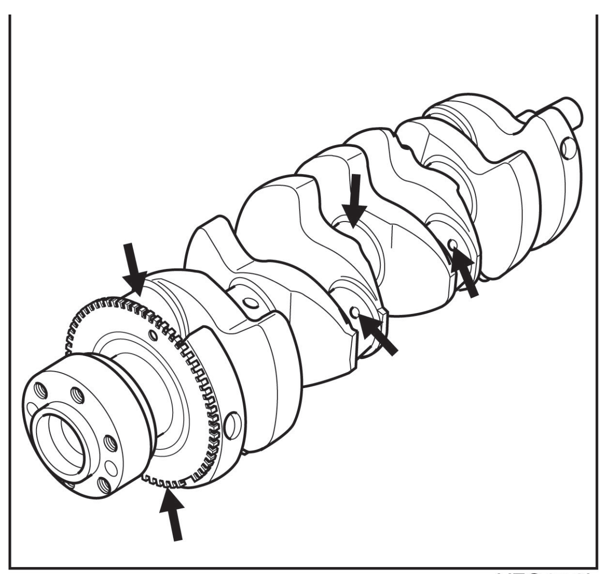
Crankshaft and Bearings Clean and Inspect

Tools Required

- J 7872 Magnetic Base Indicator Set

Caution: Wear safety glasses in order to avoid eye damage.

1. Clean the crankshaft in solvent.
2. Inspect the crankshaft oil passages for restrictions.
3. Dry the crankshaft with compressed air.
4. Inspect the crankpins for scoring or wear.
5. Inspect the reluctor wheel teeth for damage or warpage.



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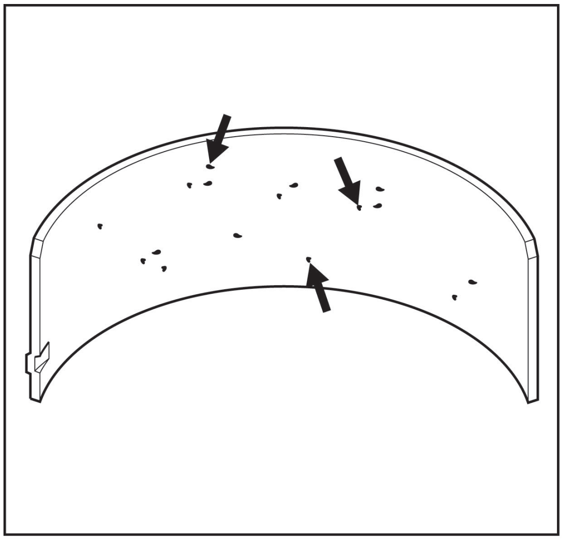

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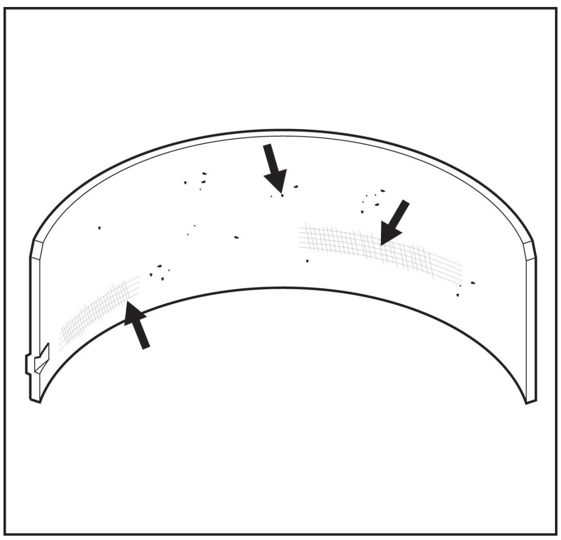
5. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.



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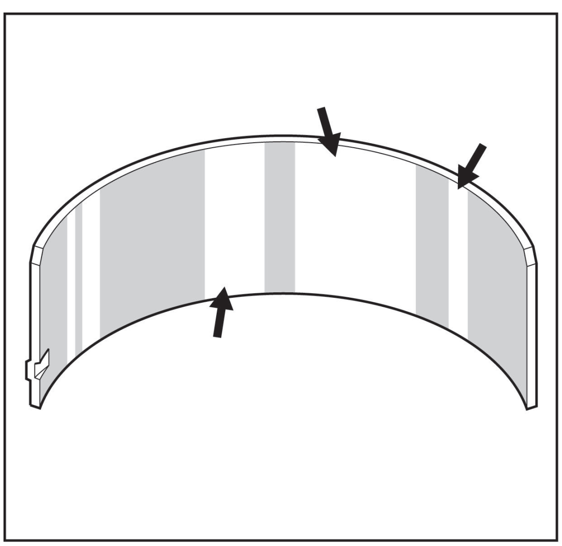
6. Inspect the crankshaft bearings for excessive scoring or discoloration.
7. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.



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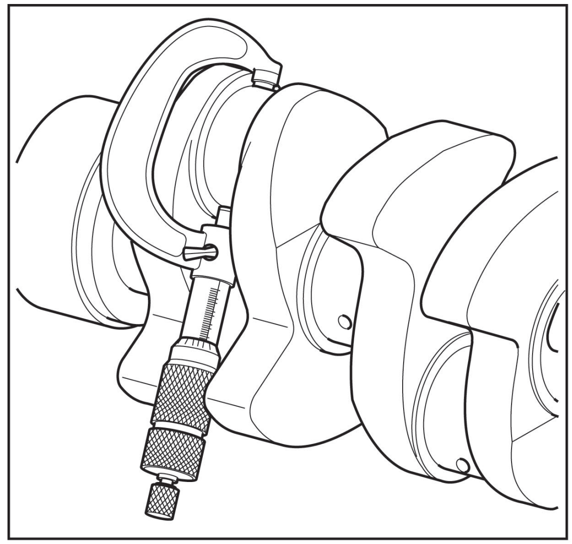
8. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.
   - If the lower half of the bearing is worn or damaged, both the upper and lower halves must be replaced.

9. Measure the crankpins for out-of-round, taper or undersize with a micrometer. Refer to Engine Mechanical Specifications.



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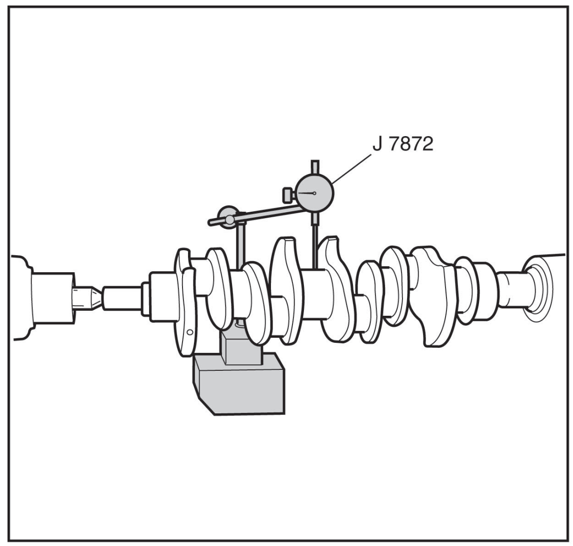
10. Support the crankshaft front and rear journals on V-blocks.
11. Measure the crankshaft run-out at front and rear intermediate journals with J 7872. Refer to Engine Mechanical Specifications.
12. Replace or recondition crankshaft if measurements are



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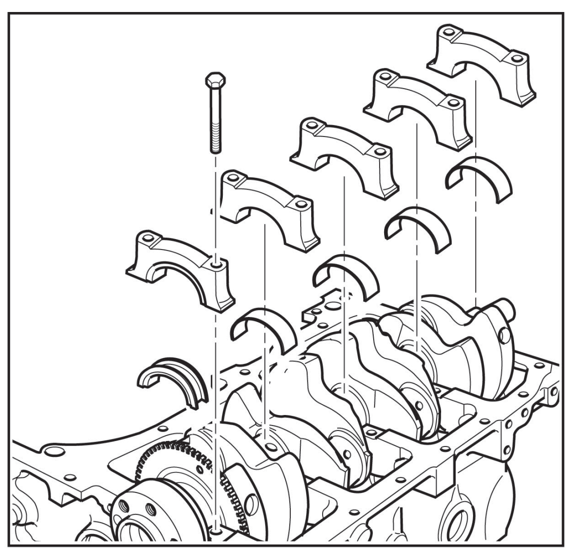
Crankshaft and Bearings Clean and Inspect (Main Bearing Clearance)

Important: Crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. Crankshaft bearing clearances are critical. If the clearances are found to be excessive, new bearings and/or engine block and cap repair may be required.

Do not rotate the crankshaft while gauging plastic is between the crankshaft journal and the bearing surface.

1. Remove the crankshaft bearing cap bolts.
2. Remove the crankshaft bearing caps.



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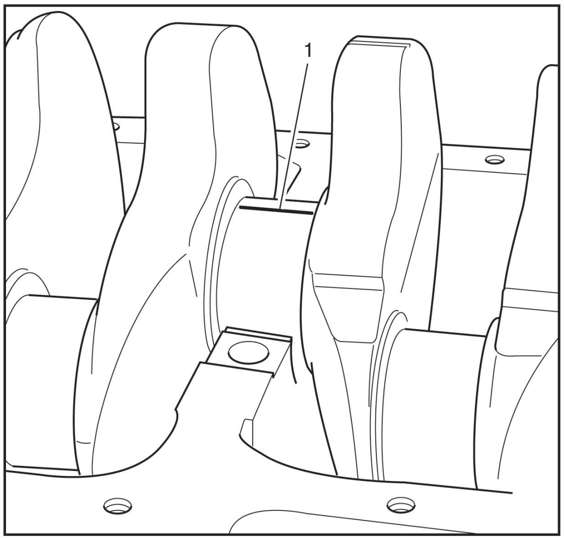

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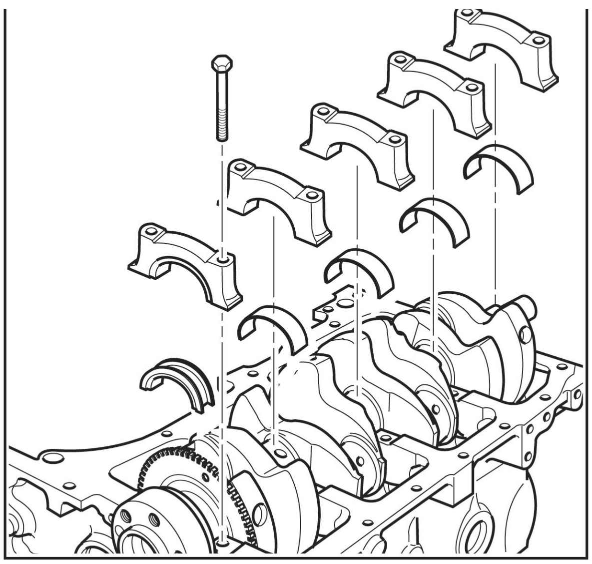
3. Install gauging plastic (1) onto the crankshaft journal. Install the gauging plastic the full width of the crankshaft bearing journal.



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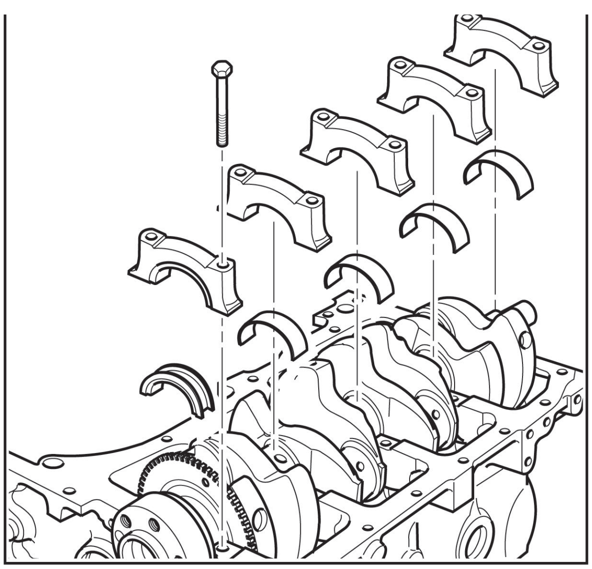
4. Install the bearing, bearing cap and bolts.

Tighten

Tighten the crankshaft bearing cap bolts to 85 N•m (63 lb ft).



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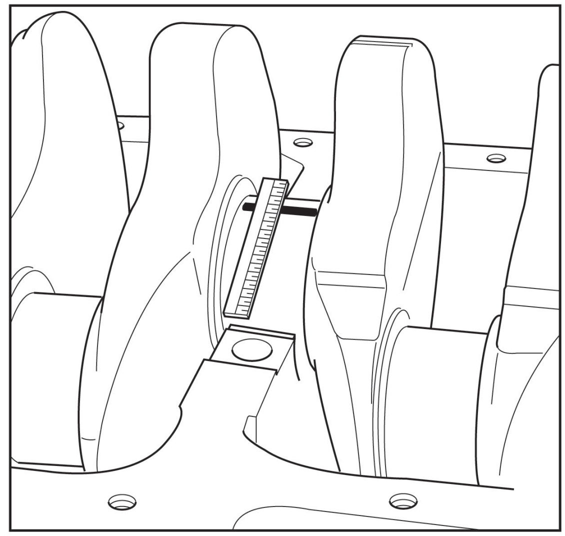
5. Remove the crankshaft bearing cap bolts.
6. Remove the crankshaft bearing caps.

7. Measure the gauging plastic at its widest area using the scale supplied with the plastic gauging kit.
8. Compare the measurements to Engine Mechanical Specifications.
   - If the gauging plastic shows irregularity in the journal exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
   - If the clearance is greater than Engine Mechanical Specifications, select and install an undersized bearing set. Measure the clearance with gauging plastic.
   - If clearance cannot be brought to specifications, grind the crankshaft for use with the next undersized



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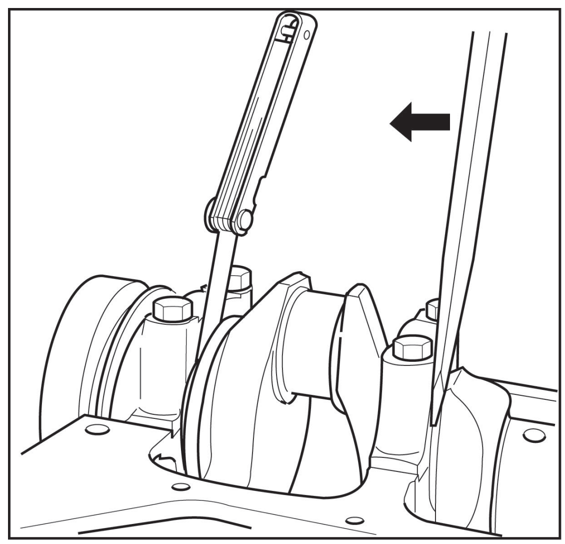
9. Use a dial indicator or feeler gauge in order to measure end play between the front of the rear of the crankshaft bearing cap and the crankshaft thrust surface in order to determine the crankshaft end play.
10. If you use a feeler gauge, measure between the thrust surface of the crankshaft bearing and the crankshaft. Refer to Engine Mechanical Specifications.



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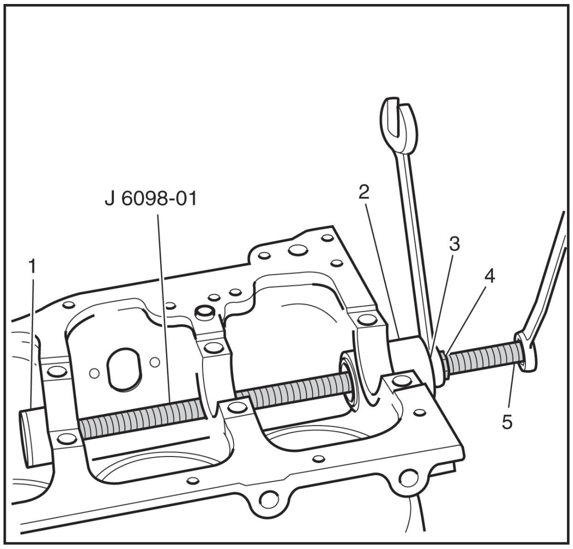

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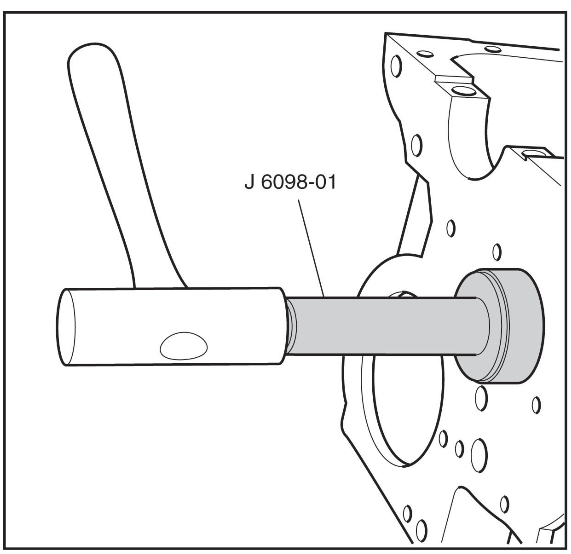
Camshaft Bearing Removal

Tools Required

- J 6098-01 Camshaft Bearing Remover/Installer

1. Remove the camshaft rear bearing hole plug.
2. Use the J 6098-01 in order to remove the inner camshaft bearings. Repeat the following procedure for each of the inner camshaft bearings:
   - 2.1. With the nut (4) and the thrust washer (3) installed to the end of the puller screw threads, index the pilot (2) in the camshaft front bearing and install the puller screw through the pilot (2) and the bearing to be removed.
   - 2.2. Install the bearing tool (1) with the shoulder toward the bearing.
   - 2.3. Using two wrenches, hold puller screw (5) while you turn the nut (4) in order to draw the bearing out of the bore.
   - 2.4. When the bearing has been pulled from the bore, remove the bearing tool and the bearing from the puller screw.
   - 2.5. Index the pilot in the rear camshaft bearing in order to remove the rear inner camshaft bearing.



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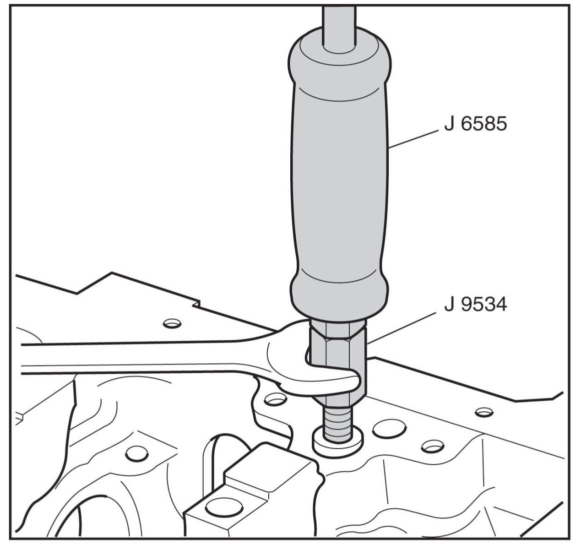
3. Use the J 6098-01 in order to remove the front and rear camshaft bearings.
   - 3.1. Assemble the bearing tool to the driver.
   - 3.2. Drive the front and rear camshaft bearings out of the block bore. Drive inward toward the center of the engine block.

Distributor Lower Bushing and Thrust Washer Removal

Tools Required

- J 9534 Distributor Lower Bushing Remover
- J 6585 Slide Hammer

1. Install the J 9534 into the distributor lower bushing.
2. Use the J 6585 in order to remove the bushing.



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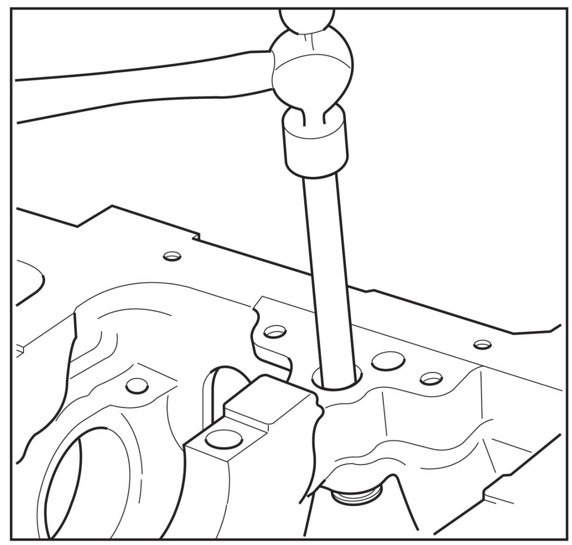
3. Use a drift punch up through the bushing bore in order to drive the thrust washer (if installed) out of the bore.
4. Clean the bushing bore in the cylinder block and inspect for burrs or damage.



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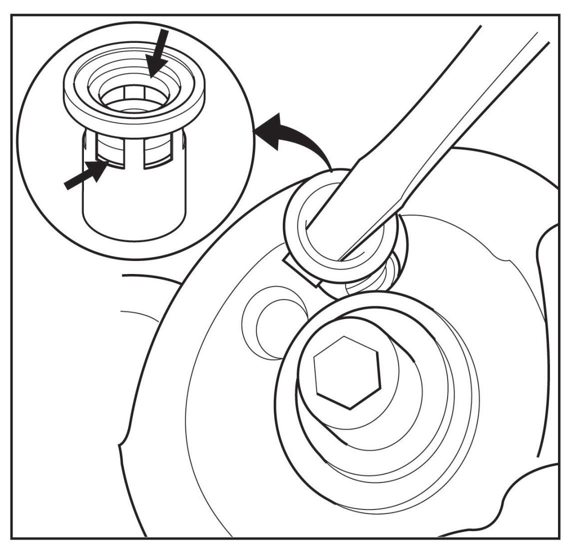
Oil Filter Bypass Valve Removal and Installation

1. Check the spring and fiber valve for operation.
2. Inspect for a cracked or broken valve.
3. Use a screwdriver in order to pry the valve out.
4. Use a 9/16 in thin-wall deep socket in order to tap the new bypass valve in place.



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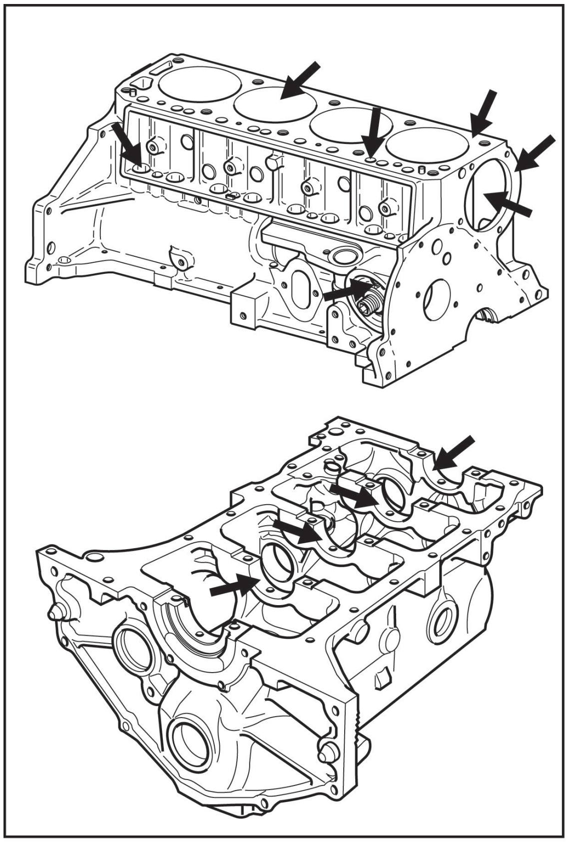
Cylinder Block Clean and Inspect

1. Clean the following areas:
   - The engine block in solvent, removing all sludge, dirt or debris

Caution: Wear safety glasses in order to avoid eye damage.

   - Dry the block with compressed air.
   - The gasket surfaces.
   - The coolant passages.
   - The oil passages.
   - The main bearing caps.
   - All threaded bolt holes.
2. Inspect the following areas:
   - The cylinder walls for excessive scratches, gouging or ring ridge.
   - The coolant jackets for cracks.
   - The valve lifter bores for excessive scoring or wear.
   - The crankshaft bearing webs for cracks.
   - The gasket sealing surfaces for excessive scratches or gouging.
   - The oil passages for restrictions.
   - All threaded bolt holes for thread damage.



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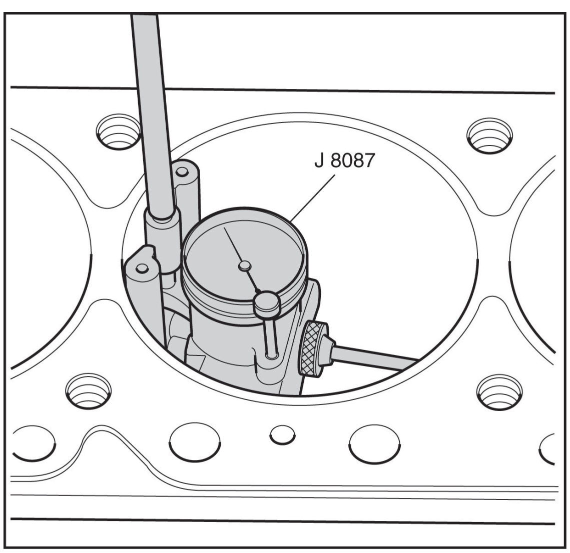
Cylinder Bore Measurements

Tools Required

- J 8087 Cylinder Bore Gauge

1. Use the J 8087 in order to check cylinder bore taper and out-of-round as follows:
   1.1. Set the gauge so that the thrust pin must be forced in about 1/4 in to enter the gauge in the cylinder bore.
   1.2. Center the gauge in the cylinder and turn the dial to "0."
   1.3. Work the gauge up and down to determine the taper.
   1.4. Turn the gauge to different point around the cylinder



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Cylinder Boring and Honing

Boring Procedure

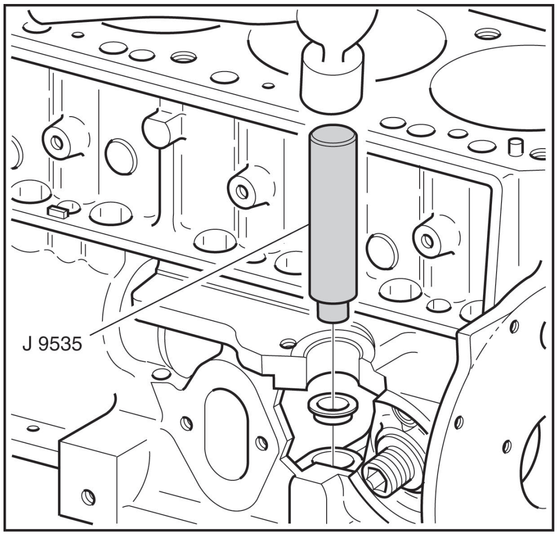
1. Before you start the honing or reboring process, measure all new pistons with the micrometer, contacting at points exactly 90° from the piston pin centerline. Refer to Piston Selection. Select the smallest piston for the piston fitting. Slightly varied pistons in a set may provide correction, in case the first piston is too loosely fitted.
2. Before you use any type of boring bar, file the top of the cylinder block in order to remove any dirt or burrs. If you do not check the cylinder block, the boring bar may be tilted, this could result in the rebored cylinder wall being at incorrect right angles from the crankshaft.
3. Carefully follow the instructions furnished by the manufacturer regarding the use of the equipment.
4. When you rebore cylinders, make sure all crankshaft bearing caps are in place. Tighten the bearing caps to the proper torque in order to avoid distortion of the bores in the final assembly. The crankshaft must be clear of the boring cutter when you bore each cylinder. Cover or tape the crankshaft bearings and other internal parts to protect during the boring or honing process.

Honing Procedure

1. When honing the cylinders, follow the manufacturer's recommendations for use, cleaning and lubrication. Use only clean, sharp stones of the proper grade for the amount of material you remove. Dull, dirty stones cut unevenly and generate excessive heat. When using coarse or medium-grade stones, leave sufficient metal so that all stone marks may be removed with the fine stones you use for finishing in order to provide for proper clearance.
2. During the honing process, thoroughly clean the cylinder bore. Check for a correct fit of the piston you select for the individual cylinder.
3. When honing to eliminate taper in the cylinder, make full strokes of the hone in the cylinder. Repeatedly check the measurement at the top, the middle and the bottom of the bore.

Notice: Handle the pistons with care. Do not force the pistons through the cylinder until you hone the cylinder to the correct size. The piston can be distorted through careless handling.

4. When finished honing a cylinder bore to fit a piston, move the hone up and down at a sufficient speed to obtain very fine, uniform surface finish marks in a cross hatch pattern at 45-65 degrees.
5. The finish marks should be clean but not sharp. The finish marks should be free from imbedded particles and torn or folded metal.
6. By measuring the piston to be installed at the sizing point specified and by adding the average of the clearance specification, you can determine the finish hone cylinder measurement. Refer to Engine Mechanical Specifications. Measure the block and the piston at normal room temperature.
7. True up the refinished cylinder bores to have less than the specified out-of-round or taper. You must final hone each bore in order to remove all stone or cutter marks and in order to provide a smooth surface.
8. For piston-to-bore tolerance specifications, Refer to Engine Mechanical Specifications.
9. After final honing and before the piston is checked for fit, clean the bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material will wear the new rings, the cylinder bores and the bearings lubricated by the contaminated oil. After you wash the bore, brush the dry bore clean with a power-driven fiber brush.
10. Permanently mark the piston for the cylinder to which the piston has been fitted.
11. Apply clean engine oil to each bore in order to



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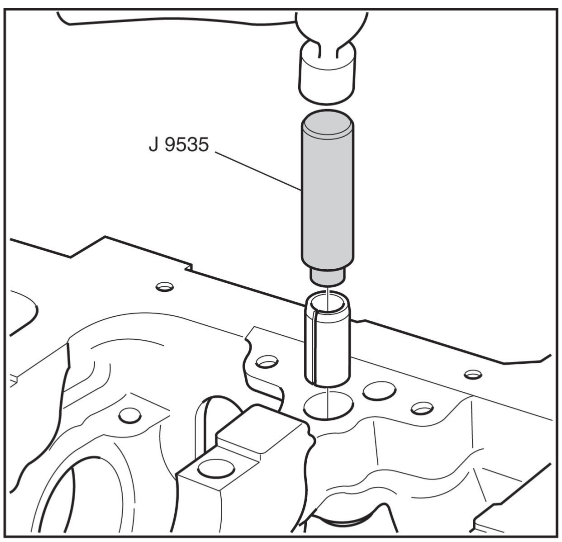
Distributor Lower Bushing and Thrust Washer Installation

Tools Required

- J 9535 Distributor Lower Bushing Installer

1. Use the J 9535 in order to drive the thrust washer (if removed) into the cylinder block.
2. Use the J 9535 with the driver-bolt in the driver handle.



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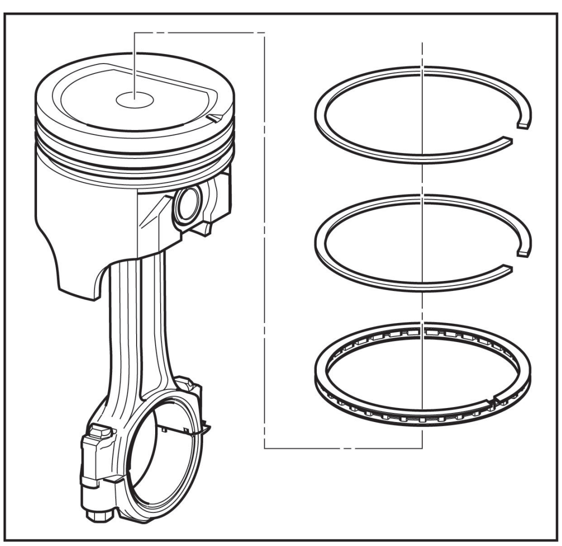
3. Install the driver into the new bushing from the large inside diameter.
4. Drive the new bushing into the cylinder block until the J 9535 bottoms against the cylinder block.



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Piston and Connecting Rod Disassemble

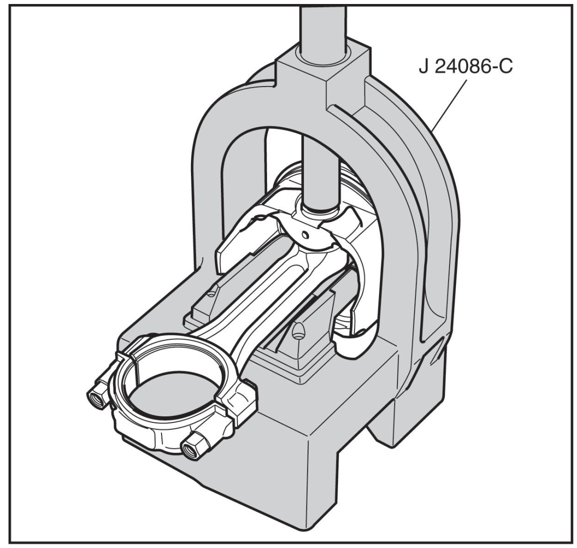
Tools Required

- J 24086-C Piston Pin Removal Set

1. Remove the piston rings from the pistons.

2. Remove the pin from the piston.

Notice: After the J 24086-C Installer bottoms on the support assembly, do not exceed 34,475 kPa (5000 psi) or the tool may be damaged.



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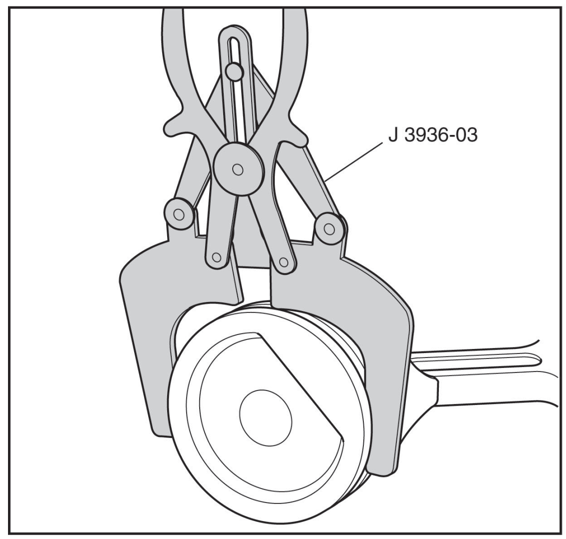
Piston and Connecting Rod Clean and Inspect

1. Clean the piston ring grooves with a groove cleaner.



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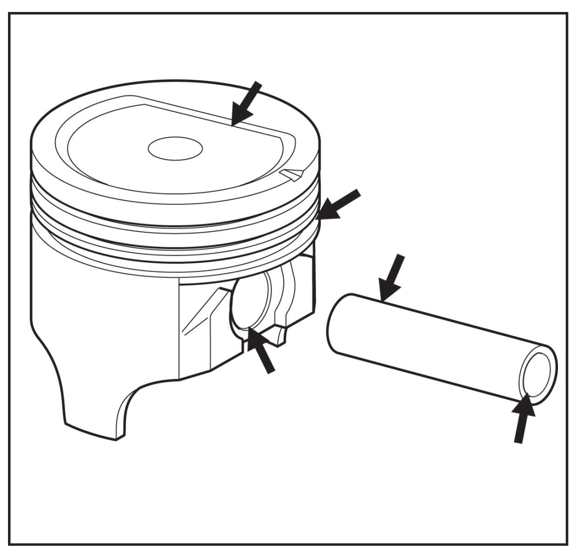
Caution: Wear safety glasses in order to avoid eye damage.

2. Clean the connecting rod in cleaning solvent.
3. Clean the varnish from the piston skirts and the pins with cleaning solvent
4. Dry the components with compressed air.
5. Do not use a wire brush in order to clean any part of the piston.
6. Clean the piston oil ring holes and the slots.
7. Inspect the connecting rod for twisting, nicks and cracks. Replace any damaged connecting rods.
8. Inspect the pistons for the following conditions:
   - Cracked ring lands, skirts or pin bosses.
   - Nicks or spurs in the grooves that may cause binding.
   - Warped or worn ring lands.
   - Scuffed or damaged skirts.
   - Eroded areas at the top of the piston.
   - Worn piston bores and piston pins.
9. Replace pistons that are damaged or show signs of excessive wear.



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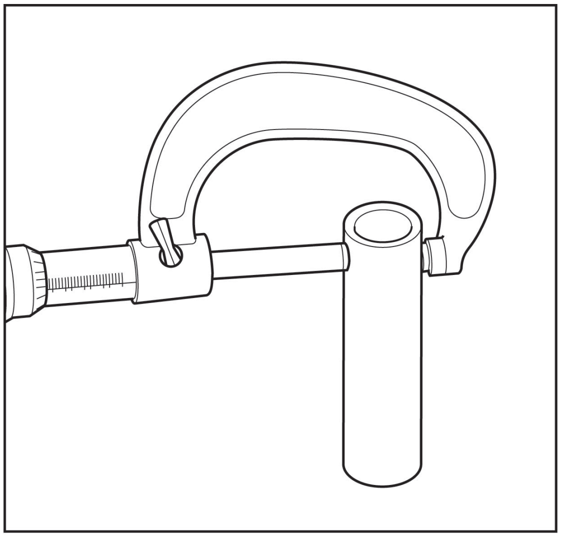
10. Measure the pin bore-to-piston clearance.
    10.1. The piston pin bores and the piston pins must be free of varnish or scuffing when being measured.
    10.2. Use a micrometer in order to measure the piston



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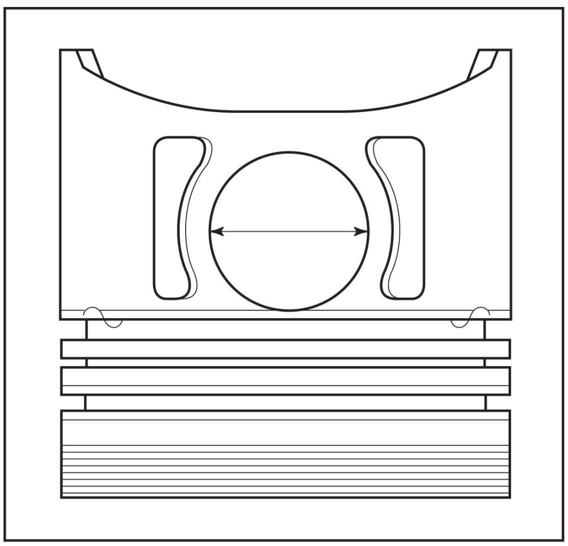
    10.3. Use an inside micrometer in order to measure the piston pin bore. Replace the piston and piston pin if the clearance is in excess of 0.0254 mm (0.001 in).
    10.4. Match the piston and piston pin. Do not service separately.



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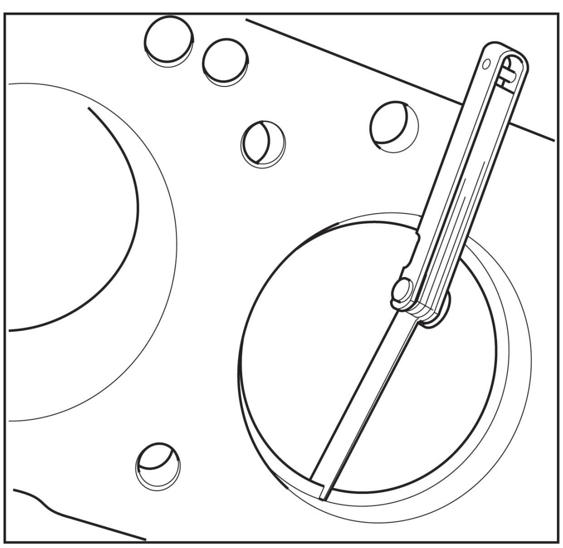
11. Measure the piston compression ring end gap.

Important: Fit each compression ring to the cylinder in which it will be used.

    11.1. Place the compression ring into the cylinder bore.
    11.2. Push the compression ring into the cylinder bore approximately 6.5 mm (0.25 in) above the ring travel. The ring must be square to the cylinder wall.
    11.3. Use a feeler gauge in order to measure the end gap.
    11.4. Select another size ring set if the end gap exceeds



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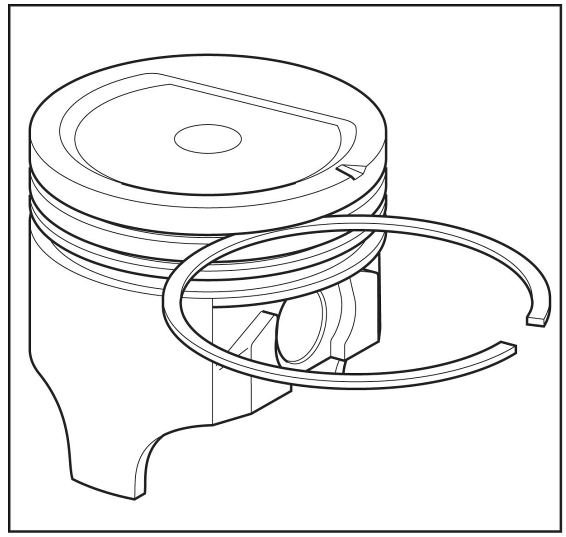
12. Measure the piston ring side clearance.
    12.1. Roll the piston ring entirely around its ring groove on the piston.
    12.2. Dress the groove with a fine cut file if the ring groove causes binding.
    12.3. Replace the piston ring if a distorted piston ring causes binding.



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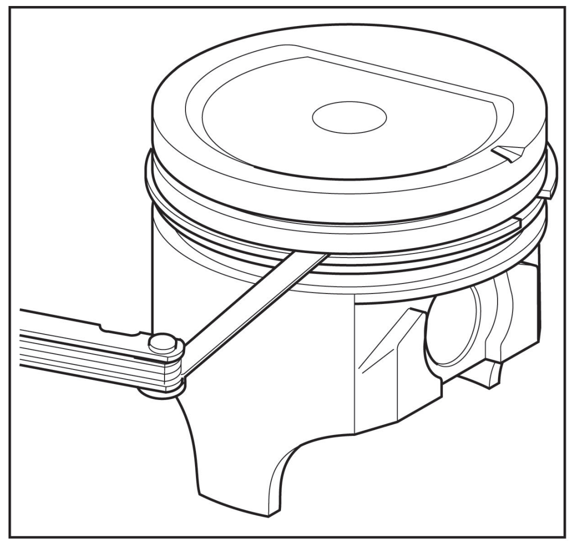
    12.4. Use a feeler gauge in order to measure the side clearance of the piston ring and groove.
    12.5. Try another piston ring if the side clearance is too small.



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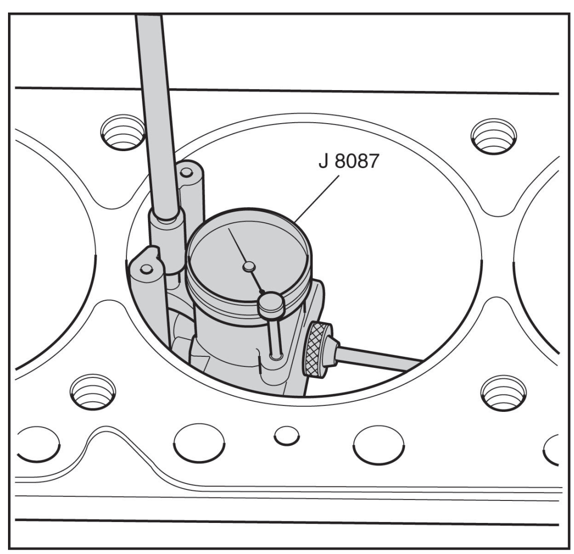
Piston Selection

Important: Measurements of all components should be taken with the components at normal room temperature.

For proper piston fit, the engine block cylinder bores must not have excessive wear or taper.

A used piston and pin set may be reinstalled if, after cleaning and inspection, they are within specifications.

1. Inspect the engine block cylinder bore. Refer to Cylinder Block Clean and Inspect.
2. Inspect the piston and piston pin. Refer to Piston and Connecting Rod Clean and Inspect.
3. Use a boring gauge in order to measure the cylinder bore diameter at a point of 66 mm (2.5 in) from the top of the cylinder bore.



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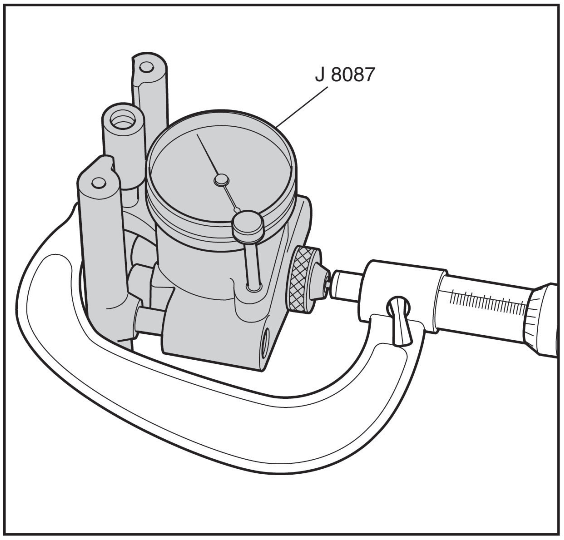

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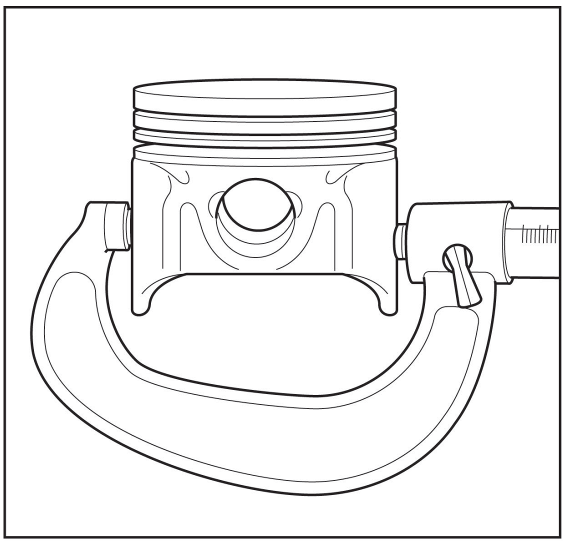
4. Measure the bore gauge with a micrometer and record the reading.



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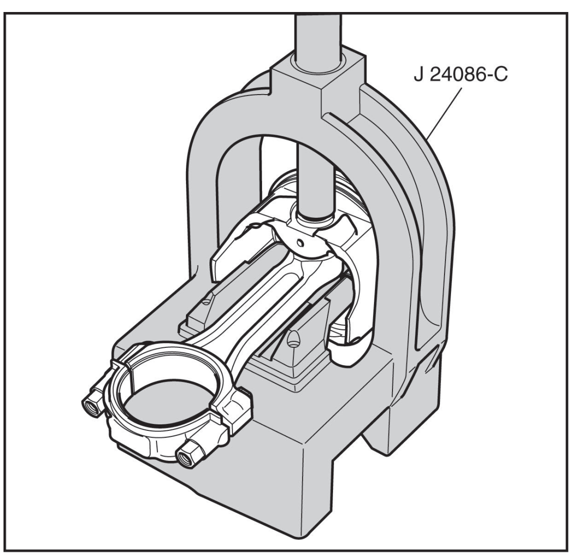
5. With a micrometer or caliper at a right angle to the piston, measure the piston 11 mm (0.433 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance, Refer to Engine Mechanical Specifications.
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances. If the proper fit cannot be obtained, the cylinder bore may require boring or honing. Refer to Cylinder Boring and Honing.
9. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation to the proper cylinder.



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Piston and Connecting Rod Assemble

Tools Required

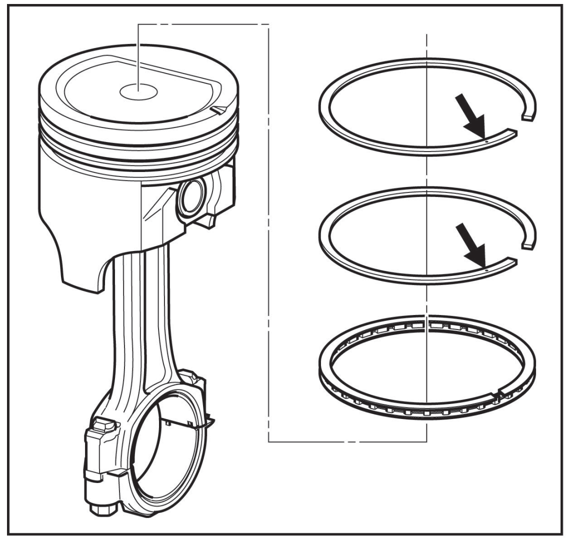
- J 24086-C Piston Pin Removal Set

Important: When assembling the piston and connecting rod, the flange or the heavy side on the connecting rod must face toward the front of the piston (stamped arrow in top of the piston head).

1. Install the piston pin and connecting rod assembly.
   1.1. Lubricate the piston pin holes in both the piston and the connecting rod assembly.
   1.2. Press the piston pin into the piston and connecting rod assembly using the J 24086-C.
   1.3. Inspect for freedom of movement of the piston on

2. Install the piston rings onto the piston.

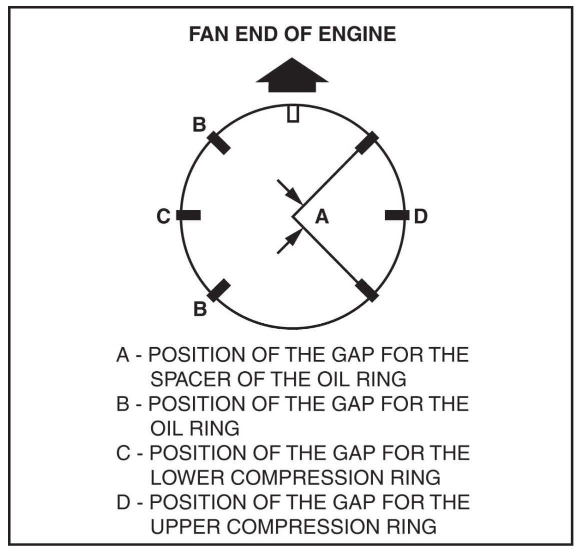
The marked side of the piston rings must face toward the top of the piston.



VE123-3L

VE123-3L

3. Use the following procedure in order to locate the piston ring gaps:
   - 3.1. Install the oil ring spacer in groove and insert anti-rotation tang in oil hole.
   - 3.2. Hold the spacer ends together and install lower oil ring rail with the gap properly located.
   - 3.3. Install the upper oil ring rail with the gap properly located.
   - 3.4. Flex the oil ring assembly to make sure the rings are free.
   - 3.5. Install the lower compression ring.
   - 3.6. Install the upper compression ring.



VE074-3L

VE074-3L

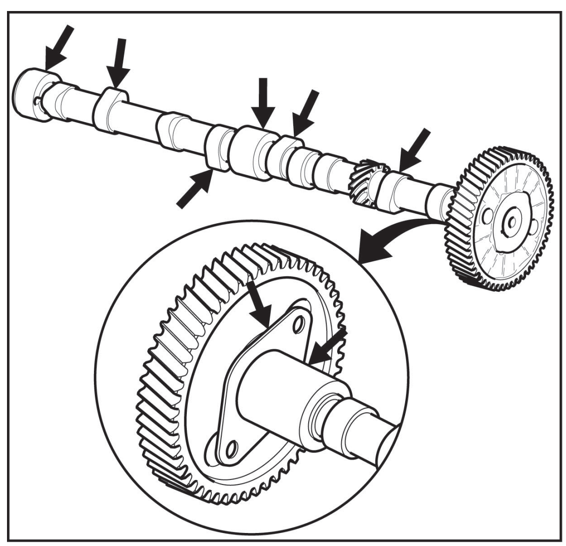
Camshaft and Bearings Clean and Inspect

Tools Required

- J 7872 Magnetic Base Indicator Set

Caution: Wear safety glasses in order to avoid eye damage.

1. Clean the camshaft in solvent.
2. Dry the camshaft with compressed air.
3. Inspect the camshaft bearing journals for scoring or excessive wear.
4. Inspect the camshaft valve lifter lobes for scoring or excessive wear.
5. Inspect the camshaft retainer plate for wear.



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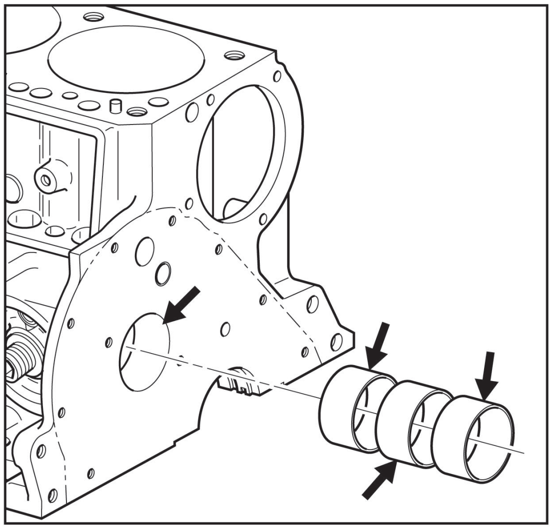

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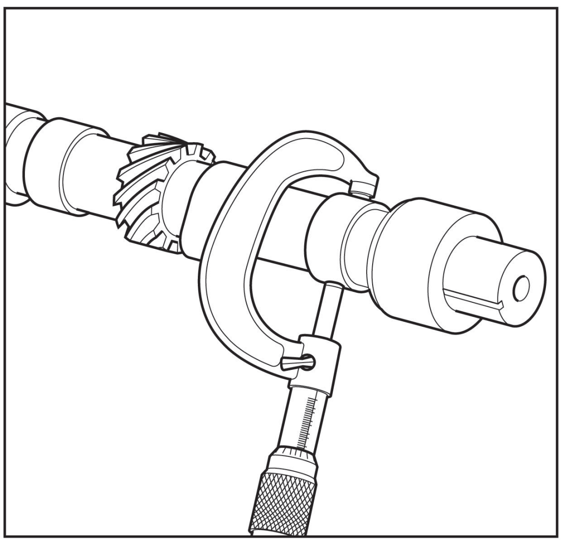
6. Inspect the camshaft bearings for proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in their engine block bearing bores.
7. Inspect the camshaft bearings for excessive wear or scoring. Bearings with excessive wear or scoring must be replaced.



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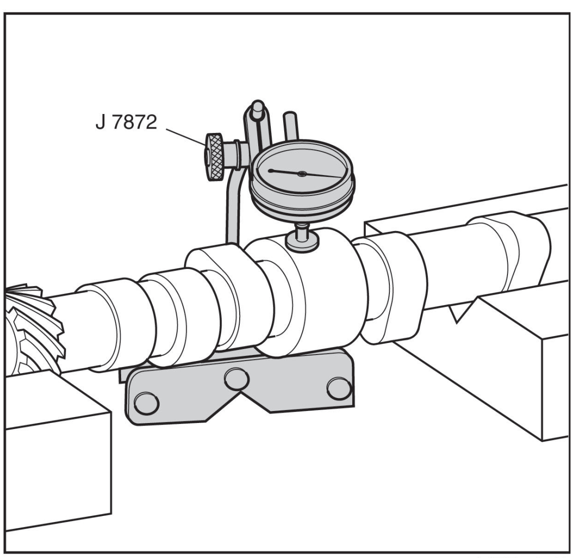
8. Measure the camshaft for out-of-round, taper or undersize with a micrometer. Refer to Engine Mechanical Specifications.



VEO78-3L
VE078-3L

9. Support the camshaft front and rear journals on V-blocks.
10. Measure the camshaft run-out at the intermediate journal with J 7872. Refer to Engine Mechanical Specifications.
11. Replace camshaft if measurements are not within specifications.

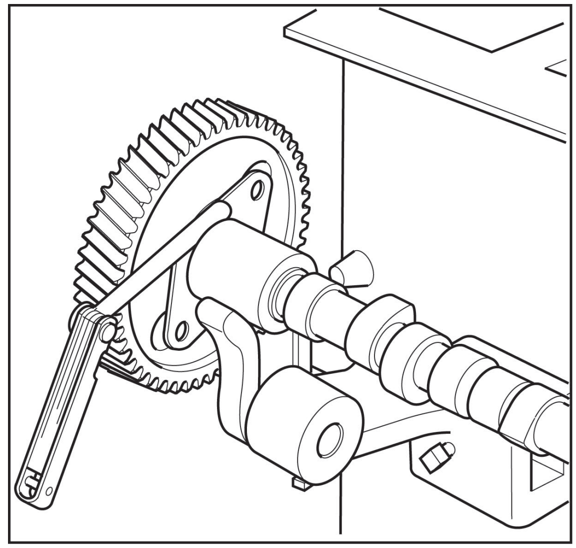
Camshaft Sprocket and Retainer Removal and Installation

Removal

Tools Required

- J 791 Camshaft Sprocket Remover

1. If the inspection indicated that the camshaft, gear and retainer were in good condition, the camshaft end play should be checked. Refer to Engine Mechanical Specifications.



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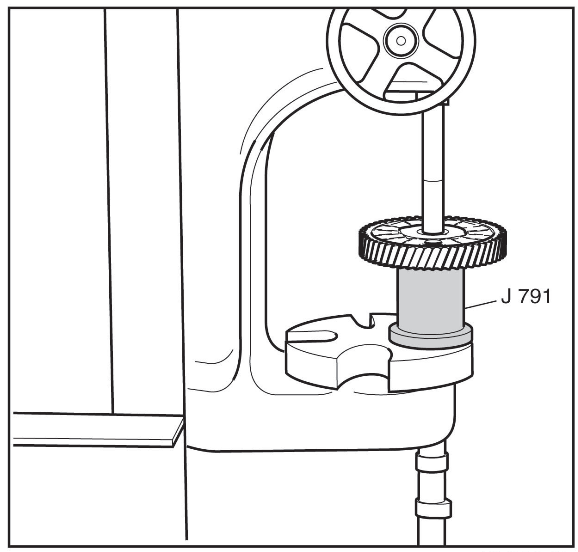
VE079-3L

2. If the inspection indicated that the camshaft, gear or retainer should be replaced, the gear must be removed from the camshaft as follows:
   2.1. Place the camshaft through the J 791.
   2.2. Place the end of the remover on the table of a press and press the camshaft out of the gear.

Important:

The retainer must be positioned so that the woodruff key in the camshaft does not damage it when the camshaft is pressed out of the gear. Also, support the hub of the gear or the gear will be seriously damaged.

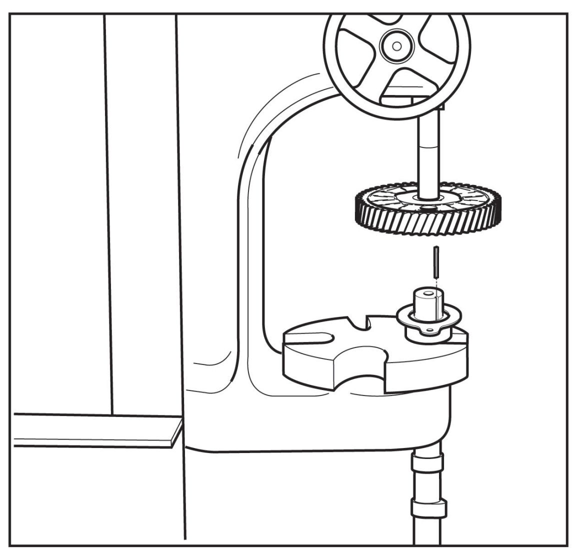


VE080-3L

VE080-3L

Installation

1. Install the camshaft sprocket, retainer and gear spacer ring to the camshaft as follows:
   1.1. Firmly support the camshaft at the back of the front journal in an arbor press.
   1.2. Place the gear spacer ring and retainer over the end of the camshaft and install the woodruff key in the camshaft keyway.
   1.3. Align the sprocket keyway with the woodruff key in the camshaft and press it onto the shaft until it bottoms against the gear spacer ring.



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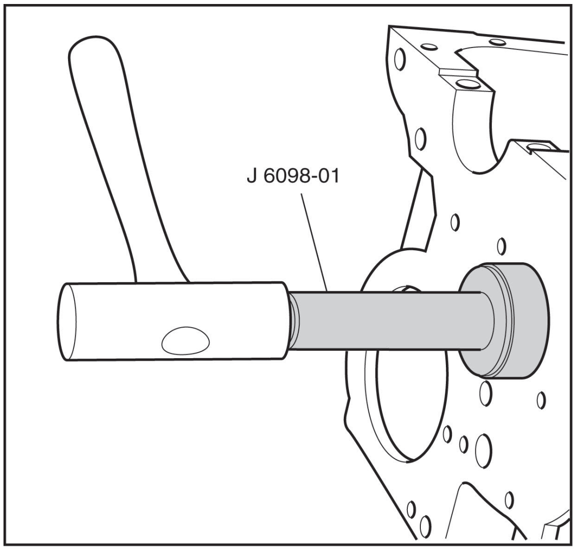

VE055-3L
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Camshaft Bearing Installation

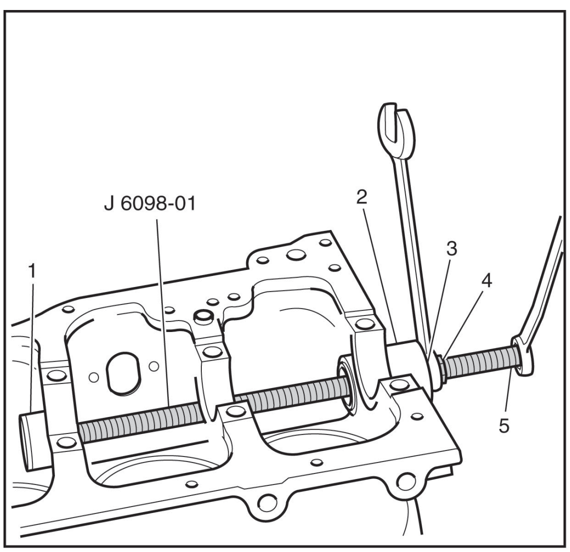
Tools Required

- J 6098-01 Camshaft Bearing Installer

Important:

- A loose camshaft bearing may be caused by an enlarged, out of round or damaged engine block bearing bore.
- The outer front and rear camshaft bearings must be installed first. These bearings serve as guides for the tool pilot and help center the inner bearings during the installation process.
- The camshaft bearing oil holes must align with the oil galleys in the engine block. An improperly aligned camshaft bearing oil galley hole will restrict oil flow to the bearing and camshaft journal.

1. Use the J 6098-01 in order to install the front and rear camshaft bearings:
   1.1. Assemble the bearing tool to the driver handle.
   1.2. Align the oil holes.
   1.3. Drive the front and the rear camshaft bearings inward toward the center of the engine block.



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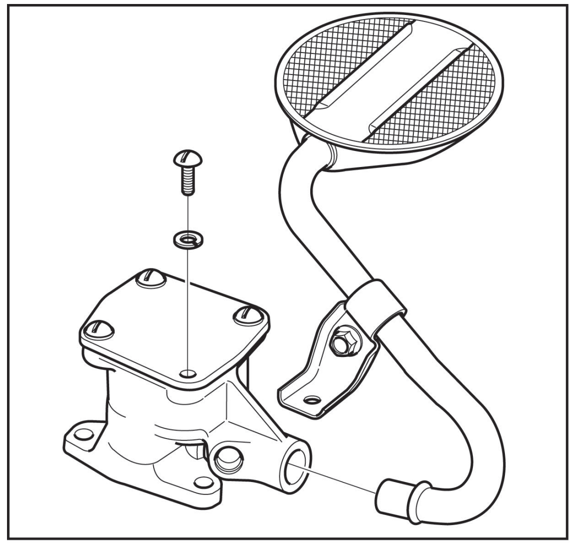
VE054-3L

2. Use the J 6098-01 in order to install the inner camshaft bearings. Repeat the following steps for each of the inner camshaft bearings:
   2.1. With the nut (4) and the thrust washer (3) installed to the end of the puller screw threads, index the pilot in the camshaft front bearing and install the puller screw through the pilot (2).
   2.2. Index the camshaft bearing in the bore. Make sure you align the oil galley holes.
   2.3. Install the puller screw through the bearing bore and bearing to be installed and assemble bearing tool (1) to the puller screw with the shoulder toward the bearing. Make sure that enough threads are engaged.
   2.4. Using two wrenches, hold the puller screw (5) while you turn the nut in order to draw the bearing into the bore. When the bearing has been pulled into the bore, remove the bearing tool and the puller screw and check the alignment of the bearing oil hole to the bore oil hole.
3. Install a new camshaft rear bearing hole plug. Coat the plug outside diameter with GM P/N 1052080 sealant, or the equivalent.

Oil Pump Disassemble

1. If necessary, remove the oil pump screen.
    - The oil pump screen has a press fit in to the pump cover.
    - Do not remove the screen from the pipe. The pipe and



VE082-3L

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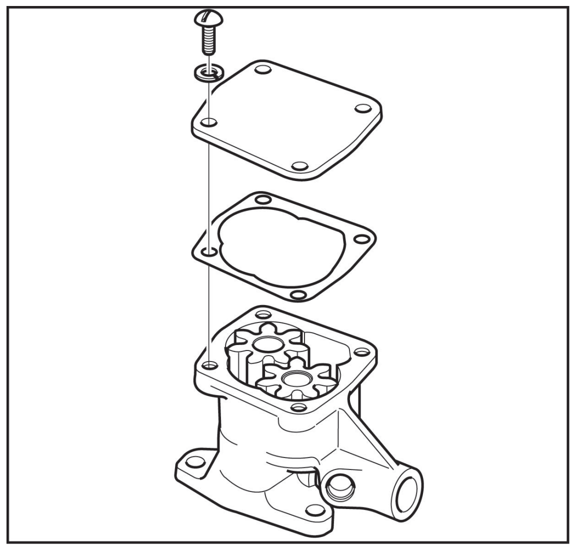
2. Remove the cover bolts.
3. Remove the pump cover.



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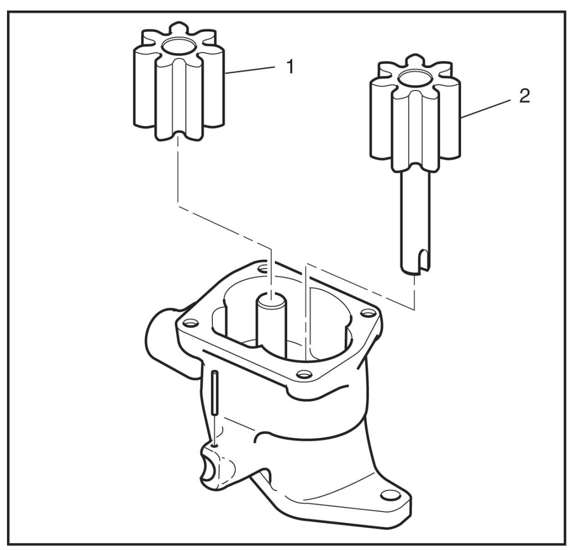
4. Remove the drive gear (2) and the driven gear (1). Matchmark the gear teeth for assembly.



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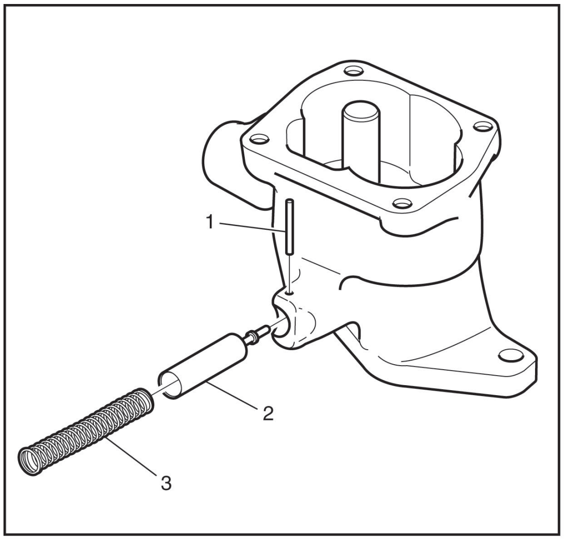

VE085-3L
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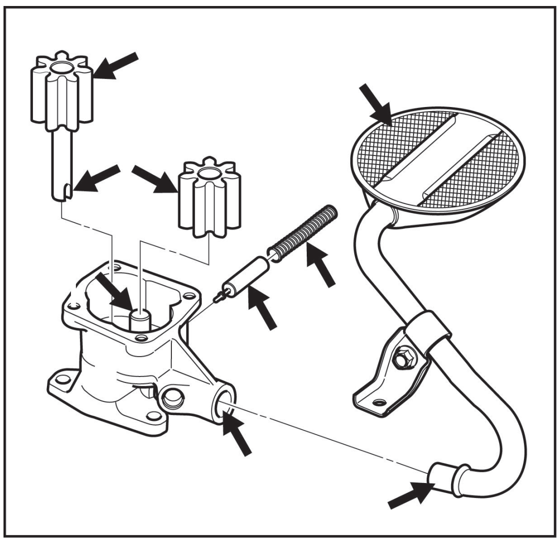
5. Remove the following items:
    - The retaining pin (1).
    - The pressure relief valve spring (3).
    - The pressure relief valve (2).



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Oil Pump Clean and Inspect

Important: The internal parts of the oil pump are not serviced separately. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

The oil pump pipe and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the pipe and screen assembly.

1. Clean all of the parts in cleaning solvent.

Caution: Wear safety glasses in order to avoid eye damage.

2. Dry the parts with compressed air.
3. Inspect the following areas:
    - The oil pump housing and cover for cracks, scoring, casting imperfections and damaged threads.
    - The drive gear shaft (If the shaft is loose in the oil pump housing, replace the oil pump).
    - The pressure relief valve for scoring and sticking (Burrs may be removed with a fine oil stone).
    - The pressure relief valve spring for loss of tension.
    - The oil pump screen for broken wire mesh or looseness (If the pipe is loose or has been removed from the screen, the oil pump screen must be replaced).
    - The gears for chipping, galling and wear.

      Important: If the drive gear and driveshaft are worn, replace the entire oil pump.

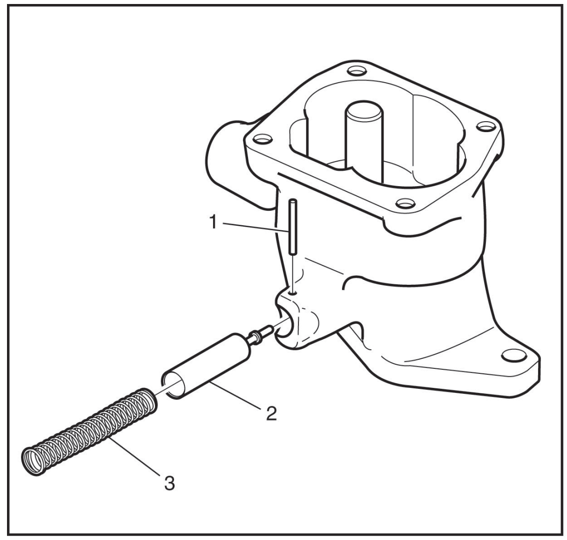
Oil Pump Assemble

Tools Required

- J 21882 Oil Suction Pipe Installer

Important: Replace the pressure relief valve spring when you reuse the oil pump.

1. Install the following items:
   - The pressure relief valve (2).
   - The pressure relief valve spring (3).
   - The retaining pin (1).



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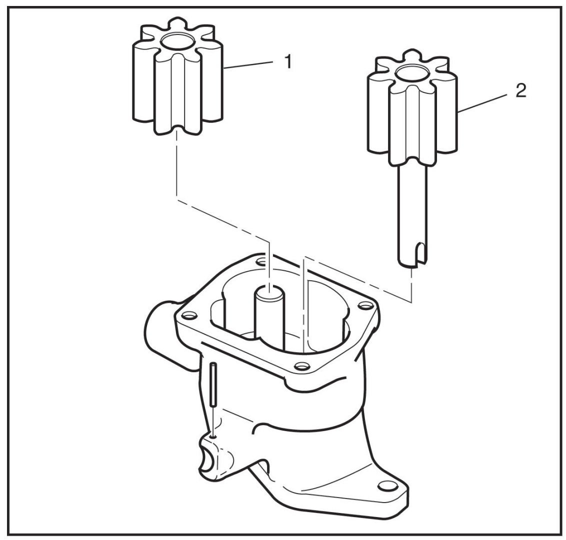
2. Coat the drive gear, the driven gear and the housing gear surfaces with clean engine oil.
3. Install the drive gear (2) and the driven gear (1) into the pump body. Align the matchmarks on the gears. Install the smooth side of the gear toward the pump cover.



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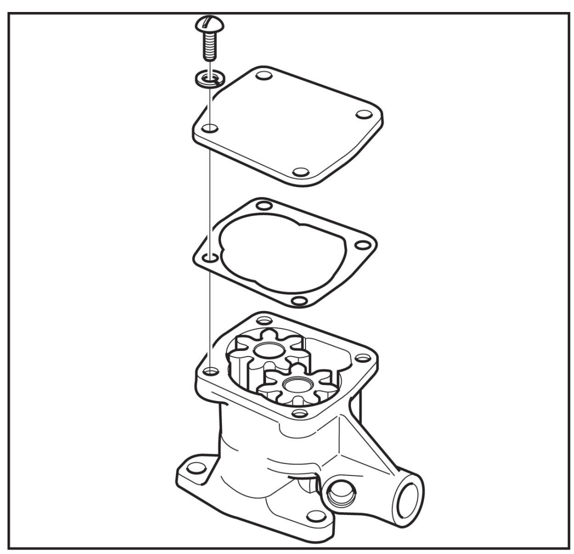
4. Install the pump cover.
5. Install the cover bolts.

Tighten

Tighten the bolts to 8 N•m (71 lb in).



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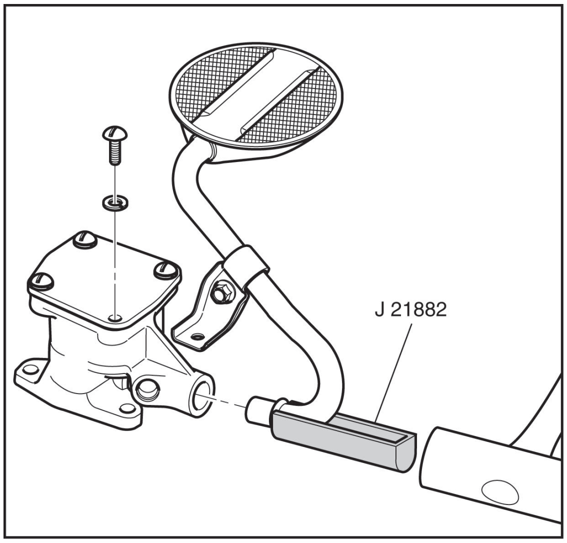

VE087-3L
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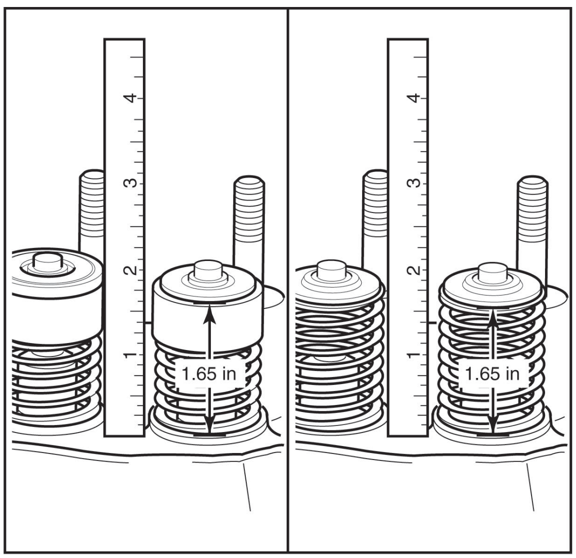
6. Inspect the pump for smoothness of operation by turning the oil pump driveshaft by hand.
7. Install the oil pump screen.
   7.1. If removed, replace the oil pump screen. The oil pump screen must have a good press fit into the oil pump body.
   7.2. Mount the oil pump in a soft jawed vise.
   7.3. Apply sealer to the end of the pipe.
   7.4. Use the J 21882 and a soft-faced hammer in order to tap the oil pump screen into the pump body. The screen must align parallel with the bottom of the oil pan when it is installed.



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VE088-3L

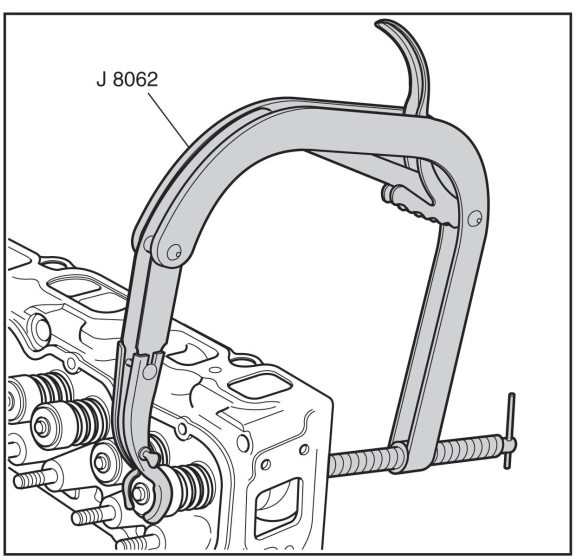
Cylinder Head Disassemble

Tools Required

- J 8062 Valve Spring Compressor

Important: Mark, organize or sort the cylinder head components for assembly. Return the components to their original location during assembly.

1. Measure the valve spring installed height using a ruler. Measure from the machined surface of the cylinder head to the top of the valve spring cap. Refer to Engine Mechanical Specifications



VE089-3L
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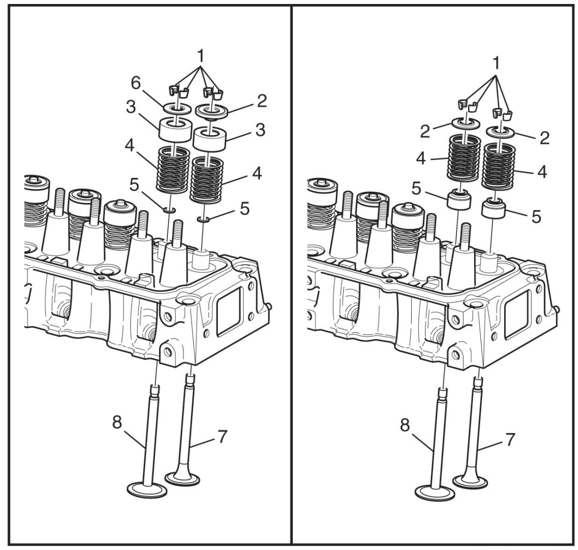
2. Use the J 8062 in order to compress the valve springs.

3. Remove the valve stem keys (1).
4. Remove the cap from the valve spring (2&6).
5. Remove the valve stem oil shield (3).
6. Remove the valve spring (4).
7. Remove the valve stem oil seal (5).
8. Remove the valve (7&8).

Important: Place the valves in a rack in the proper sequence so that you can install them in the same order.



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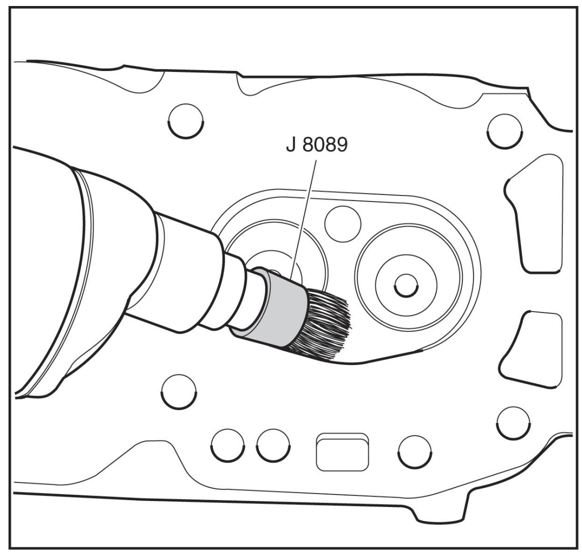
Cylinder Head Clean and Inspect

Tools Required

- J 8089 Carbon Remover Brush
- J 9666 Valve Spring Tester
- J 8001 Dial Indicator

Caution: Wear safety glasses in order to avoid eye damage.

1. Use the J 8089 in order to clean the carbon from the combustion chambers and the valve ports. Be careful not to scuff the chamber.
2. Clean the following areas:
   - 2.1. The carbon and the sludge from the valve pushrods and the valve rocker arms.
   - 2.2. The valve stems and heads on a buffing wheel.
   - 2.3. The cylinder head and engine block gasket surfaces.
   - 2.4. The bolt holes and threads in the cylinder head and



VE091-3L
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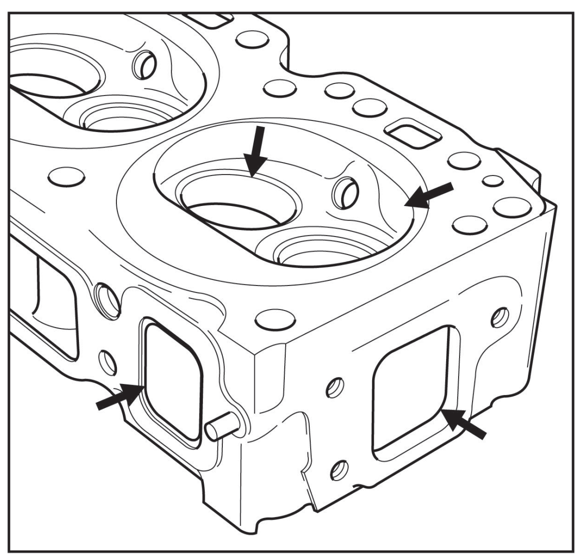
3. Inspect the following areas:
   - 3.1. The cylinder head for cracks in the exhaust ports and the combustion chambers.
   - 3.2. The cylinder head for external cracks in the water chamber.
   - 3.3. The valves for burned heads, cracked faces or damaged stems.



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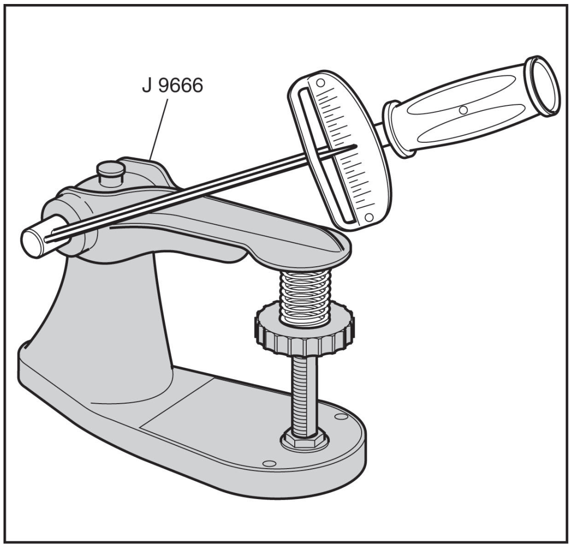

VE093-3L
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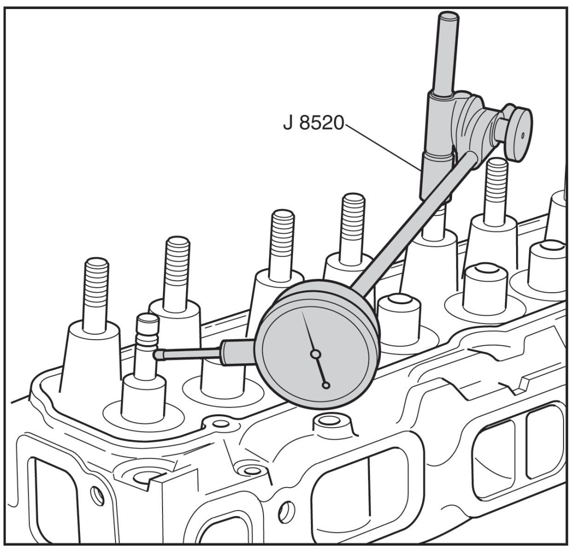
4. Use the J 9666 and a flex bar torque wrench in order to measure the valve spring pressure.
   - Replace the valve spring if the spring pressure is less than 444 N (100 lb.) at 40.9 mm (1.61 in). Refer to Engine Mechanical Specifications.



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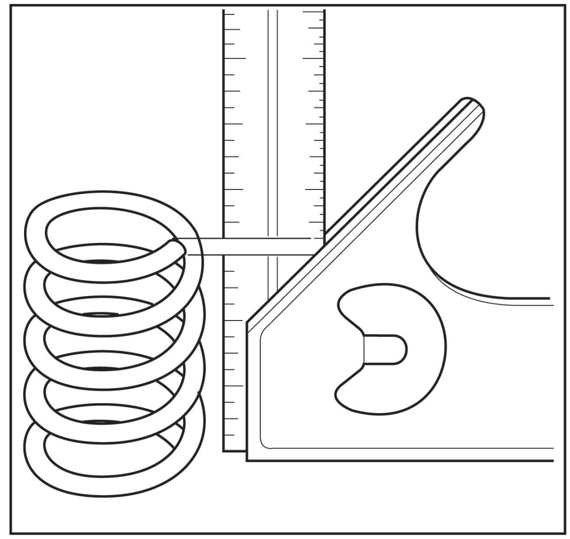
5. Excessive valve stem-to-bore clearance will cause excessive oil consumption and may cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
   - 5.1. Install the valve into the guide.
   - 5.2. Install the J 8520 onto the cylinder head.
   - 5.3. Locate the indicator so that the movement of the valve stem from side to side (crosswise to the cylinder head) will cause a direct movement of the indicator stem.
   - 5.4. The indicator stem must contact the side of the valve stem just above the valve guide.
   - 5.5. Drop the valve head about 1.6 mm (0.0064 in) off the valve seat.
   - 5.6. Use light pressure and move the valve stem from side to side in order to obtain a clearance reading.
   - 5.7. If the valve stem to guide clearance is excessive, the valve must be replaced and/or the guide must be repaired to obtain the proper clearances. Refer to Engine Mechanical Specifications.

6. Inspect the valve springs for squareness.



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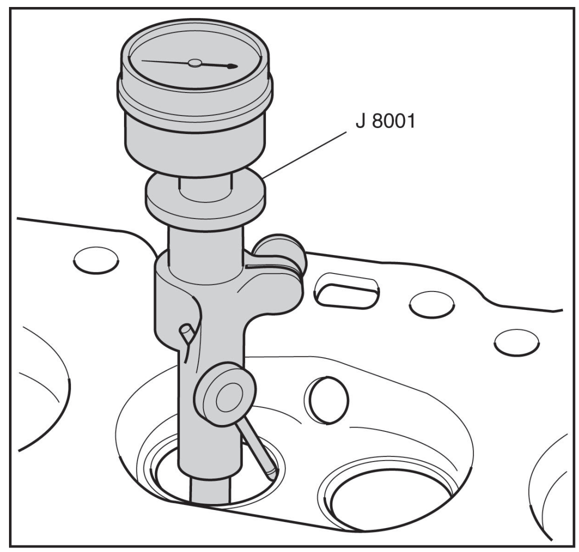
7. Measure the valve seat runout.
   - Use the J 8001 in order to check the valve seat runout.
   - The valve seats should be concentric to within 0.0508



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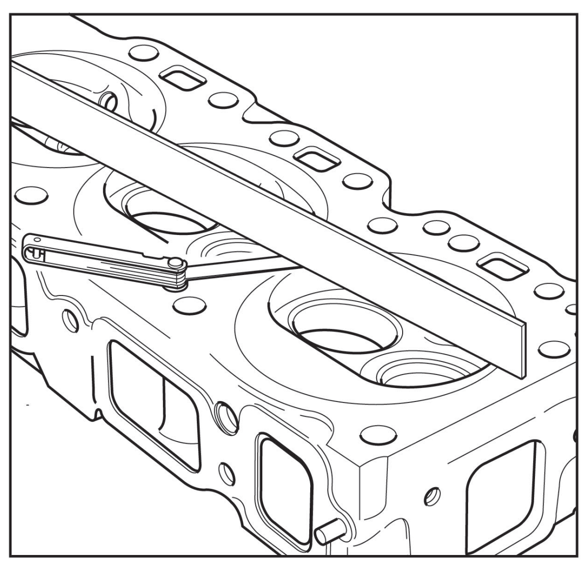
8. Measure the cylinder head for warpage with a straight edge and a feeler gauge. A cylinder head with excessive warpage must be repaired or replaced. Refer to Engine Mechanical Specifications.



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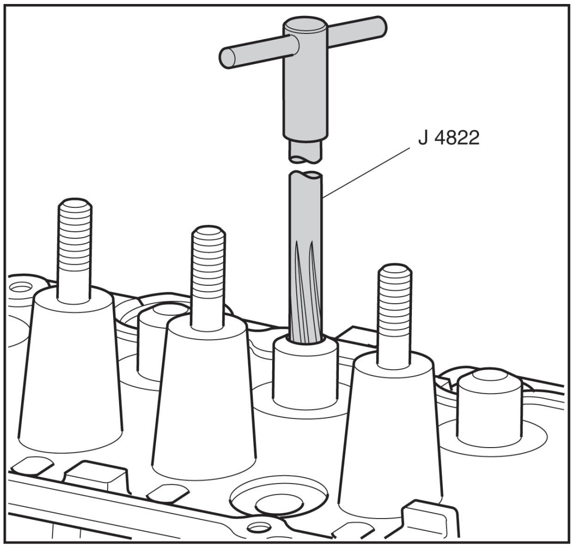
Valve Guide Reaming/Valve and Seat Grinding



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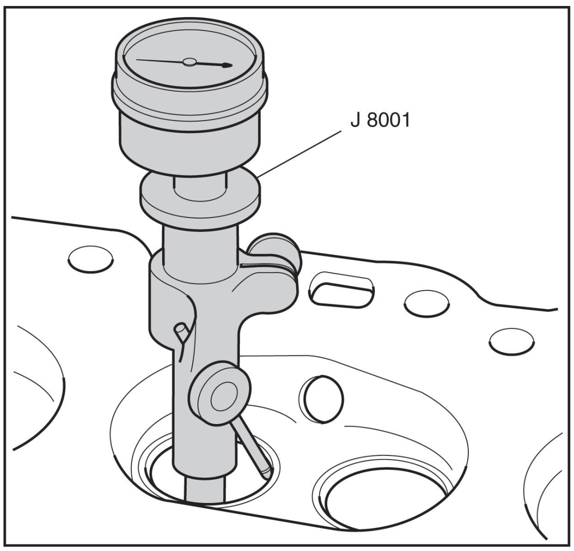
1. Ream the valve guides for oversize valves if the clearance exceeds the specifications.
2. Service valves are available in the standard and 0.038 mm (0.015 in).
3. Ream the valve guide bores for the service valves as necessary.



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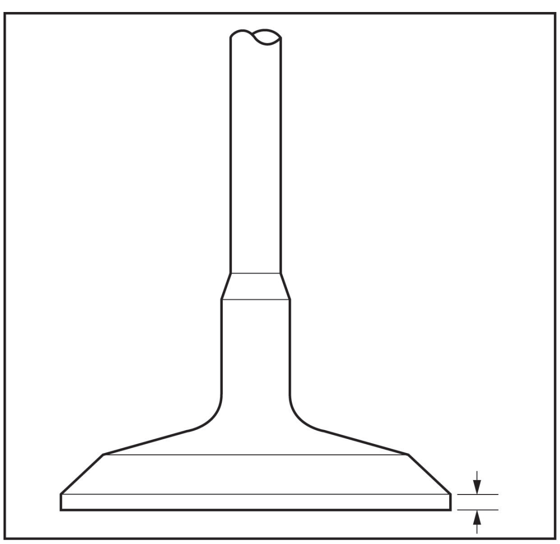
4. Reconditioning the valve seats is very important.
5. Recondition the valve seat after reaming the valve guide bores or installing the new valve guides.
   - The valves must seat perfectly for the engine to deliver optimum power and performance.
   - Cooling the valve heads is another important factor. Good contact between each valve and its seat in the cylinder head is necessary to ensure that the heat in the valve head is properly carried away.
   - Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the guide.
   - The valve seats should be concentric to within 0.0508 mm (0.002 in) total indicator reading.



VE099-3L
VE099-3L

6. Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the head and the stem.
   - Replace the valves that show excessive wear or are warped.
   - Replace the valve if the edge of the head is less than 0.8 mm (0.031 in) thick after grinding.
   - Several different types of equipment are available for reconditioning valves and valve seats. Use the manufacturers recommendations of equipment to obtain the proper results.

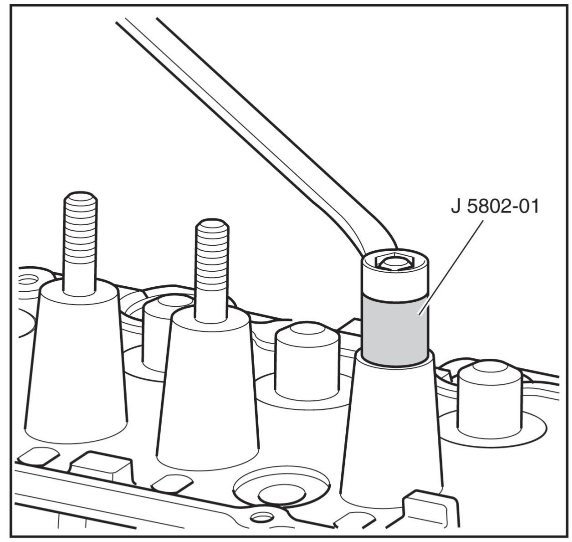
Rocker Arm Stud Removal and Installation

Tools Required

- J 5802-01 Rocker Arm Stud Remover
- J 6880 Rocker Arm Stud Installer

Rocker arm studs with damaged threads or with loose fit in cylinder head should be replaced with new, oversize studs.

1. Remove the old stud by placing J 5802-01 over the stud, installing nut and flat washer and removing the stud by turning out.



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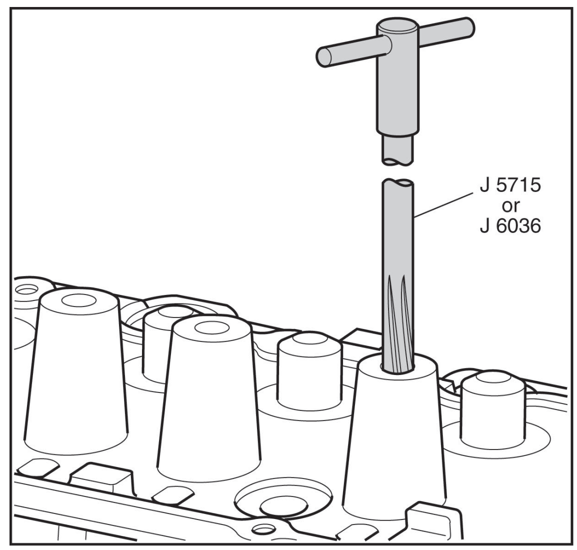
VE100-3L

2. Ream the hole for the oversize stud.

Important: Do not attempt to install an oversize stud without reaming the stud hole.



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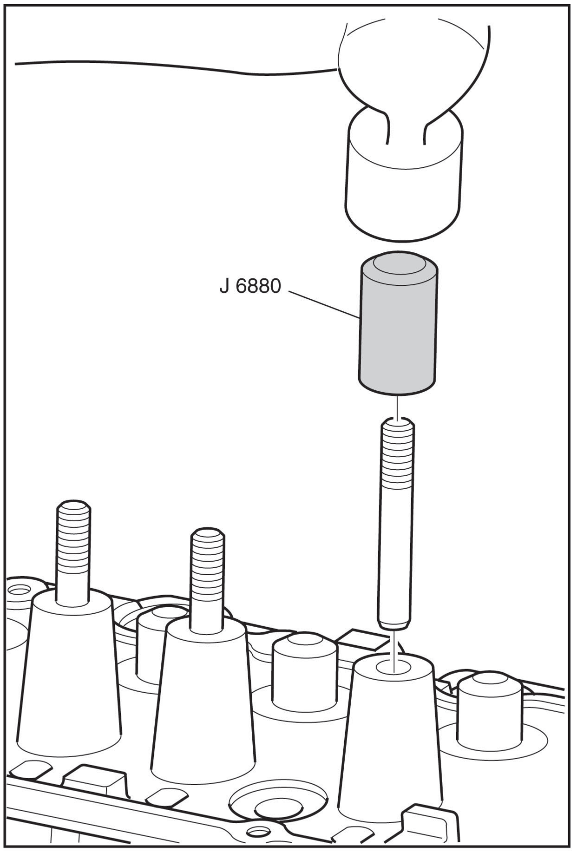

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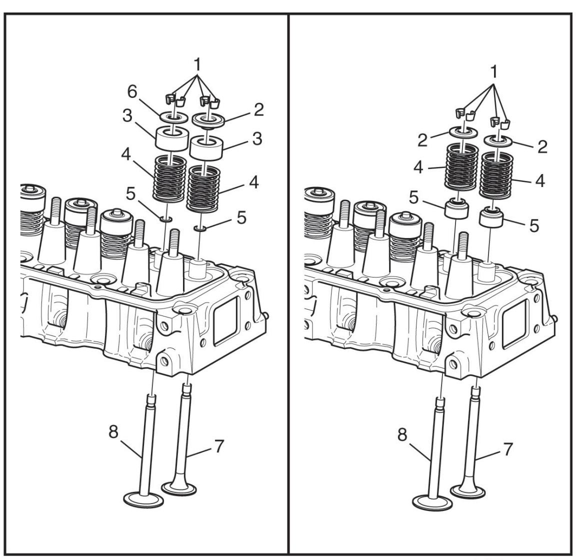
3. Coat the press-fit area of the stud with Perfect Seal.
4. Install the new stud, using J 6880 as a guide.



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Cylinder Head Assemble

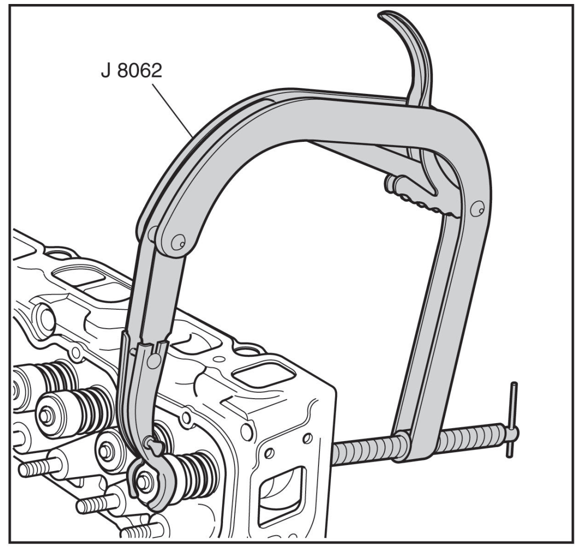
Tools Required

- J 8062 Valve Spring Compressor
- J 42073 Valve Stem Oil Seal Installer

1. Install the valve (7&8) into the proper port.
2. Lubricate oil seal (5) with clean engine oil.
3. Install the oil seal onto the valve stem. MPFI models require the use of J 42073 to install the valve stem seals.
4. Install the valve spring (4).
5. Install the valve stem oil shield (3), some models.
6. Install the cap on the valve spring (2&6).

Caution: Wear safety glasses in order to avoid eye damage.

7. Use the J 8062 in order to compress the valve spring.
8. Install the valve stem keys.
   - 8.1. Use grease to hold the keys in place while disconnecting the J 8062.
   - 8.2. Make sure that the keys seat properly in the upper groove of the valve stem.
   - 8.3. Tap the end of the valve stem with a plastic-faced hammer in order to seat the keys if necessary.



VE089-3L

VE089-3L

Service Prior to Assembly

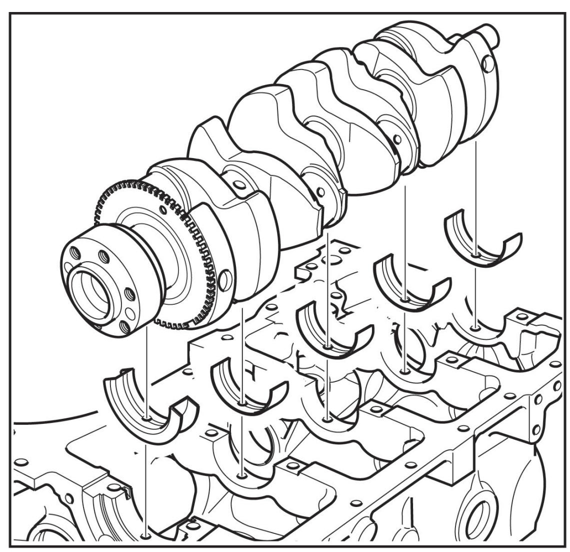
- Dirt or debris will cause premature wear of the rebuilt engine. Clean all components. Refer to Cleanliness and Care.
- Use the proper tools to measure components when checking for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When components are reinstalled into an engine, return the components to their original location, position and direction. Refer to Separating Parts.
- During assembly, lubricate all moving parts with clean engine oil or engine assembly lubricant (unless otherwise specified). This will provide initial lubrication when the engine is first started. Refer to Sealers, Adhesives and Lubricants.

Crankshaft, Bearings and Bearing Cap Installation

Important

- Crankshaft bearing caps must be installed to the proper location and direction.
- When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.
- Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.

1. Install the crankshaft bearings into the engine block and the crankshaft bearing caps.
2. Coat the crankshaft bearings with clean engine oil.
3. Install the crankshaft.



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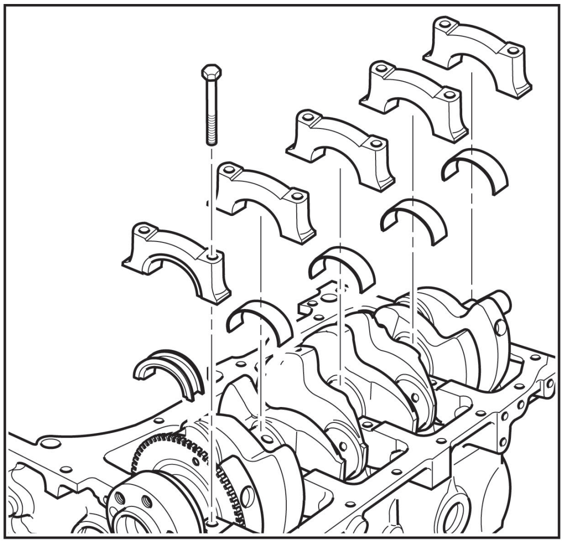
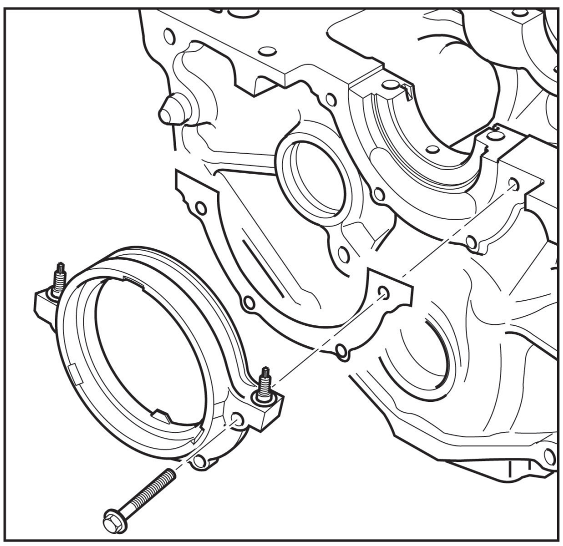


VE045-3L
VE045-3L

4. Install the crankshaft bearing caps with the crankshaft bearings.
5. Be sure that the cap directional arrows point toward the front of the engine block and the cap is in its original position.
6. Install the crankshaft bearing cap bolts.
7. Thrust the crankshaft rearward in order to set and align the thrust bearings and the bearing caps.
8. Thrust the crankshaft forward in order to align the rear faces of the rear crankshaft bearings.

Tighten

Tighten all of the bolts to 85 N•m (63 lb ft).



VE103-3L
VE103-3L

Crankshaft Rear Oil Seal and Housing Installation

Tools Required

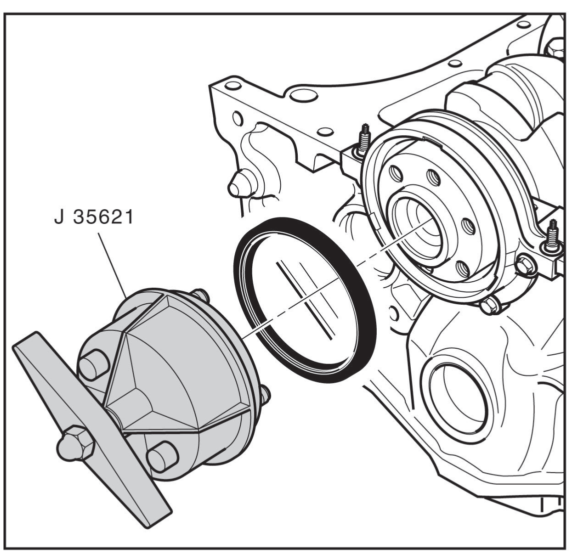
- J 35621 Crankshaft Rear Oil Seal Installer

Important: Always use a new crankshaft rear oil seal and new crankshaft rear oil seal housing gasket when you install the crankshaft rear oil seal housing.

1. Install the new gasket and the crankshaft rear oil seal housing on to the studs.
2. Install the rear oil seal housing nuts and bolts.

Tighten

Tighten the crankshaft rear oil seal housing bolts to 15 N•m (133 lb in).



VE104-3L
VE104-3L

3. Coat the new oil seal entirely with clean engine oil.
4. Install the seal onto the J 35621.
5. Install the J 35621 onto the rear of the crankshaft. Tighten the screws snugly in order to ensure that the seal will be installed squarely over the crankshaft.
6. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing. Tighten the wing nut on the J 35621 until the oil seal bottoms.
7. Remove the J 35621 from the crankshaft rear oil seal housing.

Piston, Connecting Rod and Bearing Installation

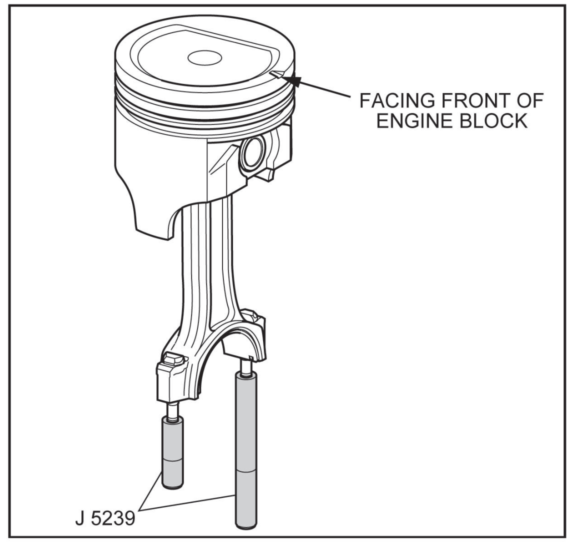
Tools Required

- J 5239 Guide Set
- J 8037 Piston Ring Compressor

Important

- The piston and cylinder bore have been measured and the bore has been sized for the proper clearance. Install the piston and connecting rod assembly into the proper cylinder bore.
- The piston alignment mark MUST face the front of the engine block.

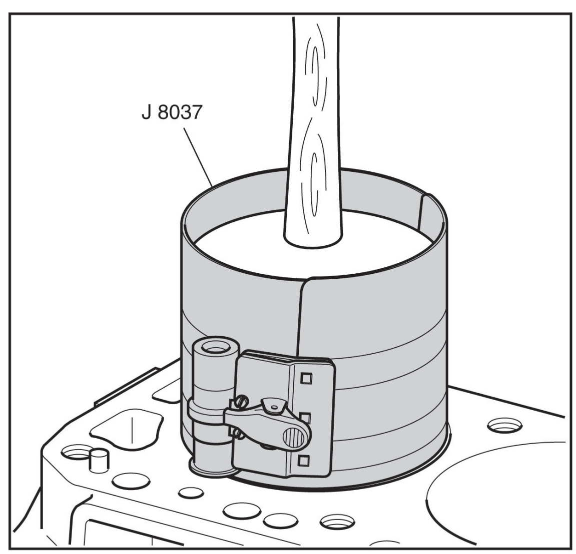
1. Lubricate the following components with clean engine oil:
   - The piston.
   - The piston rings.
   - The cylinder bore.
   - The bearing surfaces.
2. Install the connecting rod bearing into the connecting rod and bearing cap.
3. Install the J 5239 onto the connecting rod.
4. Install the J 8037 or equivalent onto the piston and compress the piston rings.



VE124-3L

VE124-3L

5. Install the piston assembly into its matched bore with the stamped arrow facing forward.
6. Use the J 8037 and the J 5239 and lightly tap the top of the piston with a wooden hammer handle.
   - Hold the J 8037 firmly against the engine block until all of the piston rings enter the cylinder bore.
   - Use the J 5239 in order to guide the connecting rod onto the crankshaft journal.



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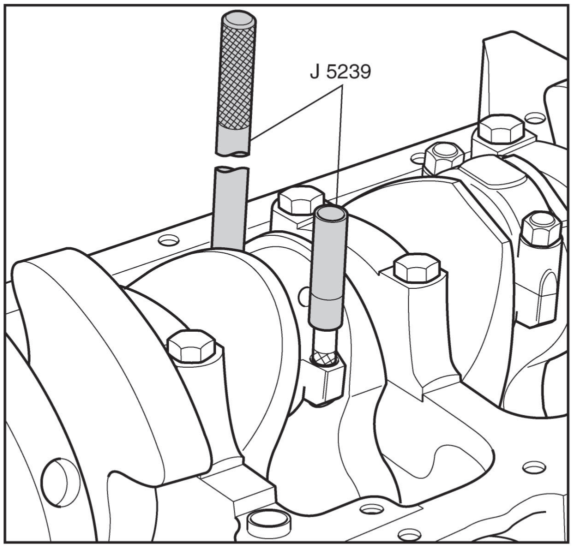

VE038-3L
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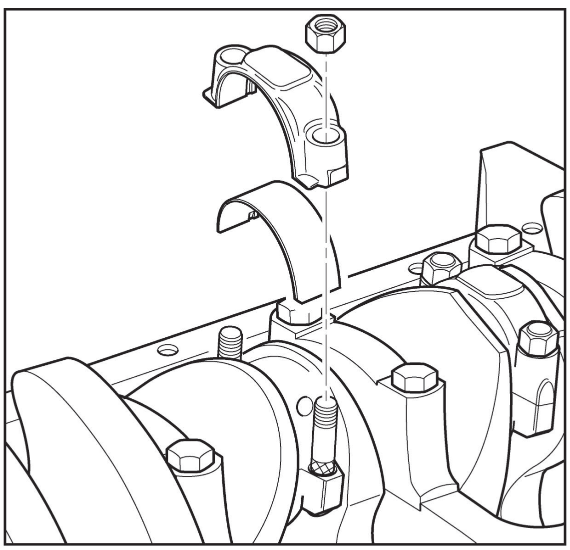
7. Remove the J 5239.



VE037-3L
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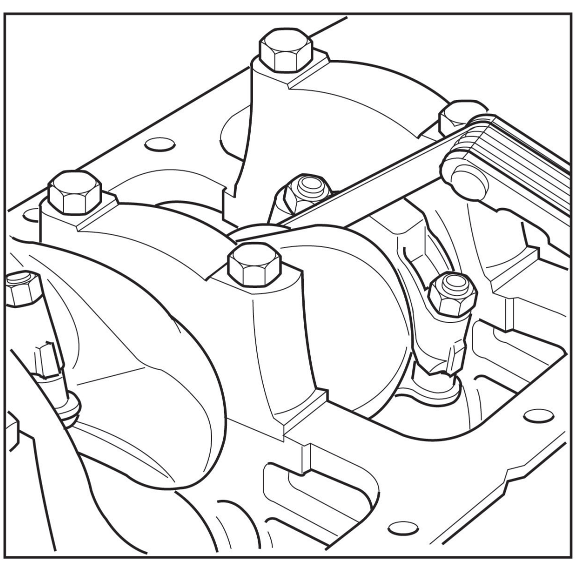
8. Install the connecting rod cap and nuts.

Tighten

Tighten the nuts evenly to 61 N•m (45 lb ft).

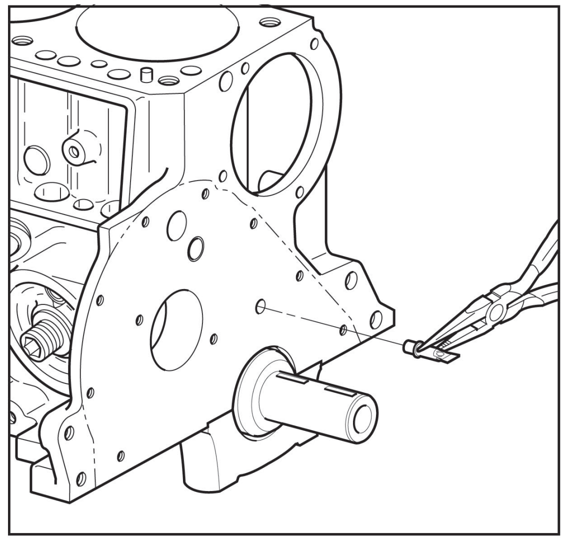


VE106-3L
VE106-3L

8. When all of the connecting rod bearings are installed, tap each connecting rod assembly lightly parallel to the crankpin in order to make sure that they have clearance.
9. Use a feeler gauge or a dial indicator in order to measure the side clearance between the connecting rod caps. Refer to Engine Mechanical Specifications.

Timing Gear Oil Nozzle Installation

1. Drive the new nozzle in place (oil hole facing up) with a suitable light plastic or rubber hammer.



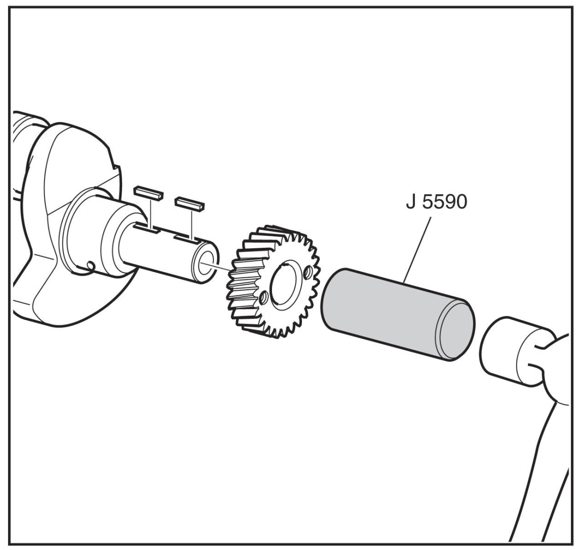
VE127-3L
VE127-3L

Crankshaft Sprocket Installation

Tools Required

- J 5590 Crankshaft Sprocket Installer

1. Install the keys into the crankshaft keyways.
2. Use the J 5590 in order to install the crankshaft sprocket.



VE107-3L
VE107-3L

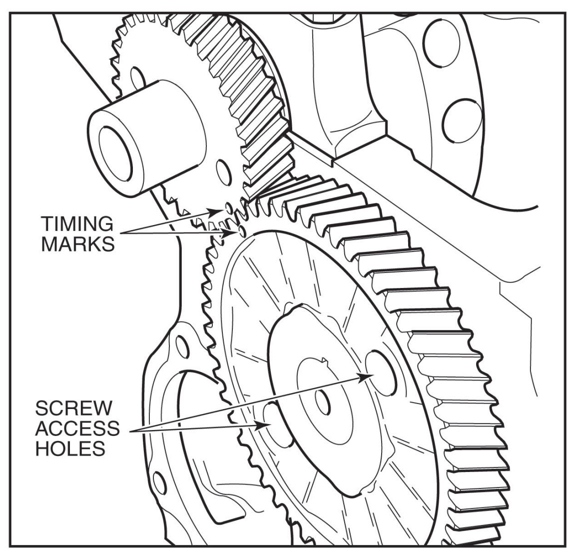
Camshaft Installation

Important: If camshaft replacement is required, the valve lifters must also be replaced.

1. Carefully rotate and install the camshaft into the engine.
2. Install the two camshaft retainer bolts working through the holes in the camshaft sprocket. Be sure to align the camshaft and the crankshaft sprocket alignment marks.

Tighten

Tighten the camshaft retainer bolts to 9 N•m (80 lb in).



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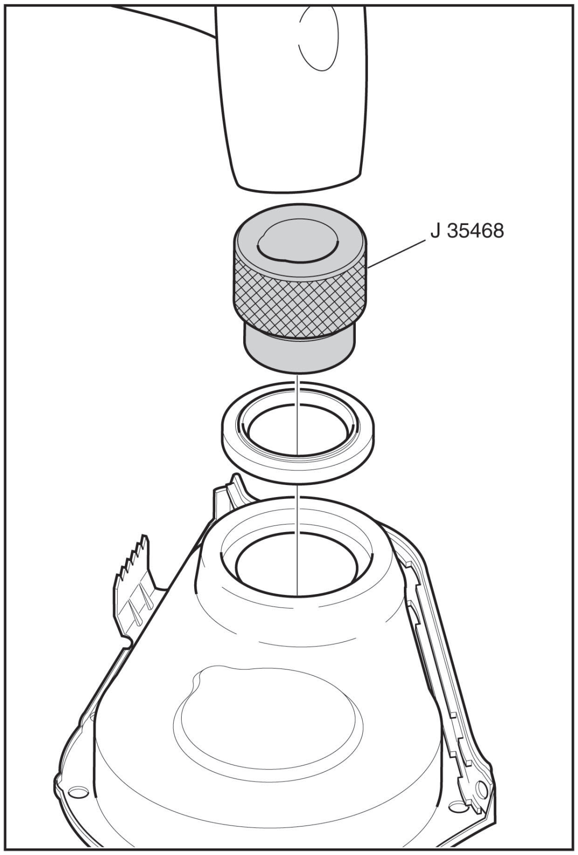

VE109-3L
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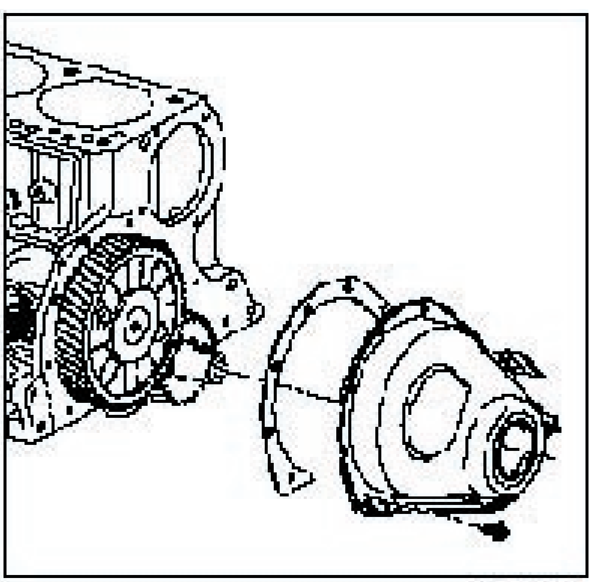
Engine Front Cover and Oil Seal Installation

Tools Required

- J 35468 Engine Front Cover Aligner and Oil Seal Installer

1. Use the J 35468 in order to install the engine front cover oil seal.



VE030-3L

2. Install the engine front cover gasket.
3. Install the engine front cover and bolts.

Tighten

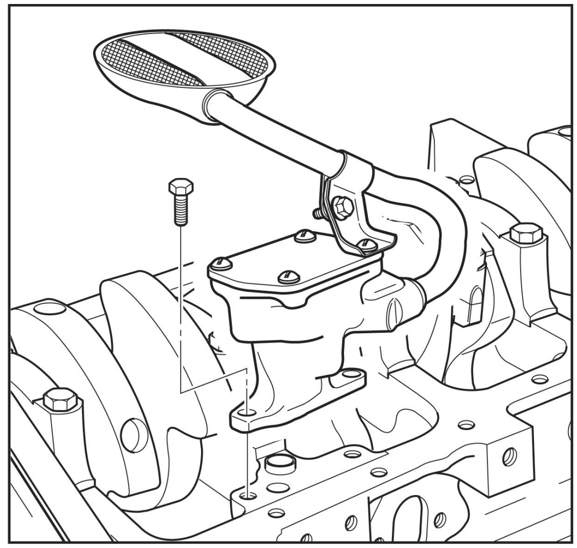
Tighten engine front cover bolts to 9 N•m (80 lb in).

Oil Pump Installation

Important: Inspect the oil pump and engine block oil galley passages. These surfaces must be clear and free of debris or restrictions.

1. Install the oil pump.
2. Install the bolts that attach the oil pump to the engine block.

Tighten



VE110-3L
VE110-3L

Oil Pan Installation

Important: Apply the sealer 25 mm (1.0 in) in either direction of the radius cavity of the junctions.

1. Apply a small amount of sealer, GM P/N 1052914 or equivalent, 10 mm (0.393 in) wide and 20 mm (0.787 in) long at the engine front cover to engine block junction.
2. Apply a small amount of sealer, GM P/N 1052914 or equivalent, 25 mm (1.0 in) long at the crankshaft rear oil seal housing to engine block junction.
3. Install the new oil pan gasket.
4. Install the oil pan.
5. Install the nuts and bolts to the oil pan.

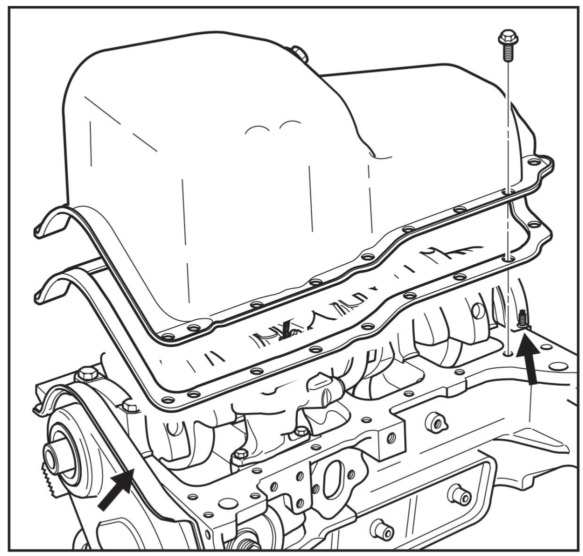
Tighten

Tighten the rear oil pan nuts to 19 N•m (168 lb in).

Tighten the oil pan bolts to the crankcase to 11 N•m (97 lb in).

Tighten the oil pan bolts to the front cover to 5 N•m (44 lb in).

Tighten the oil pan studs to the oil seal retainer to 2 N•m



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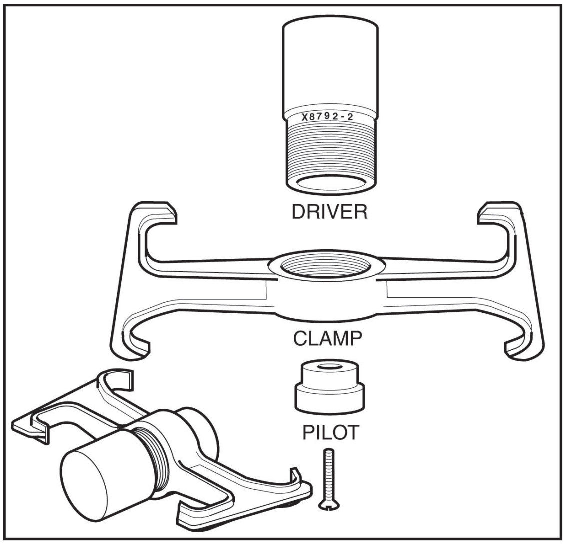


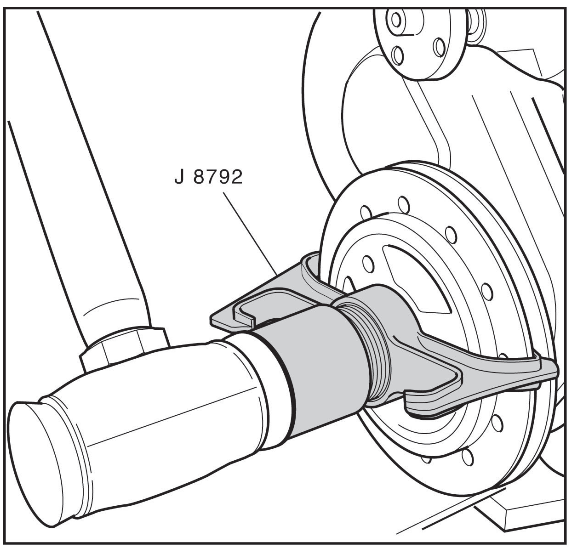
VE112-3L
VE112-3L

Crankshaft Pulley Installation

Tools Required

- J 8792 Crankshaft Pulley Installer

1. Coat the front cover oil seal contact area of the crankshaft pulley with clean engine oil.
2. Assemble the J 8792 as shown.



VE113-3L
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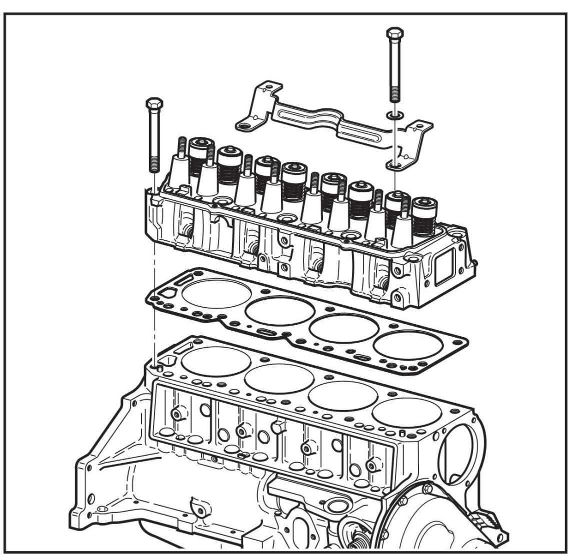
3. Install the J 8792 onto the crankshaft pulley.
4. Position the pulley on the crankshaft and drive into position until it bottoms against the crankshaft sprocket.



VE114-3L
VE114-3L

Cylinder Head Installation

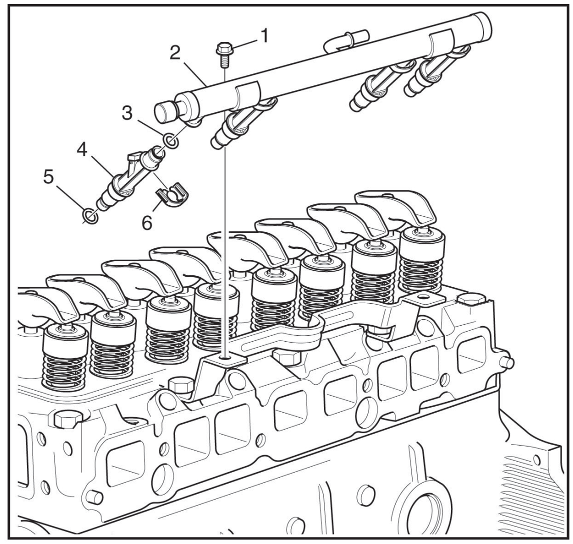
1. Install the new cylinder head gasket over the locating pins.
2. Install the cylinder head over the locating pins and the gasket.
3. Install the fuel rail bracket with two cylinder bolts and washers, finger tight.

Fuel Rail Inspection and Installation

1. Remove the fuel injector retaining clip (6), and remove the fuel injectors (4).
2. Inspect the fuel injectors (4) and the fuel injector O-rings (3, 5), replace if necessary.
3. Install the fuel injectors (4) into the fuel rail (2).
4. Install the fuel injector retaining clips (6).
5. Install the fuel rail assembly (2) and secure to the fuel rail bracket with the fuel rail bracket bolts (1).

Tighten

Tighten the fuel rail to fuel rail bracket bolts to 12 N•m (106 lb



VE132-3L

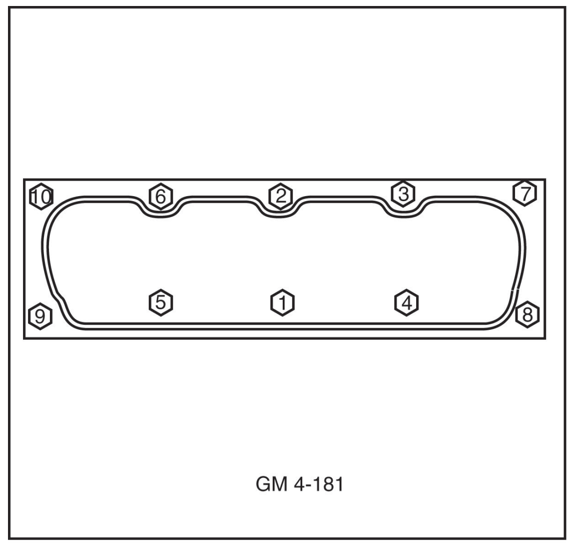
VE132-3L

Cylinder Head Torque Sequence

1. With the fuel rail bracket and fuel rail installed, tighten all cylinder head bolts.

Tighten

Tighten the cylinder head bolts in sequence to 135 N•m (100 lb ft).

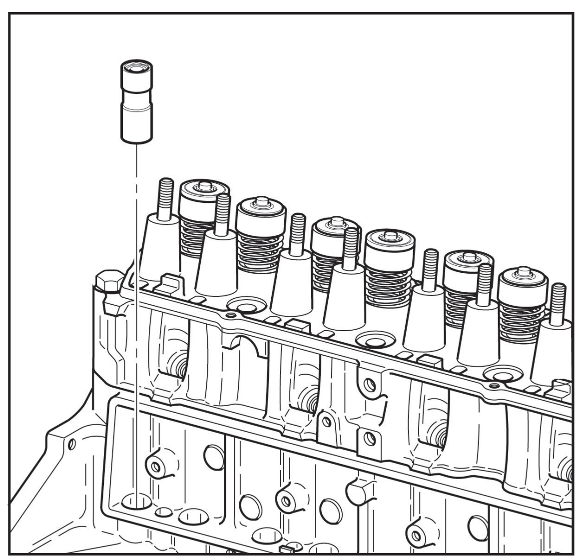


VE115-3L

VE115-3L

Valve Lifter Installation

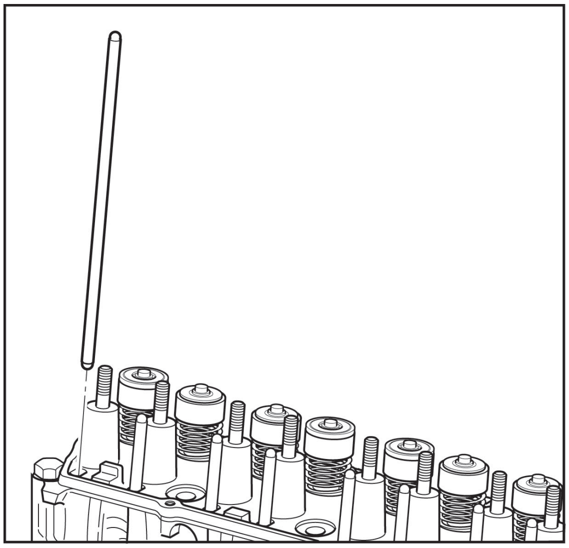
1. Coat the bottom of the valve lifters with prelube, GM P/N 03755008 or equivalent.
2. If reusing the valve lifters, install in their original location.
3. Install the valve lifters.



VE116-3L

VE116-3L

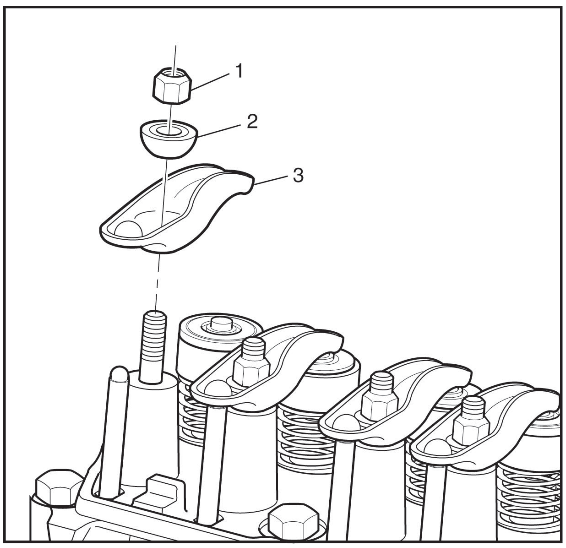
Valve Rocker Arm and Pushrod Installation



VE023-3L
VE023-3L

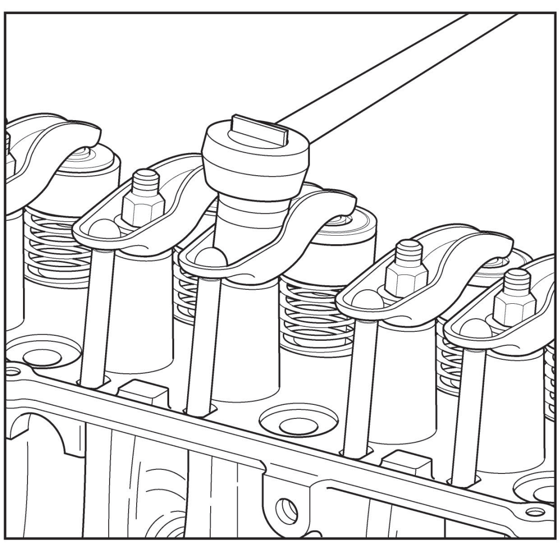
Important: Be sure to keep parts in order. Parts must be installed from where they were removed.

1. Install the valve pushrods. Be sure that the valve pushrods seat in the valve lifter sockets.



VE021-3L
VE021-3L

2. Install the following components:
   - 2.1. The valve rocker arms (3).
   - 2.2. The valve rocker arm balls (2). Lubricate the rocker arm balls with clean engine oil.
   - 2.3. The valve rocker arm nuts (1).



VE117-3L
VE117-3L

3. Adjust the valve rocker arm nuts as follows:
   - 3.1. Turn the crankshaft until the mark on the crankshaft pulley lines up with “0” on the timing tab and number 1 cylinder is at top dead center.
   - 3.2. Place fingers on the number 1 valves as the mark approaches “0.” If the valves move as the mark approaches “0,” the engine is on number 4 top dead center and should be rotated one more revolution in order to reach number 1 top dead center.
   - 3.3. With the engine at number 1 top dead center, adjust the following valves:
     - The exhaust valves 1, 3
     - The intake valves 1, 2
   - 3.4. Adjust the correct valves as follows:
     - 3.4.1. Back off the valve rocker arm nut until the lash is felt in the valve pushrod.

3.4.2. Tighten the valve rocker arm nut until all the lash is removed.

3.4.3. Zero lash can be felt by moving the valve pushrod up and down between your thumb and forefinger until there is no more movement.

3.4.4. When all the free play is gone, tighten the valve rocker arm nut 1 additional turn (360 degrees).

3.5. Turn the crankshaft 1 revolution until the mark on the crankshaft pulley lines up with “0” on the timing tab. This is number 4 top dead center.

3.6. With the engine at number 4 top dead center, adjust the following valves:

– The exhaust valves 2, 4

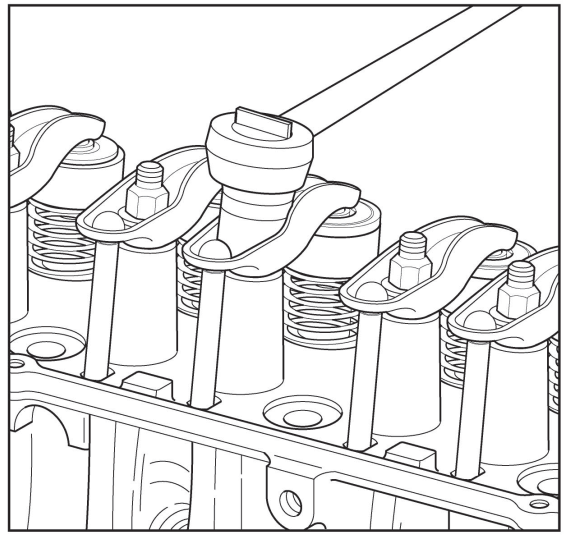
– The intake valves 3, 4

3.6.1. Back off the valve rocker arm nut until the lash is felt in the valve pushrod.

3.6.2. Tighten the valve rocker arm nut until all the lash is removed.

3.6.3. Zero lash can be felt by moving the valve pushrod up and down between your thumb and forefinger until there is no more movement.

3.6.4. When all the free play is gone, tighten the valve rocker arm nut 1 additional turn (360 degrees).



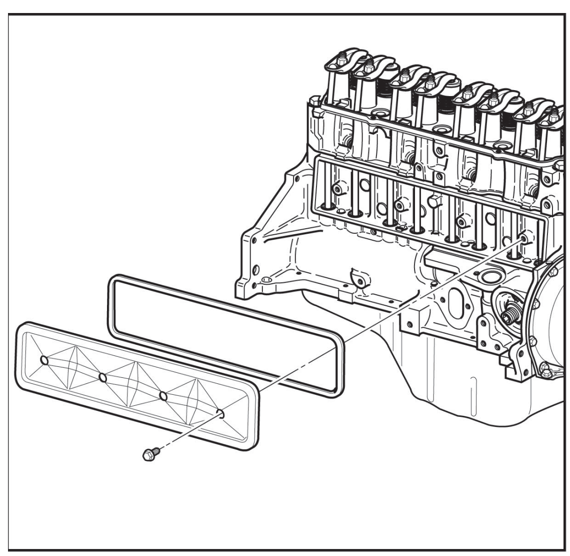
VE117-3L
VE117-3L

Pushrod Cover Installation

1. Install the pushrod cover gasket/sealer.
2. Install the pushrod cover.
3. Install the pushrod cover bolts.

Tighten

Tighten the pushrod bolts to 9 N•m (80 lb in).



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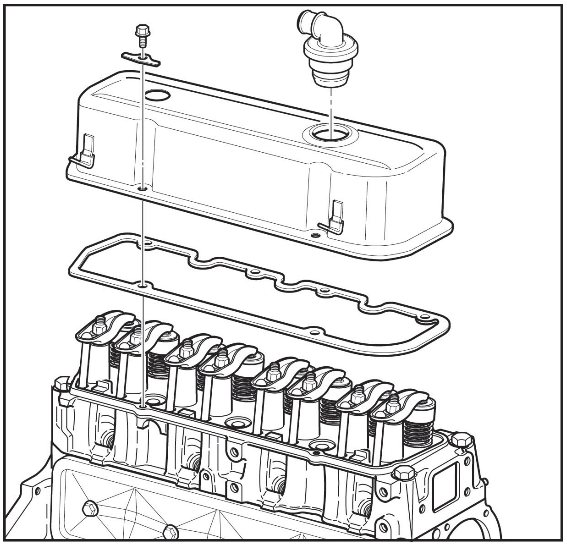


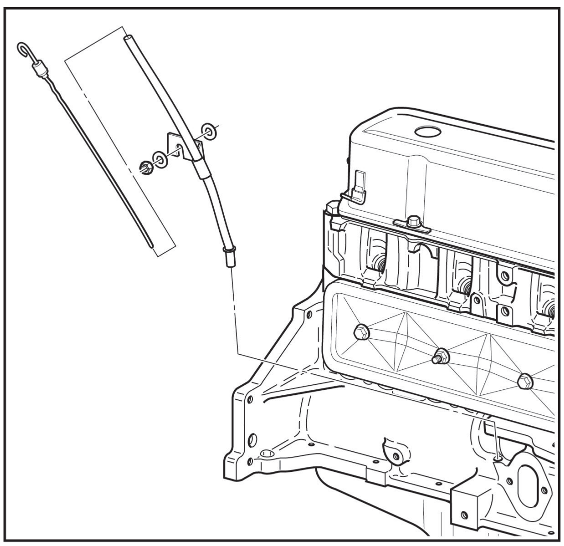
VE019-3L
VE019-3L

Valve Rocker Arm Cover Installation

1. Install the valve rocker arm cover gasket/sealer.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm bolts.

Tighten

Tighten the valve rocker arm cover bolts to 7 N•m (62 lb in).



VE120-3L
VE120-3L

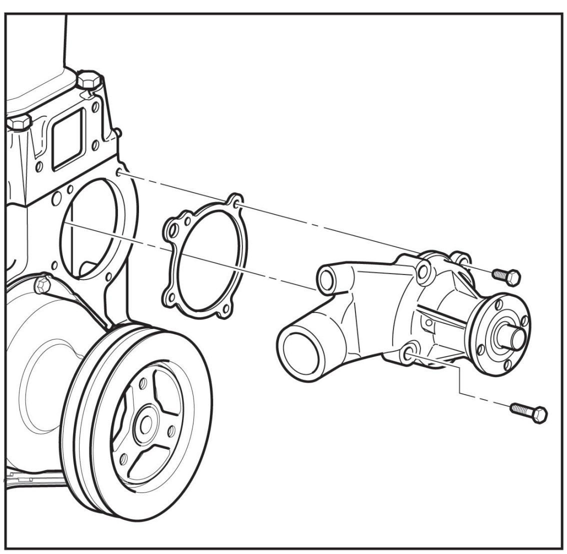
Oil Level Indicator and Tube Installation

1. Install one washer on the oil level tube stud.
2. Apply sealer to oil level indicator tube.
3. Install the oil level indicator tube into the engine block.
4. Use a light plastic or rubber hammer in order to tap the tube until it seats in the engine block.
5. Install the washer and oil level tube retaining nut.

Tighten

Tighten the retaining nut to 9 N•m (80 lb in).

6. Install the oil level indicator into the tube.



VE017-3L
VE017-3L

Water Pump Installation

1. Position the water pump and NEW gasket to the engine block.
2. Install the water pump bolts.

Tighten

Tighten the water pump bolts to 20 N•m (15 lb ft).

Water Outlet and Thermostat Installation

1. Position the thermostat housing (5) and NEW gasket (8) to the engine block.
2. Install the thermostat housing bolts (6).

Tighten

Tighten the thermostat housing bolts to 38 N•m (28 lb ft).

3. Install the thermostat (4) and NEW gasket (3) on the thermostat housing (5).
4. Install the water outlet housing (2).
5. Install the water outlet housing bolts (1).

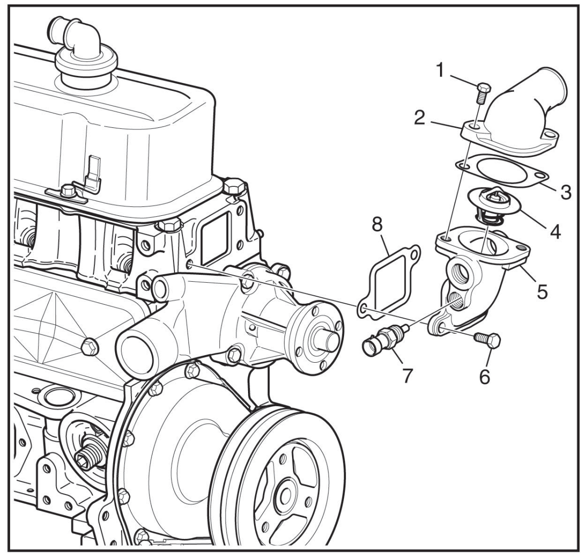
Tighten

Tighten the water outlet housing bolts to 28 N•m (21 lb ft).

6. Apply thread sealer then install the engine coolant temperature sensor (7).

Tighten

Tighten the coolant temperature sensor to 20 N•m (15 lb ft).



VE129-3L
VE129-3L

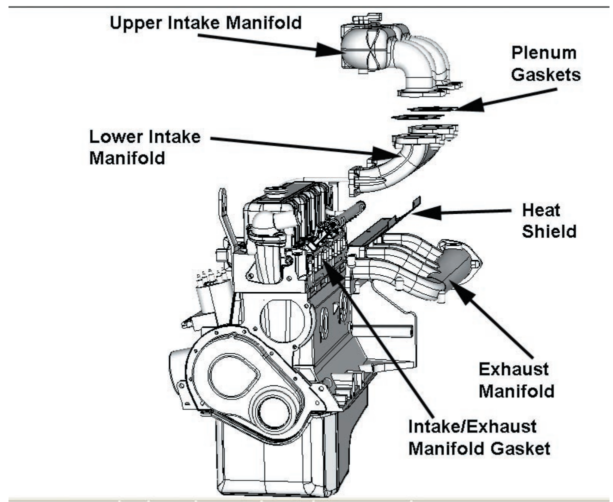
Intake/Exhaust Manifold Installation

1. Install the intake/exhaust manifold gasket over the locating pins on the cylinder head.
2. Install the bolts and clamps while holding the manifold in place.

Tighten

Tighten the four center bolts to 50 N•m (37 lb ft).

Tighten the end bolts to 50 N•m (37 lb ft).



VE014-3L

Spark Plug Installation

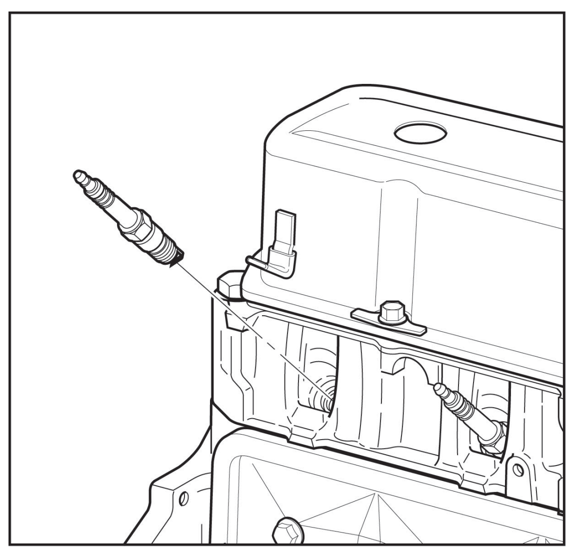
1. Check spark plug gap.

   Platinum plug: 1.28 mm (.050 in)

   Standard plug: 0.90 mm (.035 in)
2. Install the spark plugs.

Tighten

Tighten the spark plugs to 20 N•m (15 lb ft).



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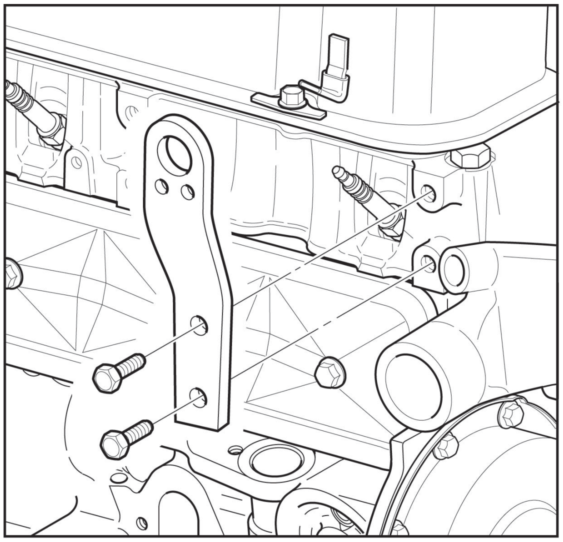

VE012-3L
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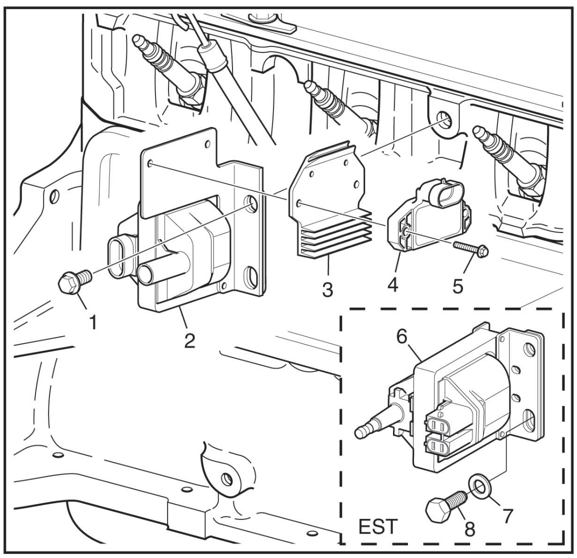
Lift Bracket Installation

1. Install the lift bracket.
2. Install the lift bracket bolts.

Tighten

Tighten the lift bracket bolts to 34 N•m (25 lb ft).



VE011-3L
VE011-3L

Ignition Coil Module Assembly Installation

1. Install the ignition coil and module assembly.
2. Some models use EST ignition coil (6) only.
3. Install the ignition coil bracket bolts (1).

Tighten

Tighten the attaching bolts to 25 N•m (18 lb ft).

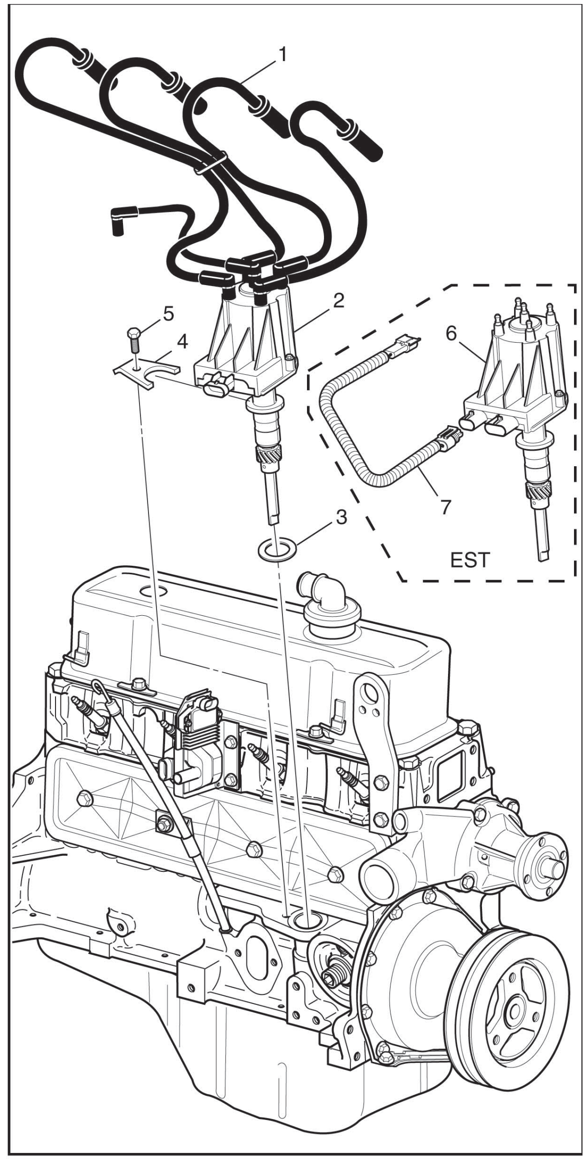
Distributor/High Voltage Switch (HVS) Installation

Important: To ensure correct ignition timing, the distributor must be installed in the correct position. Position the engine at top dead center on number one cylinder. The distributor cap must be removed in order to position the rotor when installing the distributor.

1. Install the distributor (2) and new gasket (3), making sure the distributor rotor is pointing to number one tower on the distributor cap.
2. Some models use the EST distributor (6) and primary ignition harness (7).
3. Install the distributor hold down (4) and bolt (5).

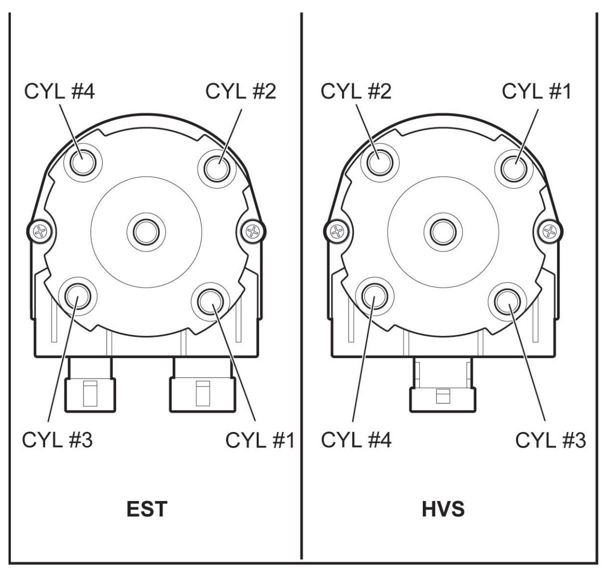
Tighten

Tighten the hold down bolt to 33 N•m (24 lb ft).



VE010-3L
VE010-3L

4. Connect the secondary ignition wires (1) to the spark plugs and the ignition coil. See diagram for specific



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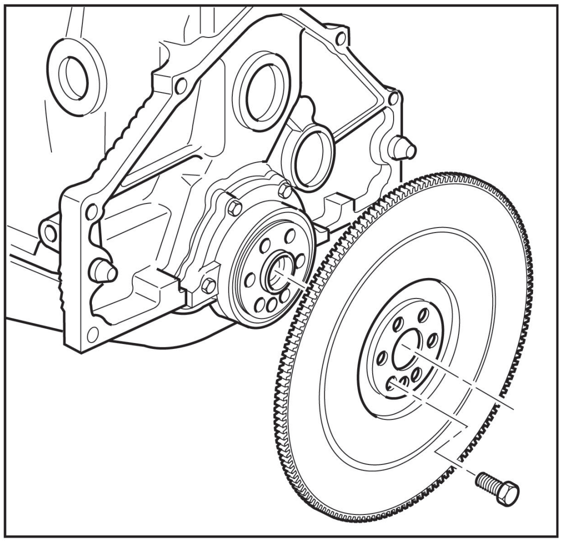


VE009-3L

VE009-3L

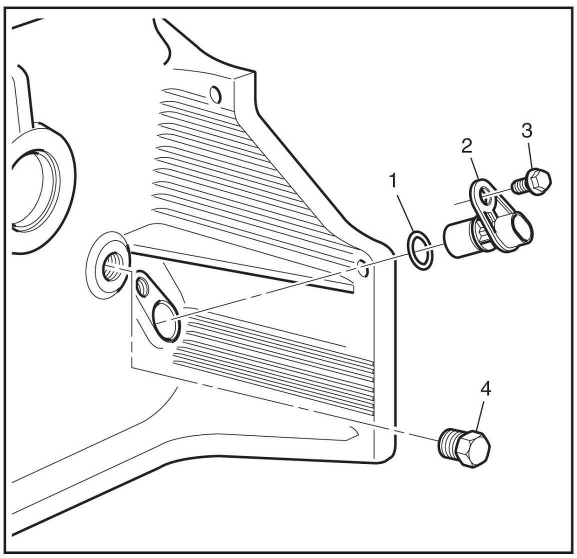
Engine Flywheel Installation

Important: Note the position and direction of the engine flywheel before removal. The flywheel center alignment hole is a tapered fit to the crankshaft. The engine flywheel must be reinstalled to the original position and direction. The engine flywheel will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts.

1. Install the engine flywheel.
2. Install the engine flywheel bolts.

Tighten

Tighten the flywheel bolts to 100 N•m (74 lb ft).



VE008-3L

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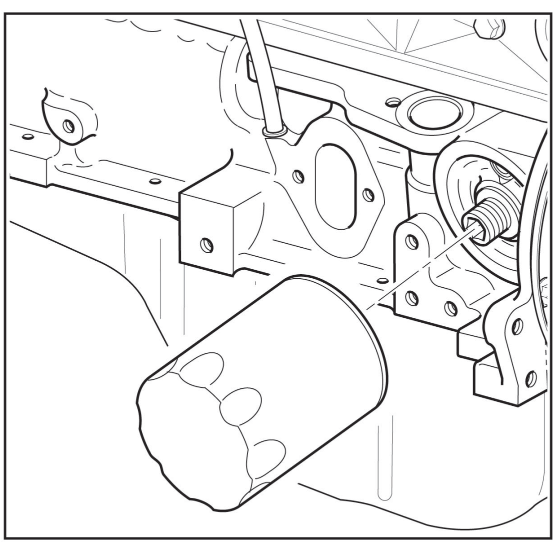
Engine Block Coolant Plug/Oil Filter/Crankshaft Position Sensor and Fuel Pump Cover Installation

1. Apply thread sealer and install the left rear engine block coolant plug (4).
2. Inspect the crankshaft position sensor O-ring (1) for damage, replace if necessary. Lubricate the O-ring with clean oil.
3. Install the crankshaft position sensor (2).
4. Install the crankshaft position sensor retaining bolt (3).

Tighten

Tighten the crankshaft position sensor retaining bolt to 10 N•m (89 lb in).



VE006-3L

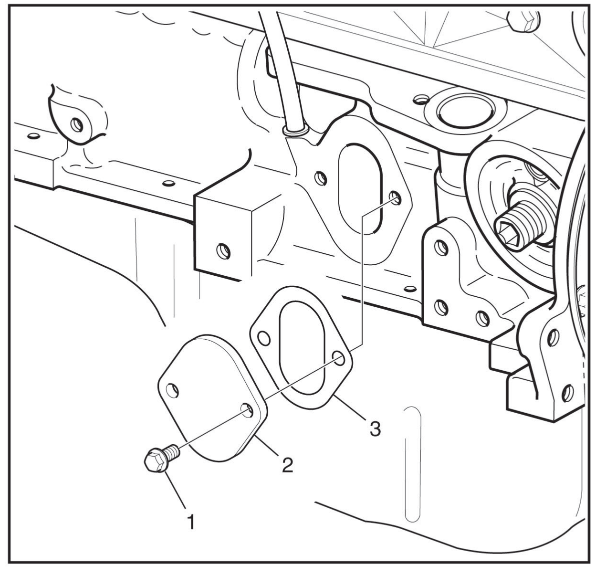
VE006-3L

5. Apply clean oil to the oil filter gasket and install the oil

6. Install the fuel pump cover gasket/sealer (3).
7. Install the fuel pump cover (2).
8. Install the fuel pump cover bolts (1).

Tighten

Tighten the fuel pump cover bolts to 19 N•m (14 lb ft).



VE133-3L

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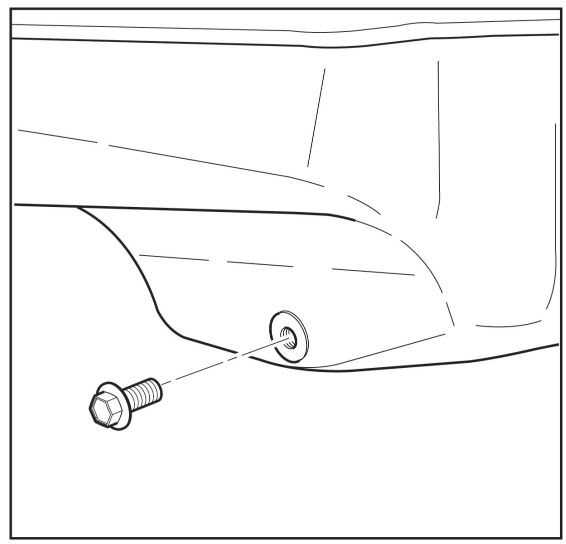
9. Install the oil pan drain plug.



VE005-3L

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Description and Operation

Engine Component Description

Engine Block

The engine block has four cylinders arranged in an “in-line” construction. Starting at the front of the engine, the cylinders are numbered 1-2-3-4. The firing order of the cylinders is 1-3-4-2. The cylinders are encircled by coolant jackets.

Cylinder Head

The cylinder head has one intake and one exhaust valve per cylinder. A spark plug is located between the valves in the side of the cylinder head. The valve guides are integral and the valve rocker arms are retained on individual threaded studs.

Crankshaft

The crankshaft is cast nodular iron and is supported by five crankshaft bearings. The bearings are retained by crankshaft bearing caps that are machined with the engine block for proper alignment and clearances.

Camshaft

A billet steel one piece camshaft is supported by four full round, sleeve-type bearings. These bearings are a press fit into the engine block. The camshaft timing sprocket is mounted to the front of the camshaft and is driven the crankshaft sprocket.

Pistons and Connecting Rods

The pistons are made of cast-aluminum alloy using two compression rings and one oil control ring assembly. The piston pins are a press fit in the connecting rods and a floating fit in the pistons.

Valve Train

The valve train is a ball-pivot type. Motion is transmitted from the camshaft through the valve lifter and valve pushrod to the valve rocker arm. The valve rocker arm pivots on its ball and transmits the camshaft motion to the valve. The valve lifters keep all parts of the valve train in constant contact. Each lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment.

Lubrication

The oil pump is gear driven from the camshaft. Oil is drawn from the oil pan through a pickup screen and tube. The gear type oil pump has a pressure regulator valve which controls the lubrication system pressure by bypassing excess oil back to the oil pan sump.

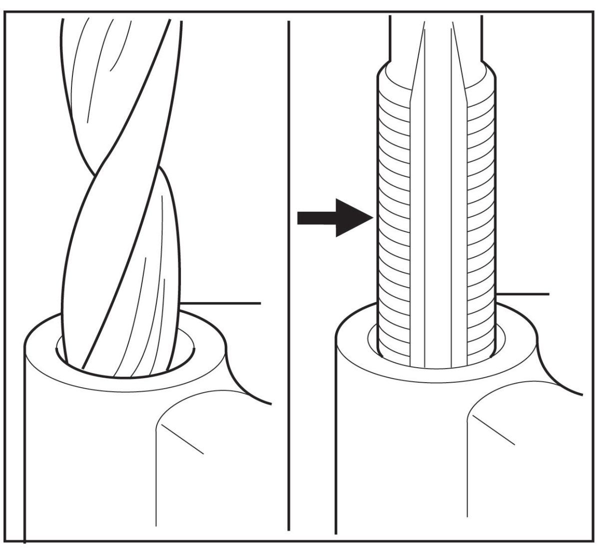
Pressurized oil from the oil pump flows to the full flow filter. A bypass valve allows oil to bypass the filter if it becomes clogged or restricted. Oil then flows into an oil passage that runs along the right side of the block and intersects the lifter bosses. Oil from this passage is routed to the crankshaft main bearings and camshaft bearings through smaller drilled passages. Oil is supplied to the connecting rod bearings by holes drilled in the crankshaft. Oil is supplied to the rocker arms through holes in the hydraulic lifters which feed oil up the pushrods to the rocker arms. The oil is metered by discs under the pushrod seat.

Many internal engine parts have no direct oil feed and are supplied by either gravity or splash from other direct feed components. Timing gears are lubricated by oil supplied through a passage from the front of the camshaft to a calibrated nozzle above the crankshaft gear.

Thread Repair

Tools Required

General purpose thread repair kits. These kits are



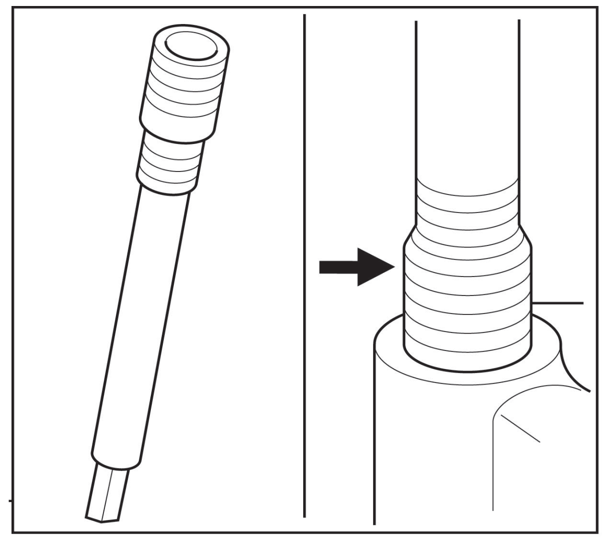
VE121-3L

VE121-3L

available commercially

Caution: Wear safety glasses in order to avoid eye damage.

1. Determine the size, pitch and depth of the damaged thread. If necessary, adjust the stop collars on the cutting tool and tap to the required depth.
2. Drill out the damaged thread. Clean out any chips.
3. Avoid any buildup of chips. Back out the tap every few turns and remove the chips.



4.

VE122-3L

VE122-3L

5.Thread the insert onto the mandrel of the installer. Engage the tang of the insert onto the end of the mandrel.

Important: The insert should be flush to one turn below the surface.

6. Lubricate the insert with light engine oil (except when installing in aluminum) and install the insert.
7. If the tang of the insert does not break off when

backing out the installer, break the tang off with a drift.

Cleanliness and Care

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly. Refer to Separating Parts.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Replacing Engine Gaskets

1. Gasket reuse and applying sealants:
   - Do not reuse any gasket unless specified.
   - Gaskets that can be reused will be identified in the service procedure.
   - Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.
2. Separating components:
   - Use a rubber mallet to separate components.
   - Bump the part sideways to loosen the components.
   - Bumping should be done at bends or reinforced areas to prevent distortion of the parts.
3. Cleaning gasket surfaces:
   - Remove all gasket and sealing material from the part using a plastic or wood scraper (if required).
   - Care must taken to avoid gouging or scraping the aluminum sealing surfaces.
   - Do not use any other method or technique to remove sealant or gasket material from a part.
   - Do not use abrasive pads, sand paper or power tools to clean gasket surfaces.
     – These methods of cleaning can cause damage to the component sealing surfaces.
     – Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
     – This grit is abrasive and has been known to cause internal engine damage.
4. Assembling components:
   - When assembling components, use only the sealant specified or equivalent in the service procedure.
   - Sealing surfaces should be clean and free of debris or oil.
   - Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
   - Components requiring lubrication will be identified in the service procedure.
   - When applying sealant to a component, apply the amount specified in the service procedure.
   - Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
   - Tighten bolts to specifications. Do not overtighten.

Use of RTV and Anaerobic Sealer

Important: Three types of sealer are commonly used in engines. These are RTV sealer, anaerobic gasket eliminator sealer and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the three types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

Pipe Joint Compound

- Pipe joint compound is a pliable sealer that does not completely harden. This type sealer is used where two nonrigid parts (such as the oil pan and the engine block) are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifolds, head gasket or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.
- To remove the sealant or the gasket material,

Refer to Replacing Engine Gaskets.

- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- Room Temperature Vulcanizing (RTV) sealant hardens when exposed to air. This type sealer is used where two nonrigid parts (such as the oil pan and the engine block) are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifolds, head gasket or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.
- To remove the sealant or the gasket material, Refer to Replacing Engine Gaskets.
- Apply RTV to a clean surface. Use a bead size as specified in the service procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when the bolt is tightened.
- Assemble components while RTV is still wet (within three minutes). Do not wait for RTV to skin over.
- Tighten the bolts to specifications. Do not overtighten.

Anaerobic Sealer

- Anaerobic gasket eliminator hardens in the absence of air. This type sealer is used where two rigid parts (such as castings) are assembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.
- To remove the sealant or the gasket material, Refer to Replacing Engine Gaskets.
- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be resealed must be clean and dry.
- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when the bolt is tightened.
- Tighten the bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

Separating Parts

Important: Many internal engine components will develop specific wear patterns on their friction surfaces.

When assembling the engine, internal components MUST be separated, marked or organized in a way to ensure reinstallation to original location and position.

Mark or identify the following components:

- Piston and the piston pin.
- Piston assembly to the specific cylinder bore.
- Piston rings to the specific piston assembly and cylinder bore.
- Connecting rod to the crankshaft journal.
- Connecting rod to bearing cap.
- Crankshaft main and connecting rod bearings.
- Camshaft and valve lifters.
- Valve lifters, guides, pushrods, pivot supports and rocker arms.
- Valve to the valve guide.
- Valve spring and shim .
- Engine block main bearing cap location and direction.
- Oil pump drive and driven gears.

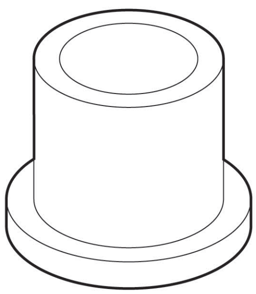
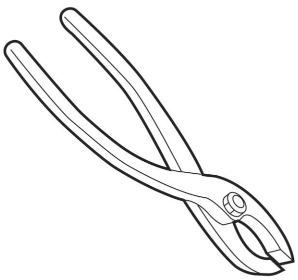
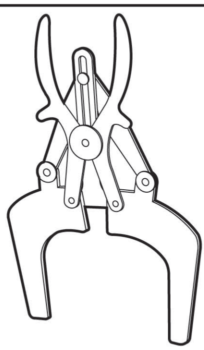
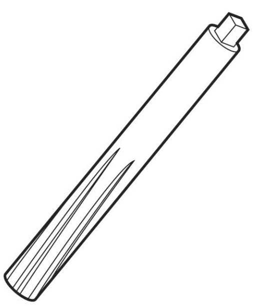
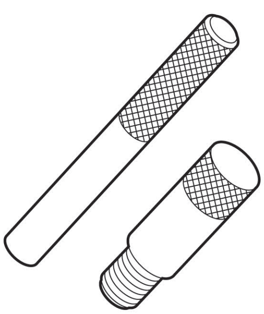
Tools and Equipment

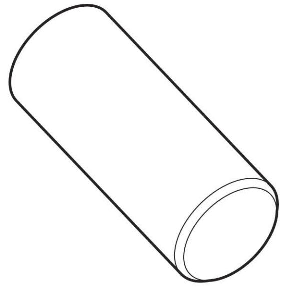
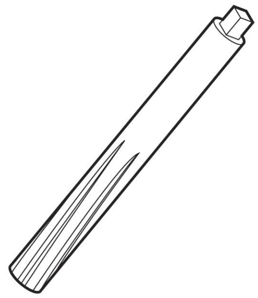
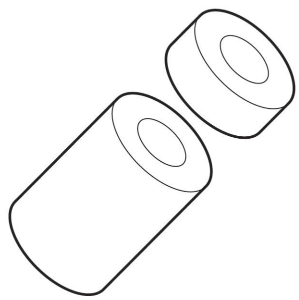
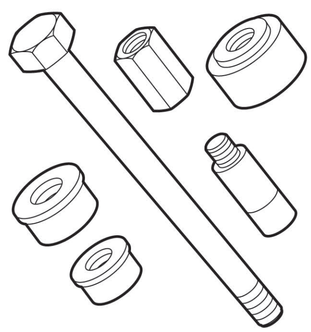
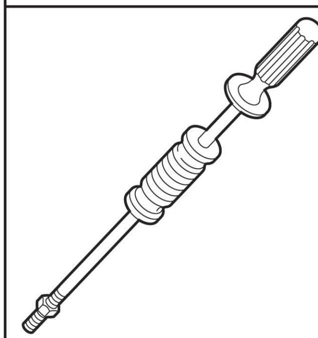
Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

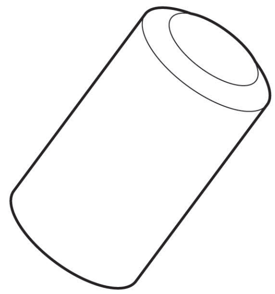
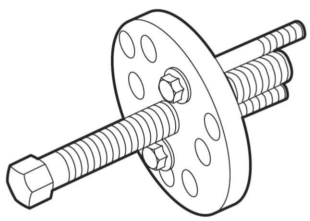
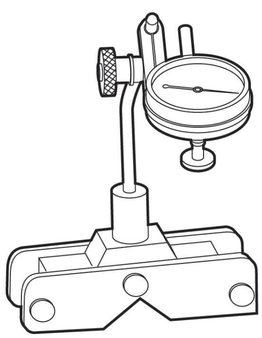
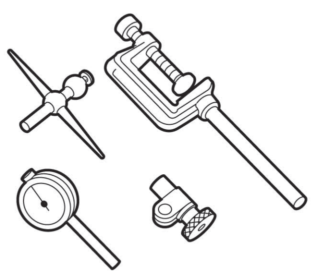
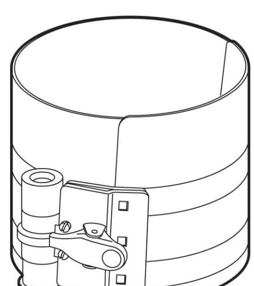
To properly service the engine assembly, the following items should be readily available:

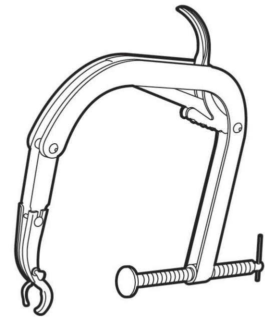
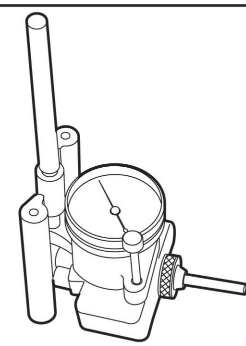
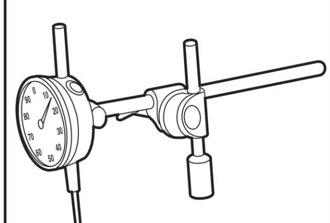
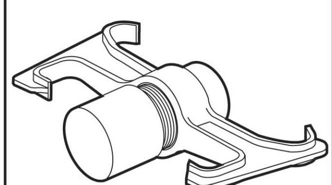
- Approved eye protection and safety gloves.
- A clean, well-lit work area.
- A suitable parts cleaning tank.
- A compressed air supply.

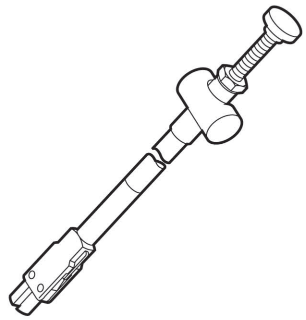
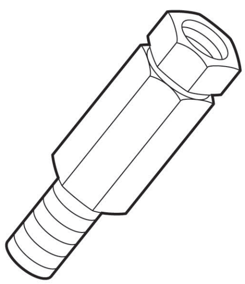
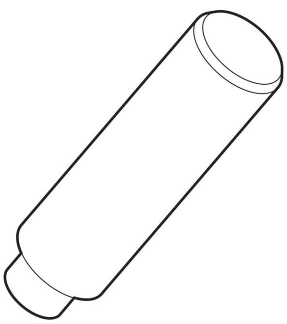
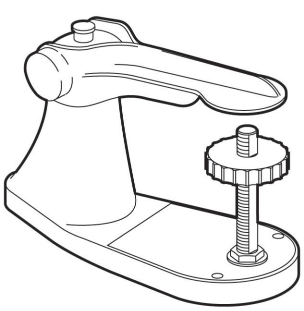
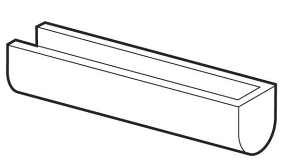
Special Tools and Equipment

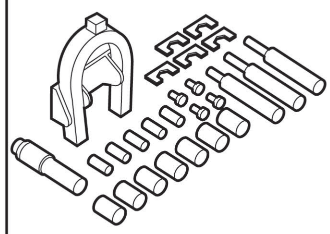
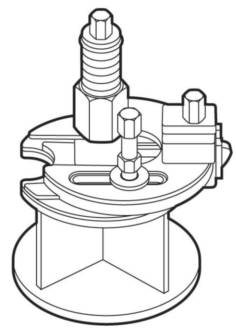
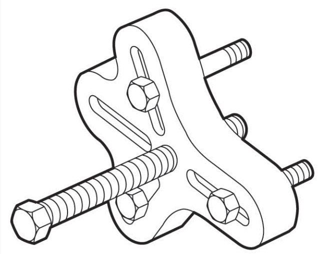
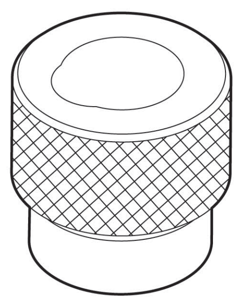
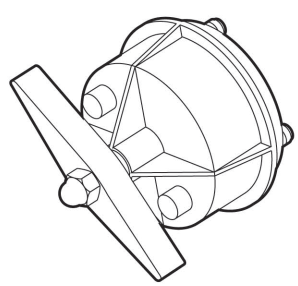
	J 791 Camshaft Sprocket Remover
	J 3049-A Valve Lifter Remover
	J 3936-03 Piston Ring Groove Cleaner
	J 4822 Valve Guide Reamer
	J 5239 Connecting Rod Bolt Guide Set

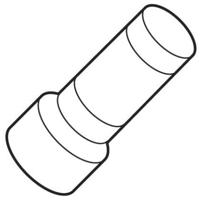
	J 5590 Crankshaft Sprocket Installer
	J 5715 or J 6036 Rocker Stud Hole Reamer
	J 5802-01 Rocker Arm Stud Remover
	J 6098-01 Camshaft Bearing Remover/Installer
	J 6585 Slide Hammer

	J 6880 Rocker Arm Stud Remover
	J 6978-E Crankshaft Sprocket Puller
	J 7872 Magnetic Base Dial Indicator
	J 8001 Dial Indicator
	J 8037 Piston Ring Compressor

	J 8062 Valve Spring Compressor
	J 8087 Cylinder Bore Gauge
	J 8089 Carbon Remover Brush
	J 8520 Camshaft Lobe Lift Indicator
	J 8792 Crankshaft Pulley Installer

	J 9290-01 Valve Lifter Remover (Slide Hammer Type)
	J 9534 Distributor Lower Bushing Remover
	J 9535 Distributor Lower Bushing Installer
	J 9666 Valve Spring Tester
	J 21882 Oil Suction Pipe Installer

	J 24086-C Piston Pin Remover/Installer Set
	J 24270 Ridge Reamer
	J 24420-C Universal Crankshaft Pulley Remover
	J 35468 Engine Front Cover Aligner and Oil Seal Installer
	J 35621 Crankshaft Rear Oil Seal Installer

	J 42073 Valve Stem Seal Installer

PSI 3.0L PFI
DUAL FUEL SYSTEM
DESCRIPTION OF OPERATION

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DESCRIPTION AND OPERATION OF THE FUEL SYSTEMS

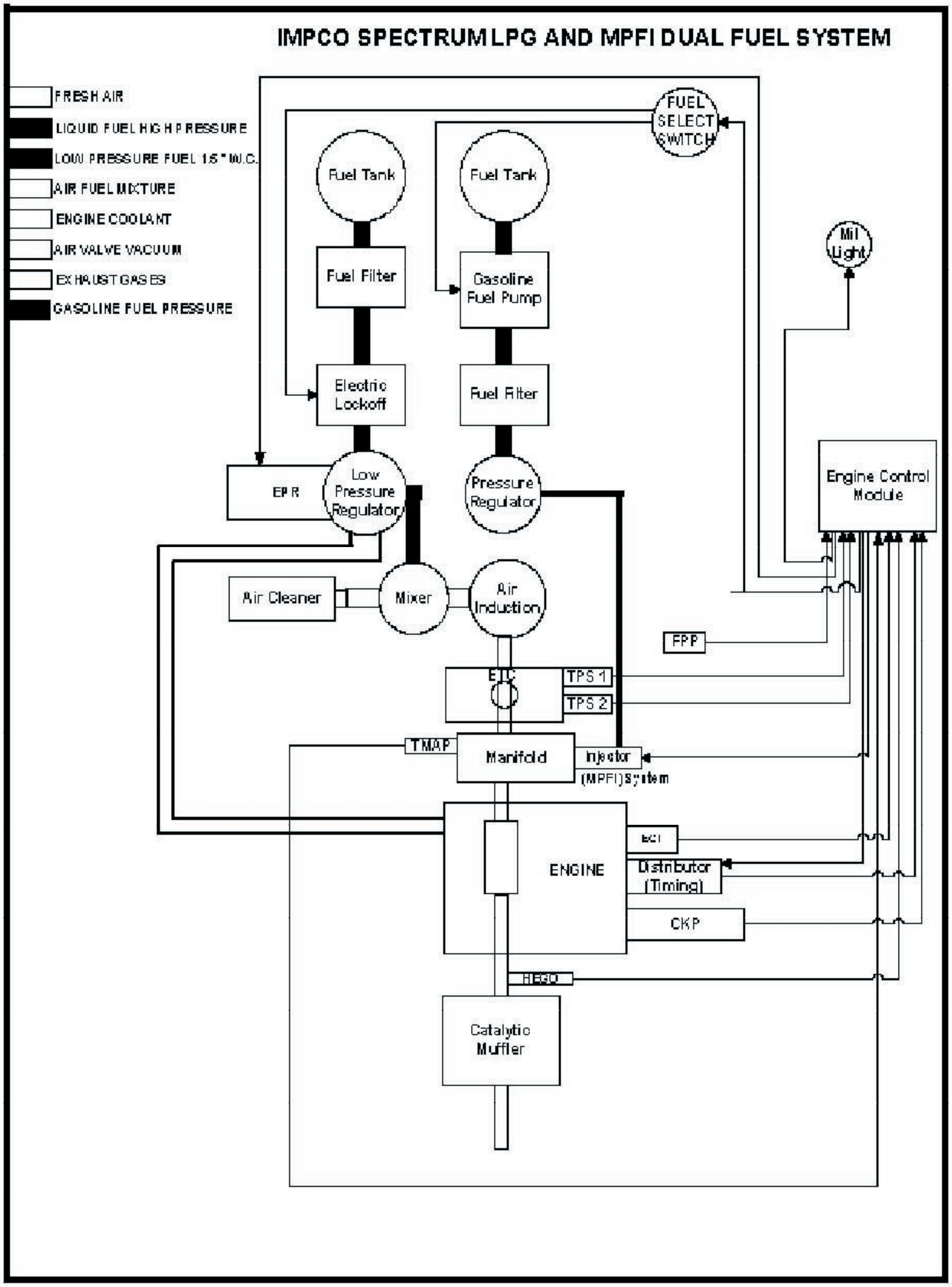


Figure 1 - *Typical IMPCO Dual Fuel System Schematic*

DUAL FUEL SYSTEM

The IMPCO Dual Fuel system is designed to offer the operator the ability to operate the vehicle on either gasoline or LPG by positioning a selector switch in the operator's platform. When the operator places the selector switch in the gasoline mode the gasoline fuel pump is energized when the operator places the ignition key in the, key ON engine off (KOEO) or the key ON engine run (KOER) modes. While in the gasoline mode the LPG fuel lock-off is isolated and will not energize. In addition the gasoline injector circuit is enabled and injector pulses are provided to each injector and the ECM calibration for gasoline is also enabled. When the operator selects the LPG mode the Low Pressure LPG lock-off is energized when the operator places the ignition key in the (KOEO) or the (KOER) modes and fuel from the LPG tank flows to the Electronic Pressure Regulator (EPR). During the (KOEO) or the (KOER) the EPR receives and electronic signal to position the secondary lever for the start or run positions and when the engine begins to crank the mixer air valve will rise and fuel will begin flowing to engine. During this mode the gasoline fuel pump is isolated and will not be activated during the (KOEO) or the (KOER) modes. The primary components of the gasoline dual fuel system are the gasoline fuel storage tank, electric fuel pump and filter, fuel supply line, injector rail and injectors and the fuel pressure regulator. The primary components of the LPG dual fuel system are the LPG fuel storage tank, in-fuel filter, LPG Low Pressure lock-off, Electronic Pressure Regulator (EPR) and the fuel mixer module. The LPG fuel system operates at pressures which range from 355.60 mm (14.0 inches) of water column up to 21.5 BAR (312 psi).

Components which are shared by both systems include the Electronic Throttle Control (ETC), Three Way Catalytic (TWC) converter and the ECM. The ECM contains a dual calibration one which controls the gasoline fuel system during gasoline operation and a calibration which controls the LPG fuel system during LPG operation. The block diagram above Figure 1 identifies the major components identified in this section and the placement, pressure and circuit relationship to the ECM.

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.

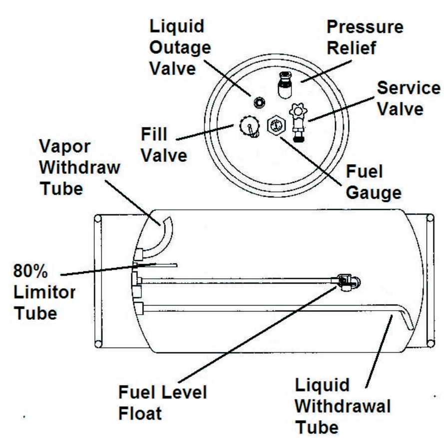


Figure 2
Typical Propane Cylinders

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 equipment’s 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 friendly to the LPG fuel and should always be replaced with an OEM supplied part.

FUEL FILTER

Propane fuel like all other motor fuels is subject to contamination from outside sources. Refueling of the equipment’s 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 *Recommended Maintenance Schedule*. In severe operating condition more frequent replacement of the filter may be necessary.

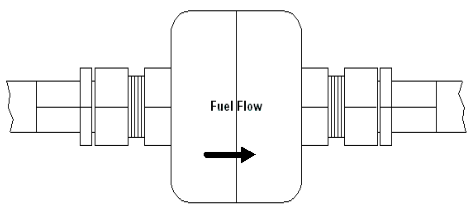


Figure 3
Inline Fuel Filter

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).

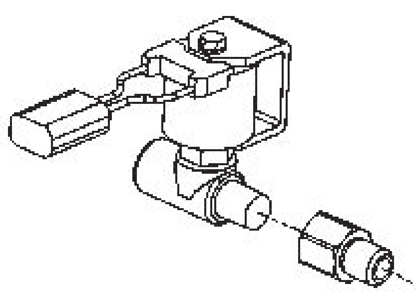


Figure 4
Electric Fuel Lock Off

EPR ASSEMBLY

The EPR assembly is a combination Low Pressure Regulator and a Voice Coil Assembly. The Voice coil is an electronic actuator which is controlled by an internal microprocessor. The microprocessor provides output data to the ECM and receives input data over a CAN BUS connection. The internal microprocessor receives electrical signals from the Fuel Pressure Sensor FPS and the Fuel Temperature Pressure FTP and communicates the data to the ECM. The ECM uses the FPS and FTP data to calculate the location of the secondary lever in the LPR and sends that data back to the EPR via the CAN BUS. The internal microprocessor in the EPR will than output a signal, which causes the voice coil to move and position the secondary lever to the correct location.

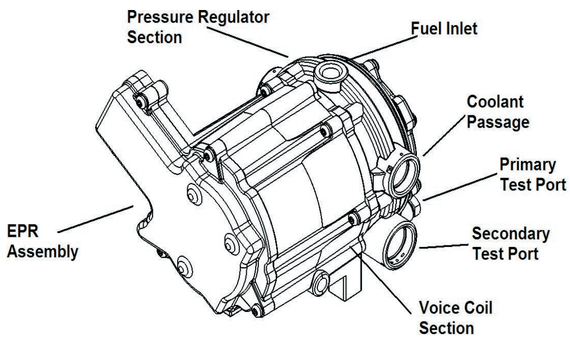


Figure 5
EPR Assembly

LOW PRESSURE REGULATOR (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 (1.5 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. This mechanical action in conjunction with the EPR reactions causes the downward action on the secondary lever causing it to open wider allowing more fuel to flow to the mixer.

WARNING

THE VOICE COIL SECTION OF THE EPR ASSEMBLY IS A EMISSIONS CONTROL DEVICE AND CANNOT BE REBUILT. IF THE COIL ASSEMBLY FAILS TO OPERATE PROPERLY REPLACE WITH AN OEM REPLACEMENT PART ONLY

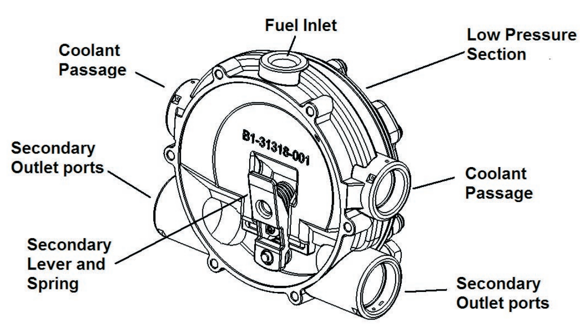


Figure 5
Low pressure regulators

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 increase 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 venture 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.

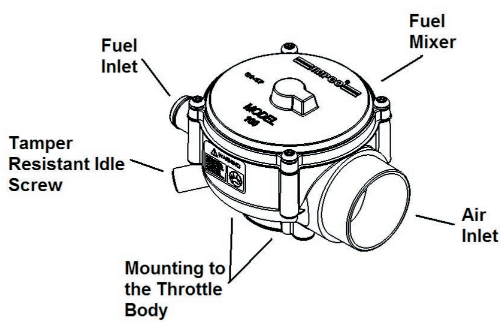


Figure 6
Air Fuel Mixer

ELECTRONIC THROTTLE CONTROL (ETC)

Engine speed and load control is maintained by an ETC device. Speed and load control are determined by the ECM. Defaults programmed into the ECM software and throttle position sensors allow the ECM to maintain safe operating control over the engine. The Electronic Throttle Control device or “throttle body assembly” is connected to the intake manifold of the engine. The electronic throttle control device utilizes an electric motor connected to the throttle shaft. When the engine is running electrical signals are sent from the equipment controls to the engine ECM when the operator depresses an equipment function switch. The ECM then sends an electrical signal to the motor on the electronic throttle control to increase or decrease the angle of the throttle blade thus increasing or decreasing the air/fuel flow to the engine.

The electronic throttle control device also incorporates two internal Throttle Position Sensors (TPS) which provide output signals to the ECM as to the location of the throttle shaft and blade. The TPS information is used by the ECM to correct for speed and load control as well as emission control.

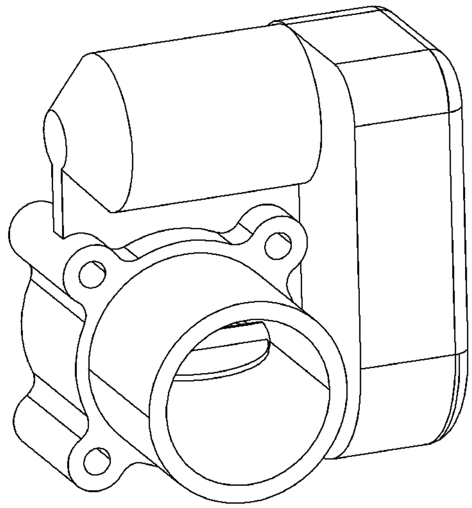


Figure 8
ETC throttle control device

THREE-WAY CATALYTIC MUFFLER

The emission certified engine has been designed and calibrated to meet the emission standards in effect for 2006. 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.

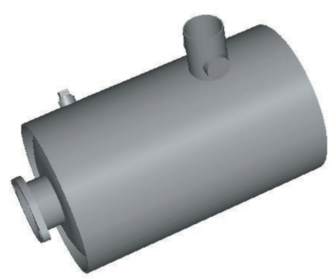


Figure 9
Three way catalytic converter

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 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 (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 out-puts signals to the EPR to correct the amount of fuel being supplied to the mixer. At the same time the ECM may correct the throttle blade position to correct speed and load of the engine.

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

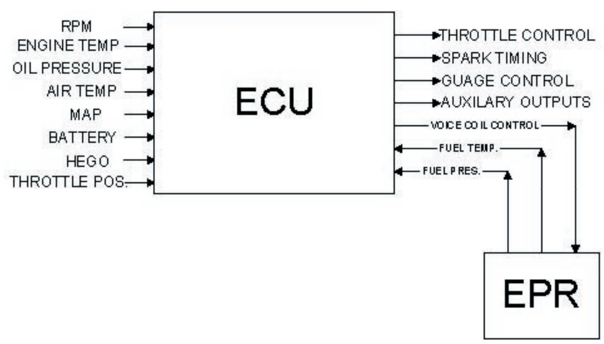


Figure 10
LPG Engine Control Unit (ECM)

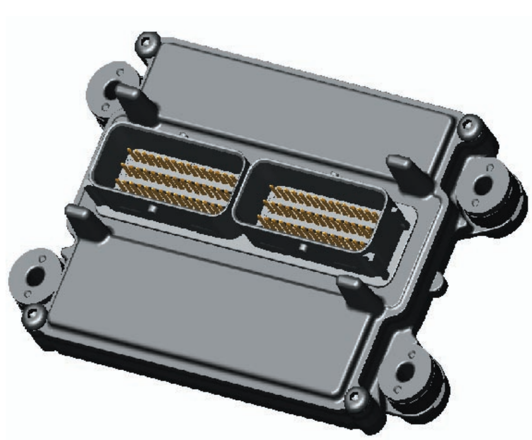


Figure 11
ECM Assembly

HEATED EXHAUST GAS OXYGEN SENSOR

On the 2006 fuel system equipped on your vehicle there are two, Heated Exhaust Gas Oxygen Sensor (HEGO). The pre-catalyst HEGO is mounted in the exhaust system downstream of the engine. The pre-catalyst 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.

The second HEGO is the Post-catalyst monitoring sensor. The sensor is mounted in the exhaust system after the catalyst. The Post-catalyst HEGO measure the amount of oxygen in the exhaust system after the catalyst treatment has been completed. The Post-catalyst sends the electronic signal to the ECM. If the ECM detects that the catalytic action in the muffler is not sufficient and fuel correction cannot correct the malfunction the MIL light is illuminated in the dash and a DTC code will be set.

CAUTION

THE HEATED EXHAUST GAS OXYGEN SENSOR IS AND EMISSION CONTROL DEVICE. IF THE HEGO FAILS TO OPERATE, REPLACE WITH AND OEM REPLACEMENT PART. THE HEGO SENSOR IS SENSITIVE TO SILICONE OR SILICONE BASED PRODUCT AND BECOME CONTAMINATED. AVOID USING SILICONE SEALERS OR HOSES TREATED WITH SILICONE LUBRICANTS IN THE AIR STREAM OR FUEL LINES

Figure 12
Heated Exhaust Gas Oxygen Sensor (HEGO)

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 pressure and temperature sensor manifold, fuel filter and fuel rail.

GASOLINE FUEL STORAGE TANK

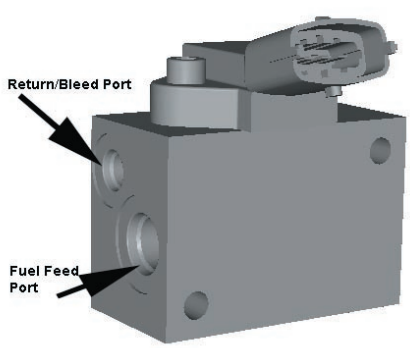
The gasoline fuel storage tank location may very on equipment applications. The fuel tank may be integrated into the chassis frame or may be a stand alone vessel mounted on the equipment. For precise location for the equipment application refer to the OEMs vehicle manual.

GASOLINE FUEL PUMP

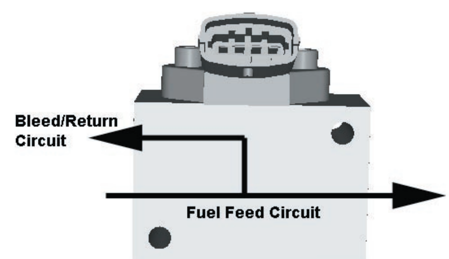
The Gasoline is stored as a liquid in the fuel tank and in drawn into the fuel system by a 12 volt electric fuel pump. Depending on the vehicle application the fuel pump may be mounted in the fuel tank or as a stand alone component. In either case the fuel pump will receive a signal from the ECM at Key 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. Consult the OEM for the location of the fuel pump.

GASOLINE PRESSURE AND TEMPERATURE SENSOR MANIFOLD

This engine is equipped with a fuel injector rail that does not have a pressure regulator or a return circuit to the fuel tank. Fuel pressure for this engine is regulated by the engine's ECM. The ECM receives fuel pressure and temperature feedback from the gasoline fuel sensor manifold and uses this information to control the ground side of the fuel pump. Fuel pressure is regulated by the ECM pulse width modulating (PWM) the fuel pump. The fuel pressure and temperature sensor manifold has a return or "bleed" circuit that connects back to the equipment fuel tank. This circuit is used to bleed off any vapor that develops in the line and returns a small amount of fuel to the tank. The fuel comes from the fuel tank and passes through the fuel pump. Fuel exits the fuel pump, passes through the filter and then enters the fuel pressure and temperature manifold assembly. Fuel flows through the feed ciruit and is delivered to the fuel injector rail. Fuel that enters the bleed circuits through the by-pass valve in the manifold is returned to the fuel tank.



Gasoline Fuel Pressure and Temperature Manifold Assembly

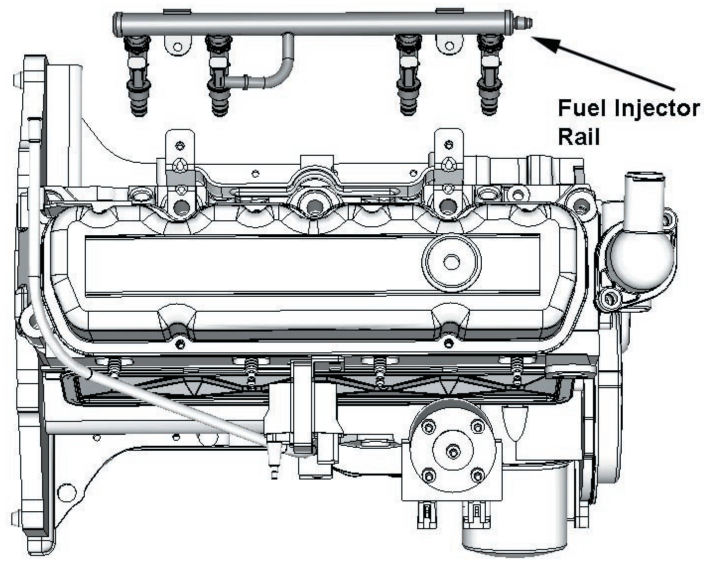


FUEL FILTER

After the fuel is drawn into the fuel pump, the fuel flows through the gasoline fuel filter. The fuel filter will trap small particles. The fuel passes through the filter to remove debris which prevents the fuel pressure and temperature manifold and fuel 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.

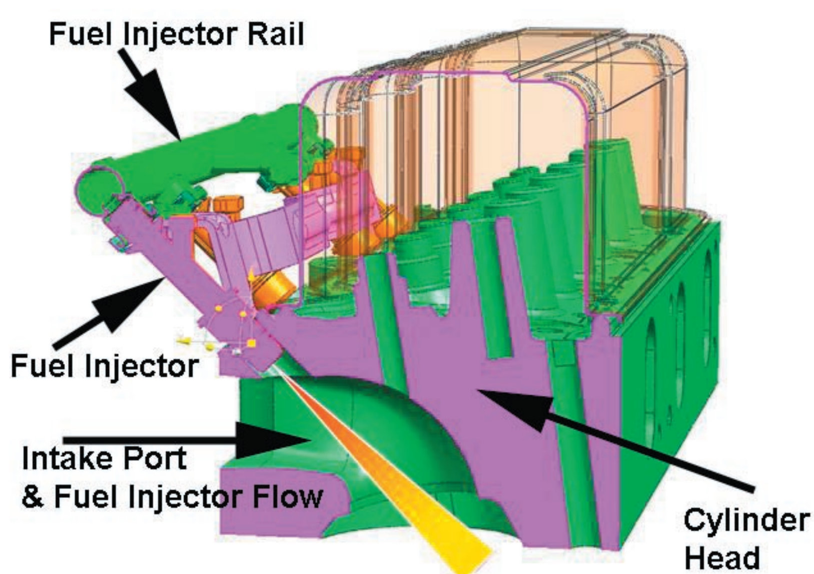
FUEL INJECTOR RAIL

The fuel flows from the fuel pressure and temperature manifold assembly to the fuel rails where the fuel is delivered to the fuel injectors. The fuel rail also contains a Schrader valve which is utilized to test the regulated pressure of the fuel system.



FUEL INJECTOR

The fuel supply is maintained on the top of the injector from the injector rail. 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.



PSI 3.0L PFI
FUEL SYSTEM REMOVE & REPLACE SECTION

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PSI POWER SOLUTIONS, INC.

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.

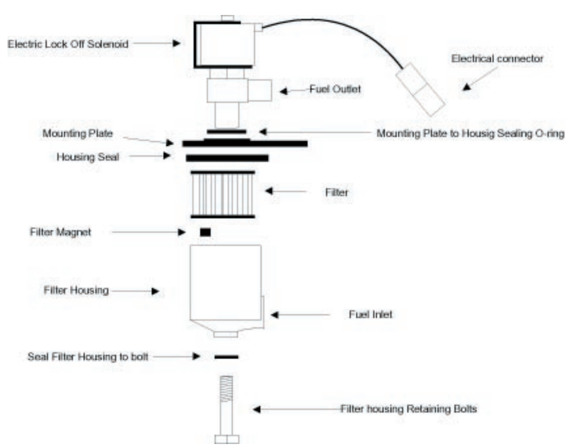
Important
- Residual vapor pressure will be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

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.

Figure 1
Filter Lock Assembly



PROPANE FUEL FILTER REPLACEMENT (FIGURE 1)

Removal Procedure

1.Relieve the propane fuel system pressure. Refer to *Propane Fuel System Pressure Relief.*
2. Disconnect the negative battery cable.
3. Slow loosen the Filter housing retaining bolt and retain.

4. Pull the filter housing down from the Electric lock off assembly
5. Locate Filter magnet and retain
6. Remove the filter from the housing
7. Remove and discard the housing seal
8. Remove and discard the retaining bolt seal.
9. Remove and discard mounting plate to lock off O-ring seal

Installation Procedure

- **Important:** Be sure to reinstall the filter magnet into the housing before installing new seal

1. Install the mounting plate to lock off O-ring seal
2. Install the retaining bolt seal
3. Install the housing seal
4. Drop the magnet into the bottom of the filter housing
5. Install the filter into the housing
6. Install the retaining bolt into the filter housing
7. Install the filter up to the bottom of the electric lock off
8. Tighten the filter retain bolt to specification

    Tighten

    12 Nm (106 in lbs).

9. Open manual shut-off valve.

Start the vehicle and leak check the propane fuel system at each serviced fitting Refer to **Propane Fuel System Leak Test.**.

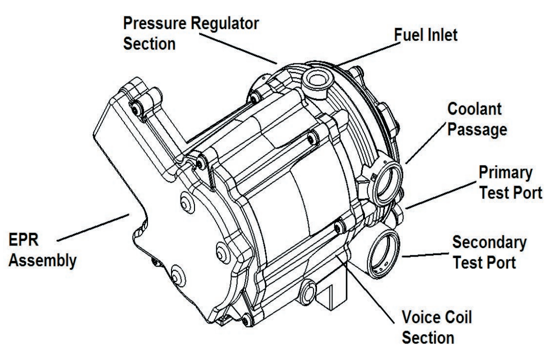


FIGURE 2
EPR Assembly

ELECTRONIC PRESSURE REGULATOR (EPR) ASSEMBLY REPLACEMENT (FIGURE 2)

The EPR assembly is a made up of two separate components. The Voice Coil Section is not serviceable and can only be replaced as an assembly. The pressure regulator section is serviceable and will be detailed in this section.

EPR Assembly Removal Procedure

1. Relieve the propane fuel system pressure. Refer to *Propane Fuel System Pressure Relief.*
2. Disconnect the negative battery cable.
3. Slowly remove the fuel inlet fitting at the Electric Lock Off

NOTE: Residual vapor pressure will be present in the fuel system.

4. Disconnect the electrical connector to the Electric Lock off
5. Remove the Electric Lock Off from the regulator
6. Remove the lock pin from the vapor fitting on the regulator housing and remove the fitting and hose and retain the pin
7. Remove the lock pin from the pressure sensor on the regulator housing and remove the Sensor and retain the pin
8. Using a clamp pliers pinch off the hoses on the coolant lines to the regulator
9. Remove the lock pin from both the water fittings on the regulator housing and remove the fittings and hoses and retain the pin
10. Disconnect the EPR electrical connector
11. Remove the (3) three nuts from the EPR isolators and the EPR mounting bracket
12. Remove the EPR from the bracket
13. Remove the (3) three mounting isolators

Installation Procedure

Important

- Do not use Teflon tape on any fuel fitting. Use a liquid pipe thread sealant when installing fittings.
- Check all the O-rings on the vapor and water fittings for any damage replace if necessary
- Lube all the O-rings with an O-ring lube before installing.

1. Install the three (3) rubber isolators to the bottom of the EPR
2. Install the EPR assembly to the bracket and tighten the retaining nuts

NOTE: Do not over tighten the isolators and cause a separation of the isolators

3. Install the fuel temperature sensor into the regulator opening and lock in place with the locking pin, connect the electrical connector
4. Insert the fuel vapor line and fitting into the regulator port and lock in place with the locking pin
5. Install both the water hoses and fittings into the regulator and lock in place with the locking pin remove the clamp pliers from the hoses
6. Install the electric lock off into the regulator inlet and tighten into proper location, connect the electrical connector
7. Connect the fuel supply line and tighten until fully seated
8. Connect the EPR electrical connector
9. Open the manual valve
10. Start the vehicle and leak check the propane fuel system at each serviced fitting Refer to *Propane Fuel System Leak Test.*

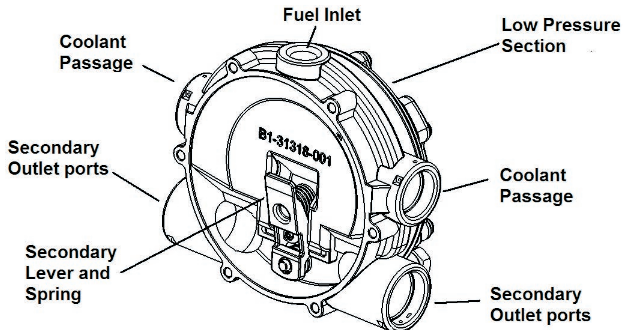


Figure 3
Pressure Regulator Section

Pressure Regulator Section Removal

1. Remove the EPR refer to *EPR Removal Procedure*
2. Remove the six (6) regulator to voice coil screws using the special tool and separate the regulator from the actuator.

IMPORTANT: DO NOT REMOVE THE SECONDARY DIAPHRAGM RETAINING PLATE AND DIAPHRAGM THIS WILL VOID THE WARRANTY OF THE ACTUATOR SECTION.

Installation Procedure

1. Install the regulator to the actuator section using the six (6) retaining screws and tighten to specification.
   Tighten
   8 Nm (70 in lbs).
2. Install the EPR refer to *EPR Installation*

TEMPERATURE MANIFOLD ABSOLUTE PRESSURE (TMAP) SENSOR (Figure 4)

Removal Procedure

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

Installation Procedure

- Apply a small amount of O-ring lubricant before installation

1. Install in reverse order
2. Tighten retaining bolts
   Tighten
   7 Nμ (62 lb-in)
3. Start the vehicle

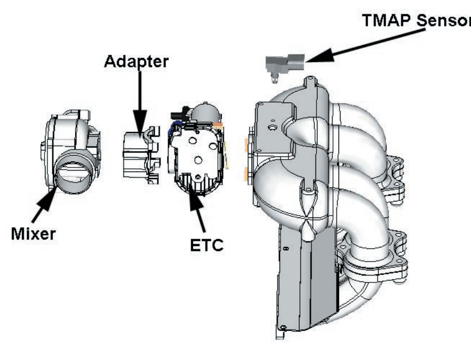


Figure 4
TMAP Sensor & Electronic Throttle Control (ETC)

ELECTRONIC THROTTLE CONTROL REPLACEMENT (FIGURE 4)

Removal Procedure

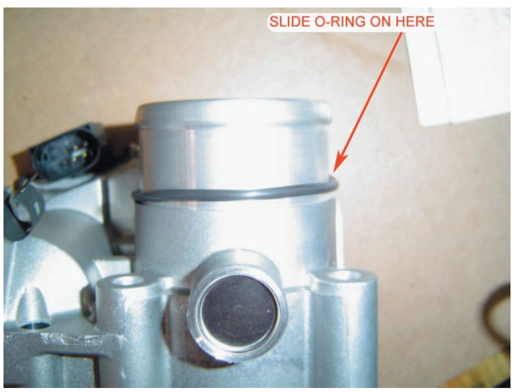
1. Disconnect the negative battery cable.
2. Remove the air intake duct.
3. Release the hose clamp on the vapor fuel line and remove the vapor hose
4. Disconnect the TMAP electrical connector
5. Disconnect the electronic throttle control device connector
6. Remove the manifold to throttle body adapter bolts and remove the throttle body mixer assembly
7. Pull the throttle body assembly from the adapter
8. Remove electronic throttle control device
9. Remove the O-rings gasket and discard

Installation Procedure

Important

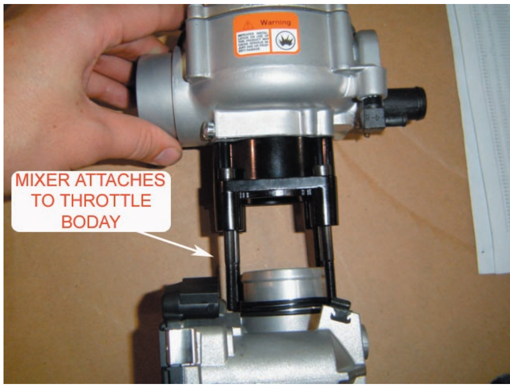
- **Lightly Lubricate the both the O-rings of the throttle control device to adapter**

1. Install the O-ring (32501097) on throttle body. Press it down to the bottom of the surface.



2. Install the two quad seals (33000599). Install one seal at a time to insure the seal does not roll. The seal must sit flat on the throttle body.

3. Attach mixer and throttle body together. The two parts do not bolt together; they will be secured when you mount it on the intake. Notice the orientation of the air inlet and throttle body cover.



4. Place gasket on intake manifold and attach mixer/throttle assembly to manifold.

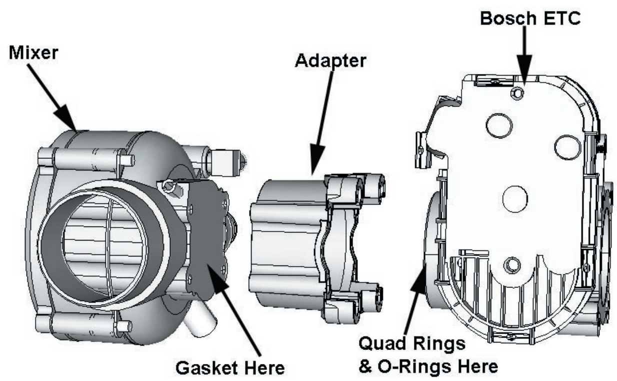


Figure 4A
Mixer Assembly

MIXER REPLACEMENT (FIGURE 4A)

1. Remove the Throttle control device *Refer to Electronic Throttle Body Replacement*
2. Remove the four (4) bolts to the throttle control device to mixer adapter bolts
3. Remove and discard the mixer to adapter gasket.

Installation Procedure

Important
- Cover Throttle body adapter opening to prevent debris from entering engine until reassembly

1. Install Mixer to adapter gasket onto the mixer
2. Install the mixer to the throttle control device to mixer adapter and secure with the 4 retaining screws

Tighten
9 N•m (80 lb-in)

3. Install Throttle body *Refer to Electronic Throttle Control Device Replacement*
4. Start the engine and leak check all fittings and connections

COOLANT HOSE REPLACEMENT

1. Drain the coolant
2. Using a hose clamp pliers disconnect both hose clamps on each hose
3. Remove the hose from each of the fittings

NOTE: Use hose material and lengths specified by the OEM

4. Install the hose clamps to each hose and set the clamp back on each hose to make installation easier
5. Fit the hose to the fittings
6. Secure by positioning each of the clamps

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

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 O2 sensor electrical connector
3. Using a O2 Sensor socket remove the O2 Sensor and discard

Installation Procedure

Important
- **Before install the O2 sensor lubricate threads with anti-seize compound GM P/N 5613695 or equivalent. Avoid getting compound on the sensor tip**

4. Install O2 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. Inspect and replace any gaskets and/or sealing rings as necessary
4. Start engine
5. Check for any DTC codes and clear
6. Verify engine is in closed loop and no MIL lights are present

PSI 3.0L PFI
FUEL SYSTEM DIAGNOSIS SECTION

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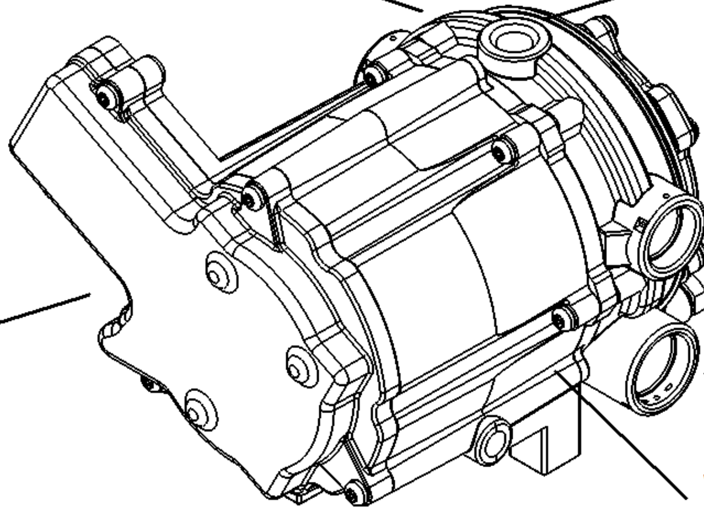
LPG Fuel System Diagnosis



Fuel System Description

To maintain fuel and emission control on the LPG fuel system the Engine Control Units (ECM) relies on numerous engine sensor and output data from the Electronic Pressure Regulator (EPR). The ECM will then determine the target fuel calibration and command the EPR to reposition the voice coil to the proper position which, subsequently reposition the secondary lever in the pressure regulator to maintain proper control. The EPR and ECM will continue to communicate back and forth during normal operation.

In the event that the EPR fails to communicate or the Communications Area Network (CAN) cable fails to transmit data the regulator will operate in an open loop configuration. As the air valve vacuum in the mixer venturi is communicated to the secondary chamber of the regulator the secondary diaphragm will be drawn in a downwards motion. This downward motion will cause the secondary lever to open thus allowing more fuel to enter the mixer.

In the (LPR) the fuel is vaporized and the pressure reduced in two stages. The first stage reduces the pressure to approximately 6.8 to 20.6 kPa (1.0 to 3.0 psi). The second stage reduces the pressure to approximately negative 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)
- DVOM (GM J 39200, Fluke 88 or equivalent).
- 12 volt test light

Diagnostic Scan Tool
- Diagnostic Display tool.

Pressure Gauges
- IMPCO ITK-3 Test kit
- 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 determines if the LPR requires replacement
6. This step determines if the problems are in the mechanical side of the Pressure Regulator or the Electronic Voice Coil
10. This step determines if the Mixer requires replacement
14. This step determines if the Lock Off requires replacement
17. This step determines if the Fuel Filter requires replacement.

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. Is the fuel pressure within the specified range?	-.5" to -2.5" w.c	Go to *Step 25*	Go to *Step 6*
6	1. Disconnect the EPR electrical connectors. **Note:** This action will cause a DTC to be set by the ECM 2. With the engine idling observe the pressure reading on the secondary test port. Is the fuel pressure **WITHIN** the specified range?	-.5" to -2.5" 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 any vacuum hoses for leaks 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*

Step	Action	Value(s)	Yes	No
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 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?	1- 3 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 Ω - 16Ω	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*

Step	Action	Value(s)	Yes	No
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 18*
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 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 *Lock-off 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*	—

Step	Action	Value(s)	Yes	No
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 SNOOP® or equivalent, leak check the test port plugs. Is the action complete?	—	System OK	—

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.**
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 ECM 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 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. • 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.

Checks	Action
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

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	**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 EPR • Check for air intake system leakage between the mixer and the throttle body. • Check the fuel system pressures. Refer to the *Fuel System Diagnosis*.
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 moisture in the distributor cap if applicable. • Check for loose ignition coil connections. **Important**: 1. If the engine starts but then immediately stalls, Check the Crankshaft Position (CKP). 2. Check for improper gap, debris or faulty connections.

Checks	Action
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* or *Exhaust System* in the GM Base Engine Service Manual
Additional Checks	•

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 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 EPR electrical connections.
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 each 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 sensor.
Exhaust System Checks	• Check the exhaust system for a possible restriction: – Inspect the exhaust system for damaged or collapsed pipes – Inspect the muffler for signs of heat distress or for possible internal failure. – 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

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 EPR. • 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.
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 – 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	**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 ECM grounds for being clean, tight, and in their proper locations. • Check the battery cables and ground straps. They should be clean and secure. Erratic voltage may cause all sensor readings to be skewed resulting in poor idle quality..

Checks	Action
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 ECM 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

PSI 3.0L PFI
ELECTRICAL SECTION
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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.

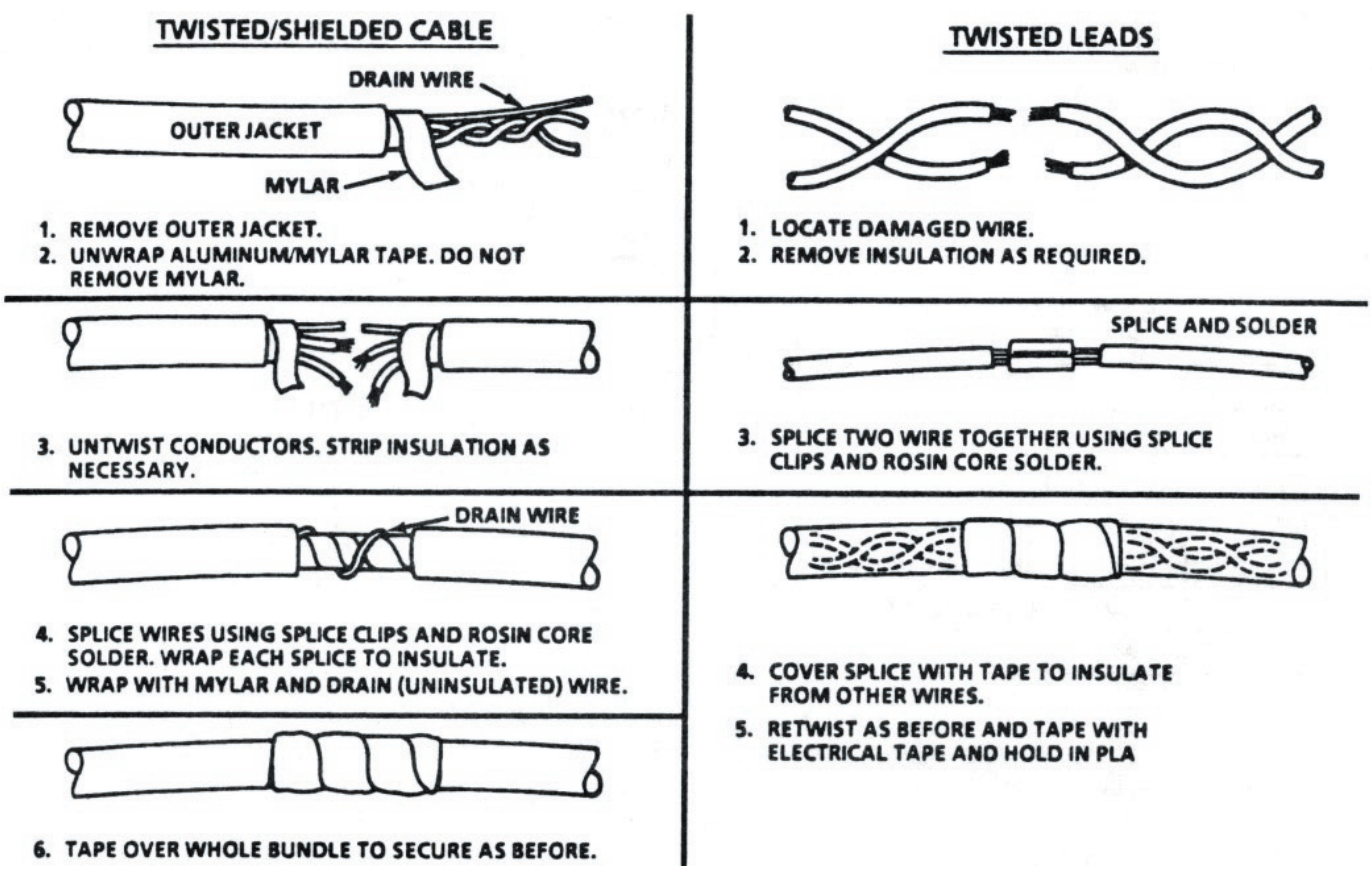
CONNECTORS AND TERMINALS

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



Micro-Pack

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

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).

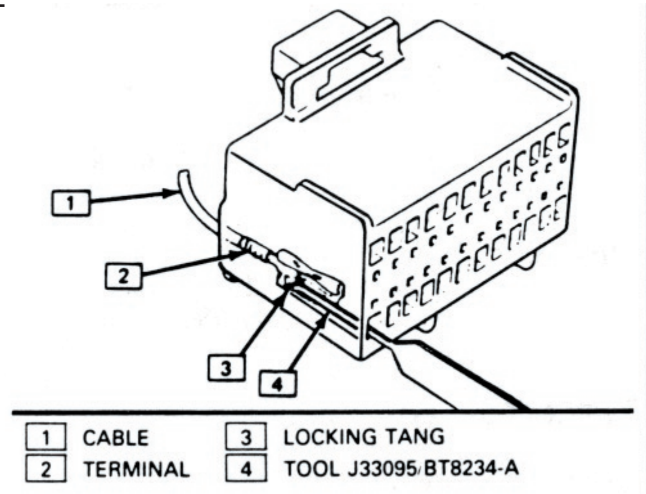


FIGURE 2 MICRO_PACK CONNECTOR

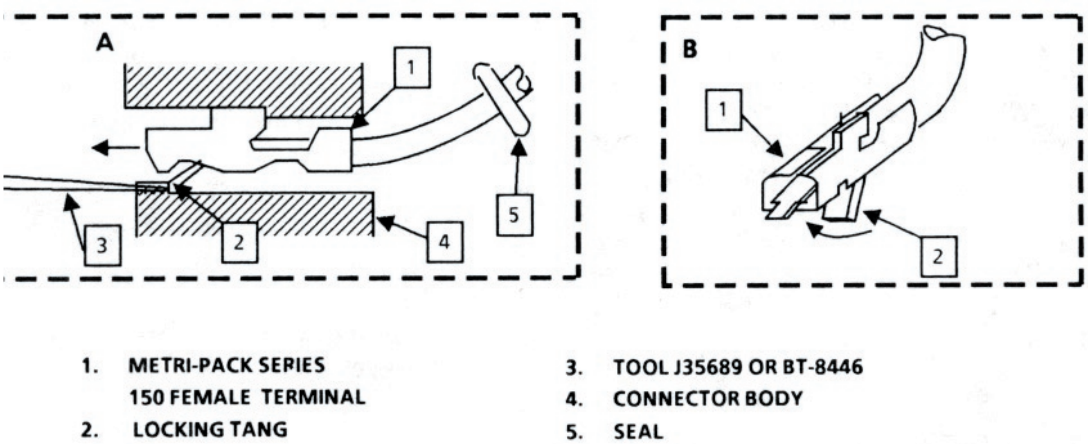


FIGURE 2 METR-PACK SERIES 150 TERMINAL REMOVAL

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.

Repair of a Weather-Pack terminal is shown in Figure 4. Use tool J 28742, 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.

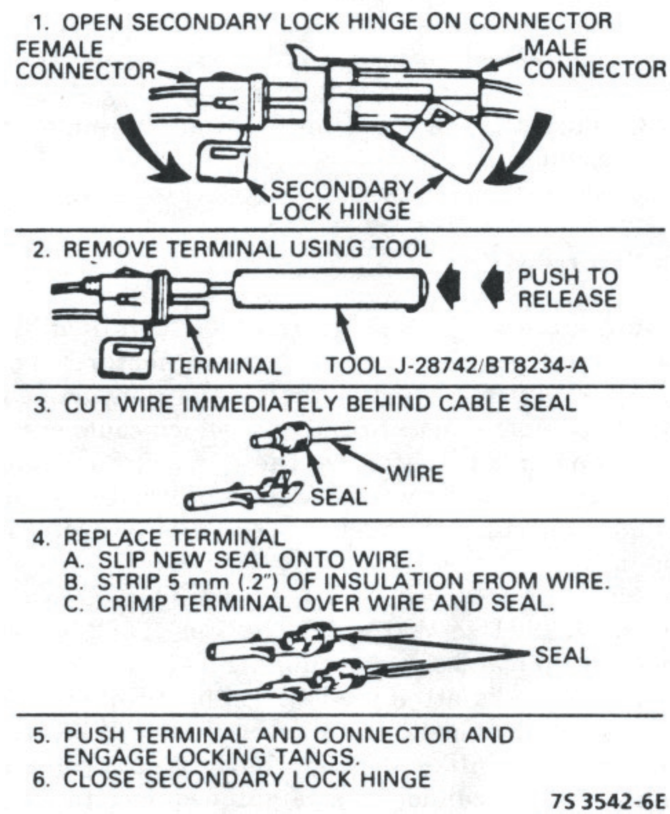
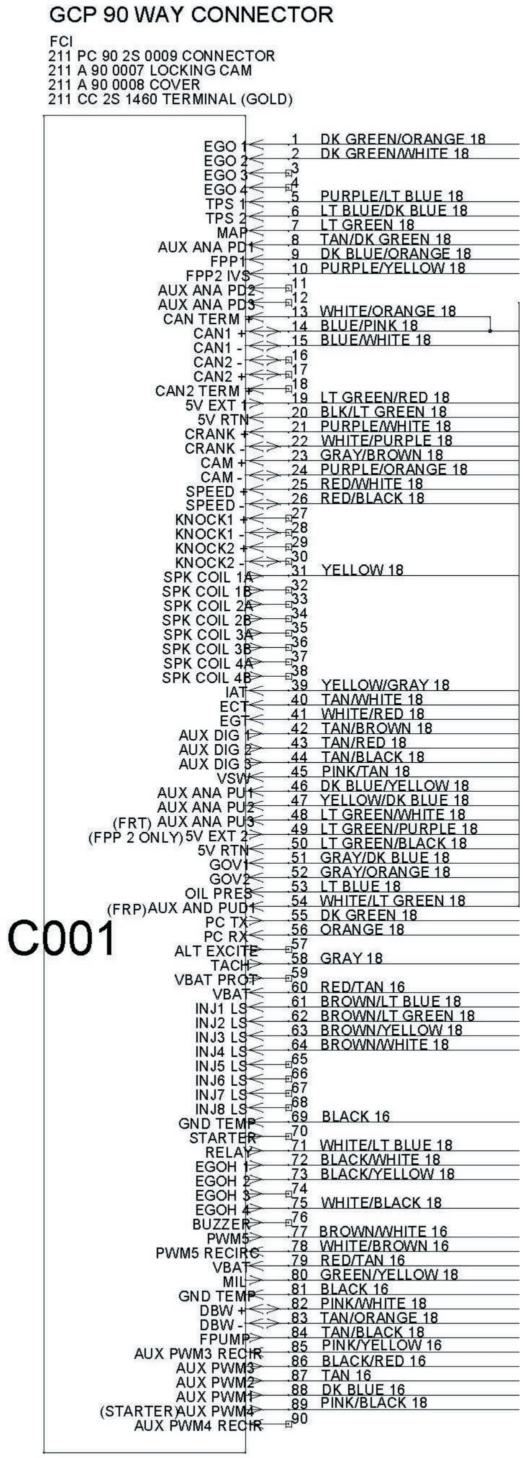
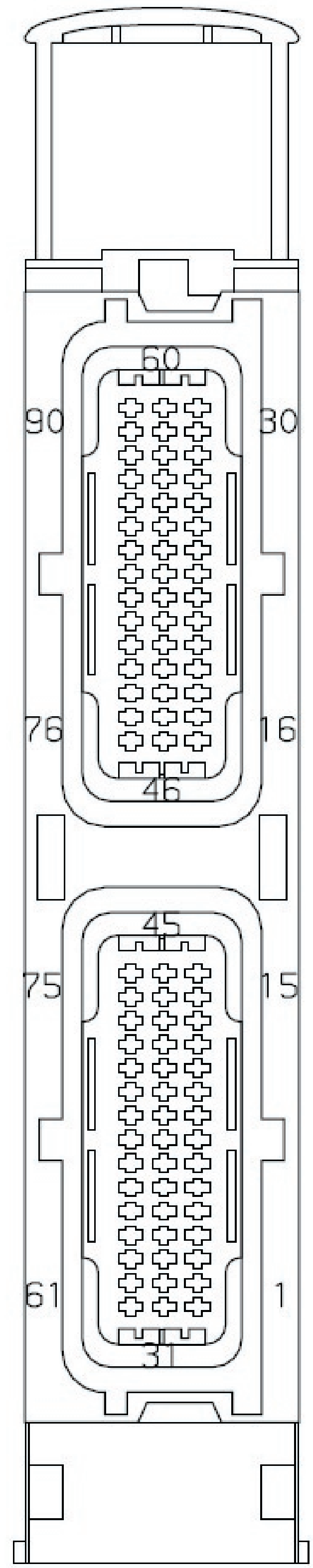


FIGURE 4 WEATHER PACK TERMINAL REPAIR

ECM Header Connector Pin-Out



ECM Header Connector Termnial Identification



Customer Interface Connector Pin-Out

CONNECTOR 2

PED_15326868 CONN
PED_15304707 TERM
PED_12191153 SEAL

C010

PINK/DK GREEN 16	S	12V RELAYED POWER
TAN/DK GREEN 18	R	AUX ANA PD1
RED/BLACK 18	P	VS -
RED/WHITE 18	N	VS +
TAN/BLACK 18	M	AUX DIG 3
TAN/RED 18	L	AUX DIG 2
GRAY/DK BLUE 18	K	GOV SELECT 1
GRAY/ORANGE 18	J	GOV SELECT 2
DK BLUE/YELLOW 18	H	AUX ANA PU1
YELLOW/DK BLUE 18	G	AUX ANA PU2
TAN 18	F	AUX PWM 2
BLACK 16	E	GROUND
GRAY 18	D	TACH
BROWN/WHITE 16	C	AUX PWM 5
WHITE/BROWN 16	B	AUX PWM 5 RECIRC
	A	UNUSED

VEHICLE INTERFACE CONNECTORS

CONNECTOR 1

PED_15326863 CONN
PED_12191819 TERM
PED_12191153 SEAL

C011

LT GREEN/PURPLE 18	S	5V EXT 2 (FPP2 ONLY)
LT GREEN/BLACK 18	R	5V RTN 2
BLUE/WHITE 18	P	CAN1 -
BLUE/PINK 18	N	CAN1 +
LT GREEN/RED 18	M	5V EXT 1
BLACK/LT GREEN 18	L	5V RTN 1
DK BLUE/ORANGE 18	K	FPP1
PURPLE/YELLOW 18	J	FPP2/IVS
TAN/BROWN 18	H	FUEL SELECT (AUX DIG 1)
GREEN/YELLOW 18	G	MIL
LT BLUE/PINK 16	F	START COMMAND
DK BLUE 18	E	AUX PWM 1
PINK/YELLOW 16	D	FUEL PUMP +
BLACK/RED 16	C	FUEL PUMP -
PURPLE 16	B	ALT EXCITE
PINK 18	A	VSW

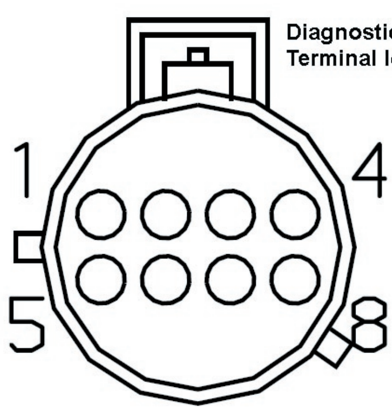
DIAGNOSTIC CONNECTOR

EPC_1F1T-14A624-AA-004 CONN
GTS_0330-930009 TERM (18-20)
GTS_0330-940001 TERM (14-16)
EPC_E6DB-14A468-DA LOCK
EPC_F5AB-14A666-AA CAP

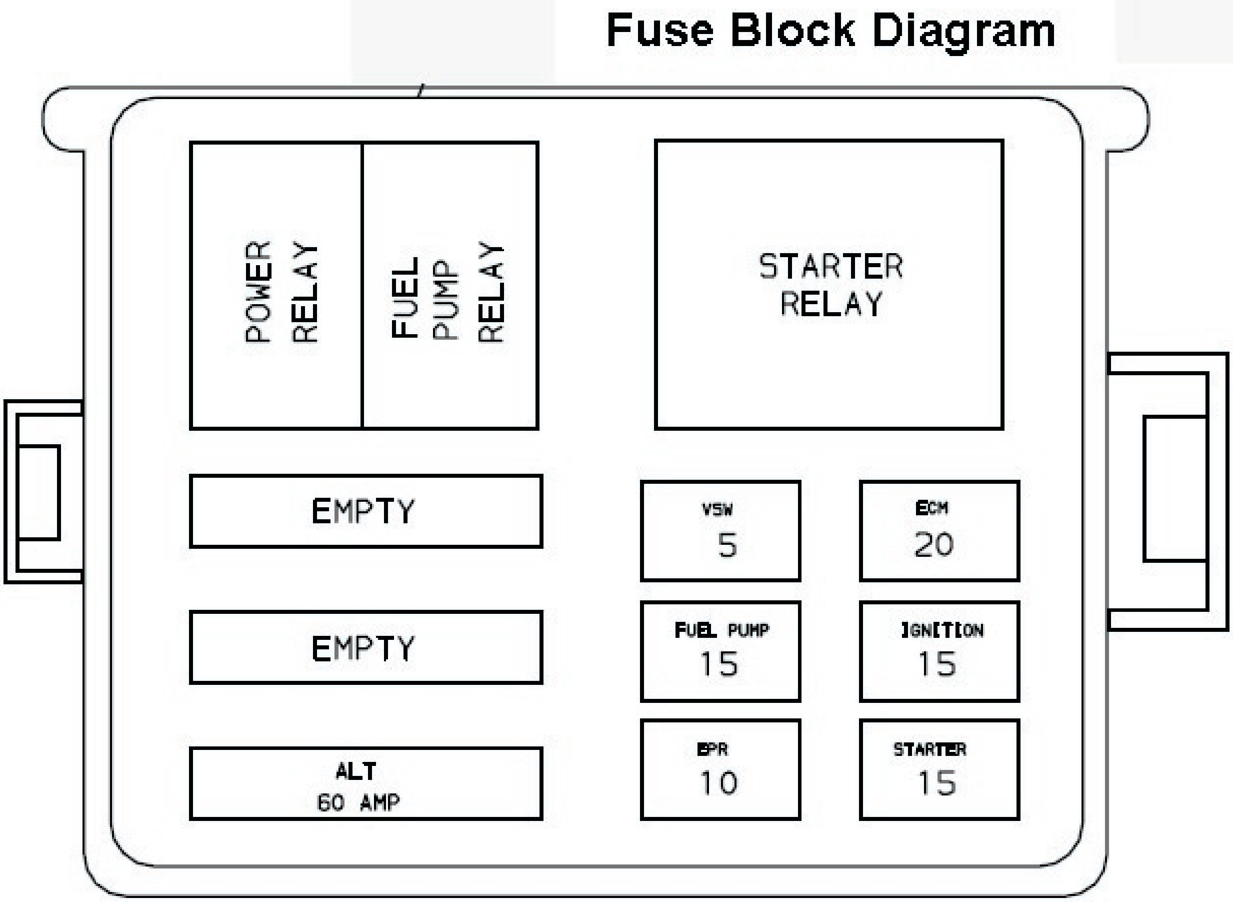
C016

BLACK/LT GREEN 18	1	ANA RTN
LT GREEN/RED 18	2	5V REF
DK GREEN 18	3	PC TX
ORANGE 18	4	PC RX
	5	UNUSED
	6	UNUSED
BLUE/PINK 18	7	CAN1 +
BLUE/WHITE 18	8	CAN1 -

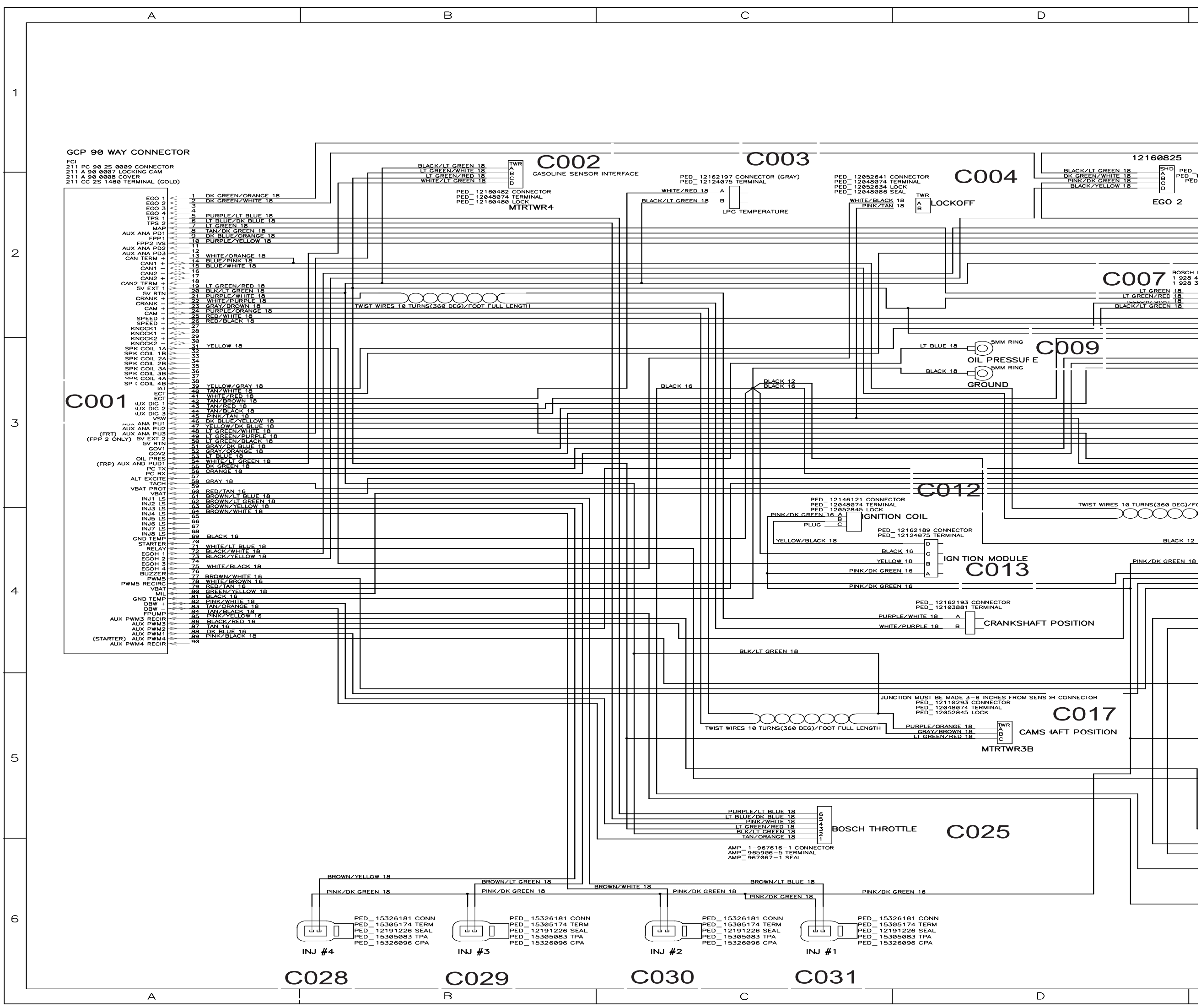
Diagnostic Connector Terminal Identification



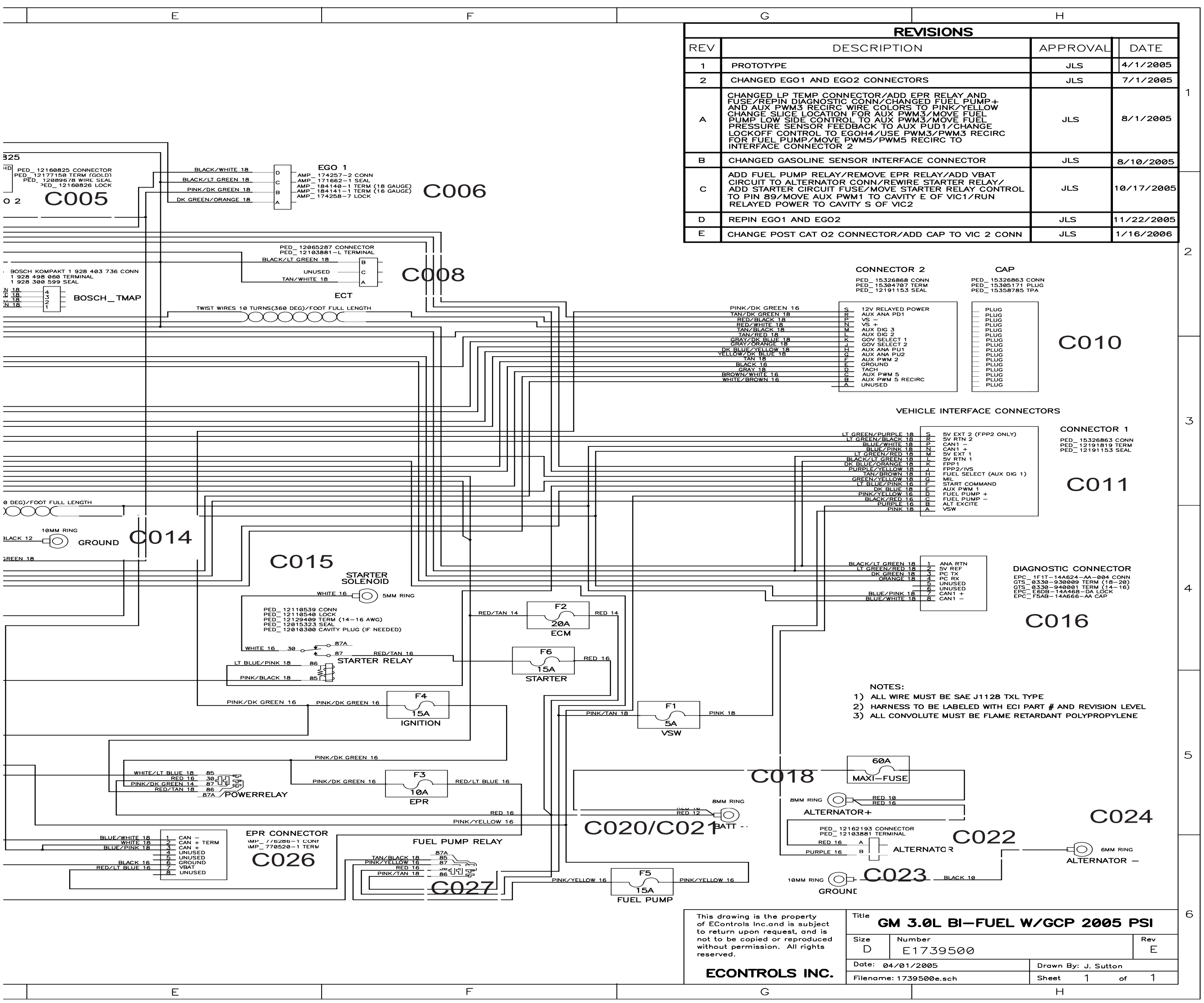
Engine Wire Harness Fuse and Relay Center Layout



Engine Wiring Schematic - Part A



Engine Wiring Schematic - Part B



Diagnostic Service Tool Installation Instructions

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

Supported operating systems are:

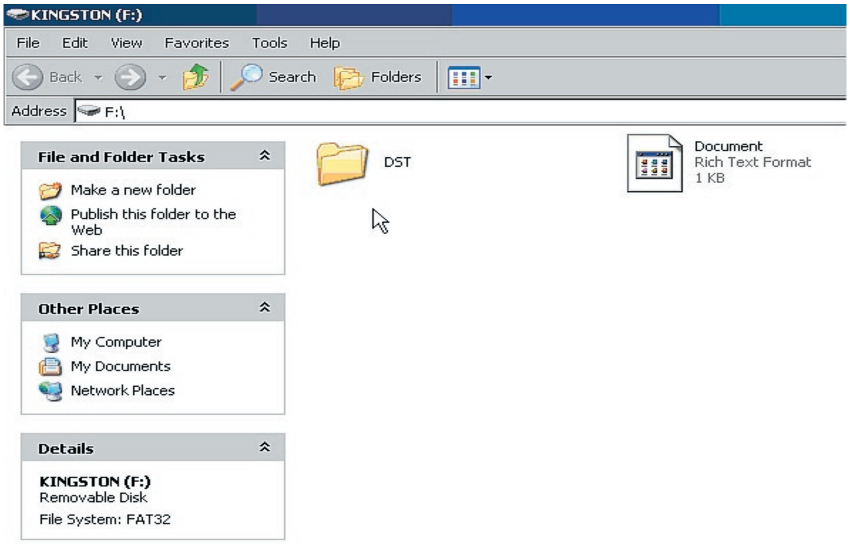
Windows XP
Windows 2000
Windows 98SE (Second Edition)

Minimum processor speed:
Pentium II 450 MHz

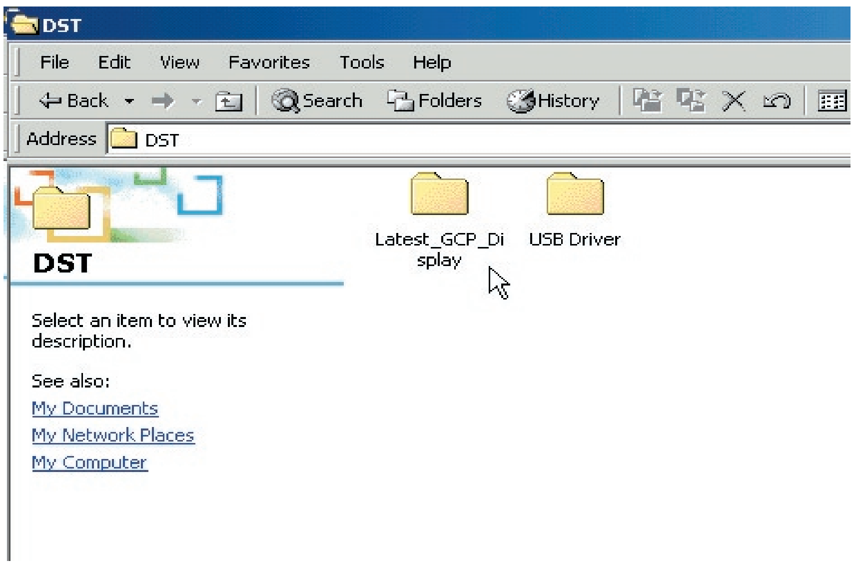
Minimum RAM requirement:

Windows XP	256 MB
Windows 2000	128 MB
Windows 98SE	128 MB

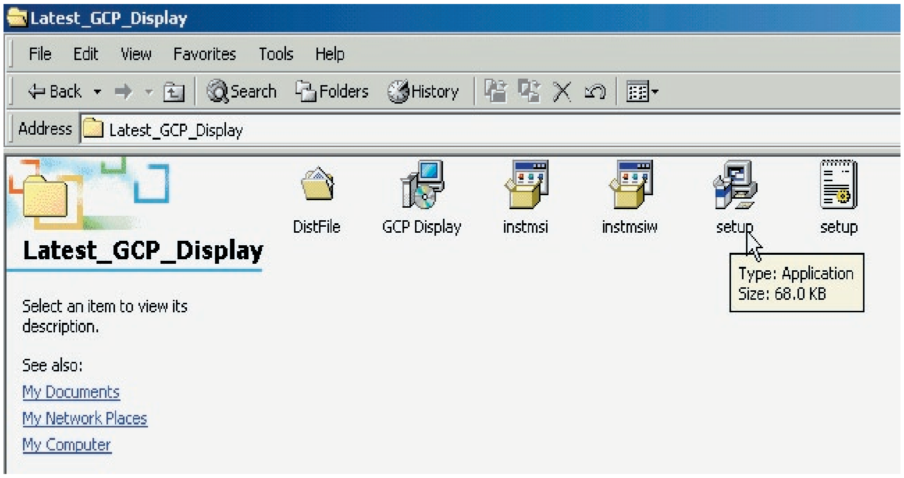
* At least one available RS232 serial or USB port.
* USB Driver does not support Windows 98SE (Second Edition)



- Open the DST folder

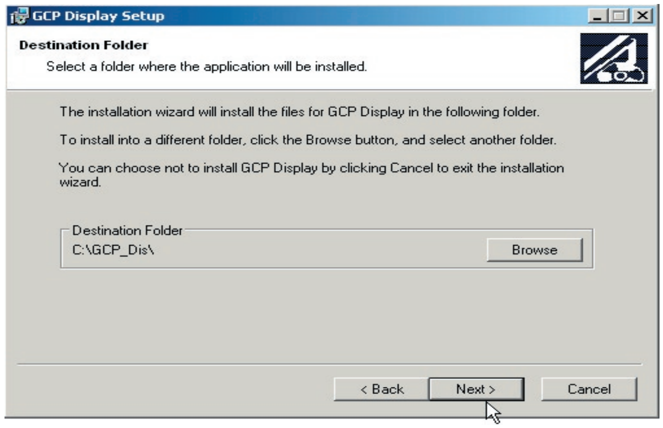


- Open the Latest_GCP_Display folder

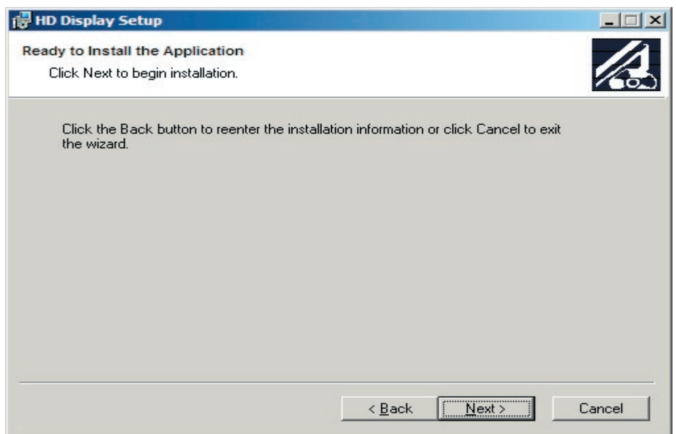


- Double click on “setup.exe” (application file) to start the windows installer. If a previous version of the GCP software is installed, the uninstaller will remove the previous version and exit. You will be required to start the installer again to install the new version.

- Click next to continue

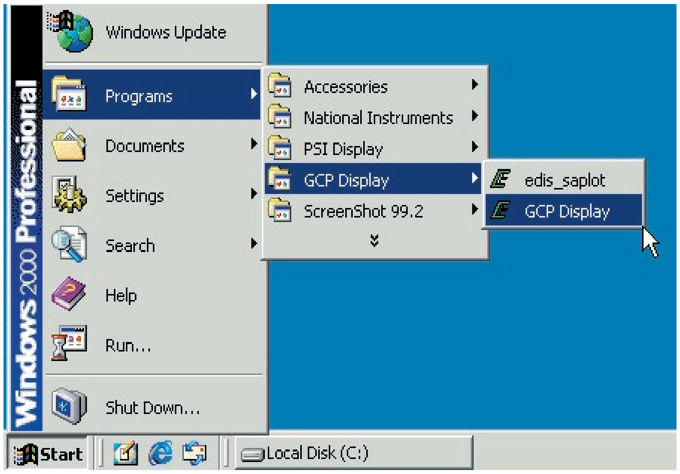


- Click next to continue



- Click next to continue

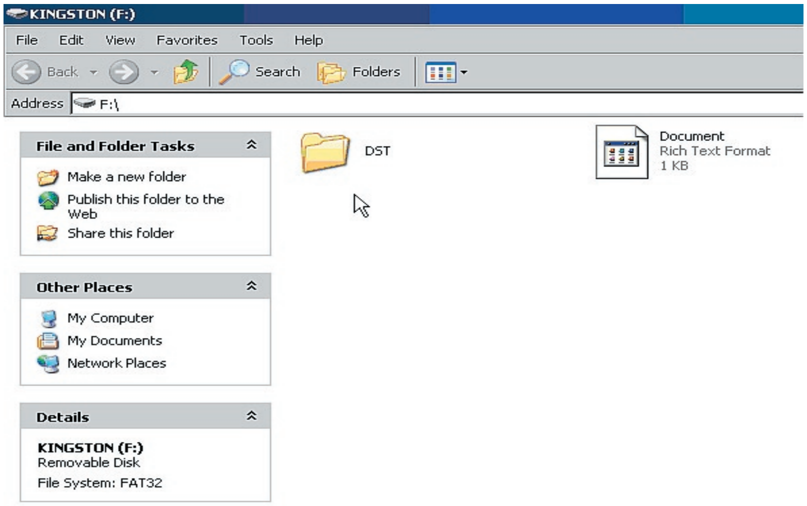
- Click the “finish” box to complete the installation.



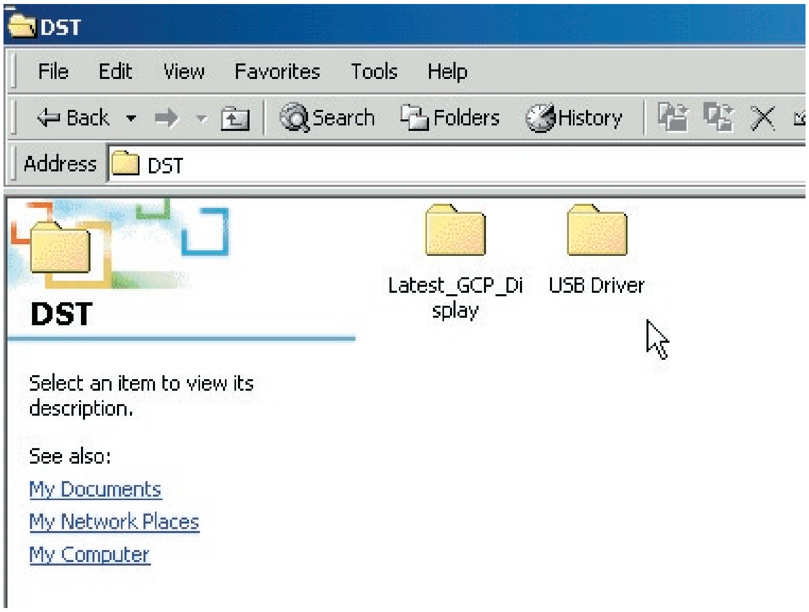
Once installed, the software can be accessed from
Start Menu → Programs → GCP Display → GCP Display

Installing the USB Adapter Driver

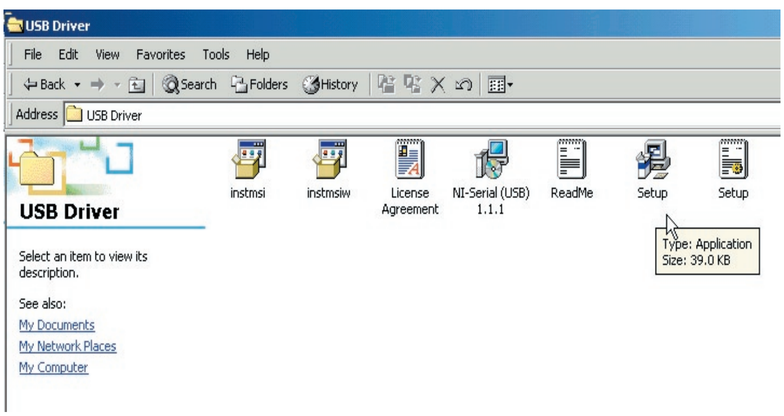
If your computer does not have an RS232 serial port, you will need to install the USB adapter driver. The installation of this driver is similar to the GCP display.



- Open the DST folder



- Open the “USB Driver” folder



- Double click on "setup.exe" (application file) and follow the on screen prompts.

Password Login

Figure 1 shows the password dialog box, which is displayed when a software session begins. Login can be accomplished in two ways.

1. Enter an 'All S/N Password' which is applicable to all ECMs of a given original equipment manufacture (OEM).

2. Enter a 'Single S/N Password' and corresponding serial number for a single ECM. A Single Serial Number password is only applicable for the specific ECM serial number it applies to, and is useful for authorizing service personnel to make changes or view information for a single ECM for which they would otherwise not have access to.

In most instances the top "all" serial number boxes should be used for password entry. In this case, do not check the single serial number box. Each password is a 16-character alpha-numeric string specific to each customer and determines which pages and variables are visible through the software. Passwords are assigned to an OEM by PSI and may change periodically. Check the "save password" box to automatically retain the password for future use.

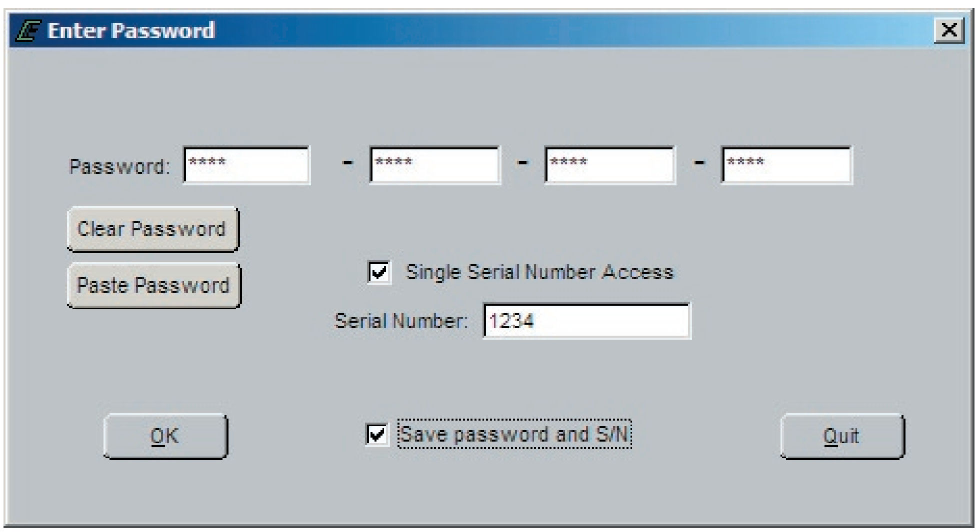


Figure 1: Populated Password Dialog Box

Password Dialog Box Functions

- Clear Password Button- Erases the current password from the password field
- Paste Password Button- Allows the user to copy a 16-character string from any word processor and paste the string in the password field
- Single Serial Number Access Checkbox- Tells the software that the password is applicable for single serial number access
- Serial Number Field- Only applicable when Single Serial Number Access Checkbox is checked. The entry field must be populated for the 6-digit serial number for which the Single Serial Number Access password

applies (NOTE: Leading zeros included in the serial number are not required).

- Save Password and S/N Checkbox- Retains the password, and serial number (if applicable) for the next software session.

Should an invalid password be entered, the error prompt shown in figure (2) will be displayed and the software will not load. This prompt signifies the following:

- The All S/N password is invalid
- The Single S/N password is incorrect for the Single Serial Number entered
- An All S/N password is entered for Single Serial Number use
- The Single Serial Number password is valid, however, the Single Serial Number Access Checkbox is not checked

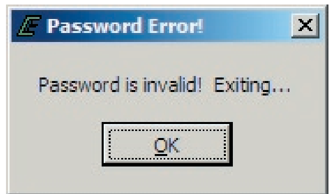


Figure 2: Password Error Prompt

If the Single S/N password entered is correct for the software but does not match the entered S/N of the targeted ECM, the prompt in Figure 3 will be displayed.

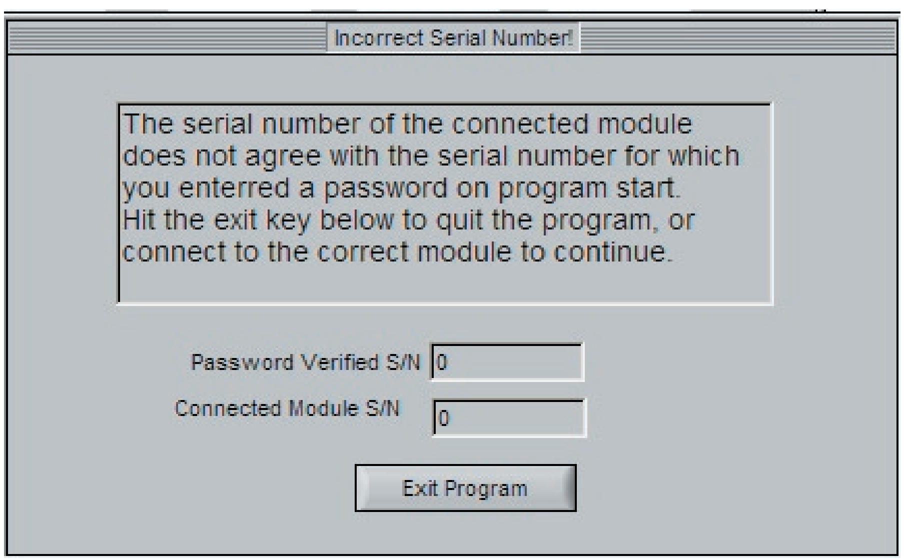


Figure 3: Incorrect Serial Number Message

Figure 4 shows the communication status if a valid software password is entered when attempting to connect to an ECM with a different key. In this instance the software will load but will not connect to the target (ECM).

Figure 4: Not Authorized to Connect Message

In the event you receive this error message call your OEM support group for more information.

Connecting the PC to the Engine Control System

A laptop computer is the required tool for performing proper diagnostic testing of the engine control and fuel 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 DST software also performs several special tests.

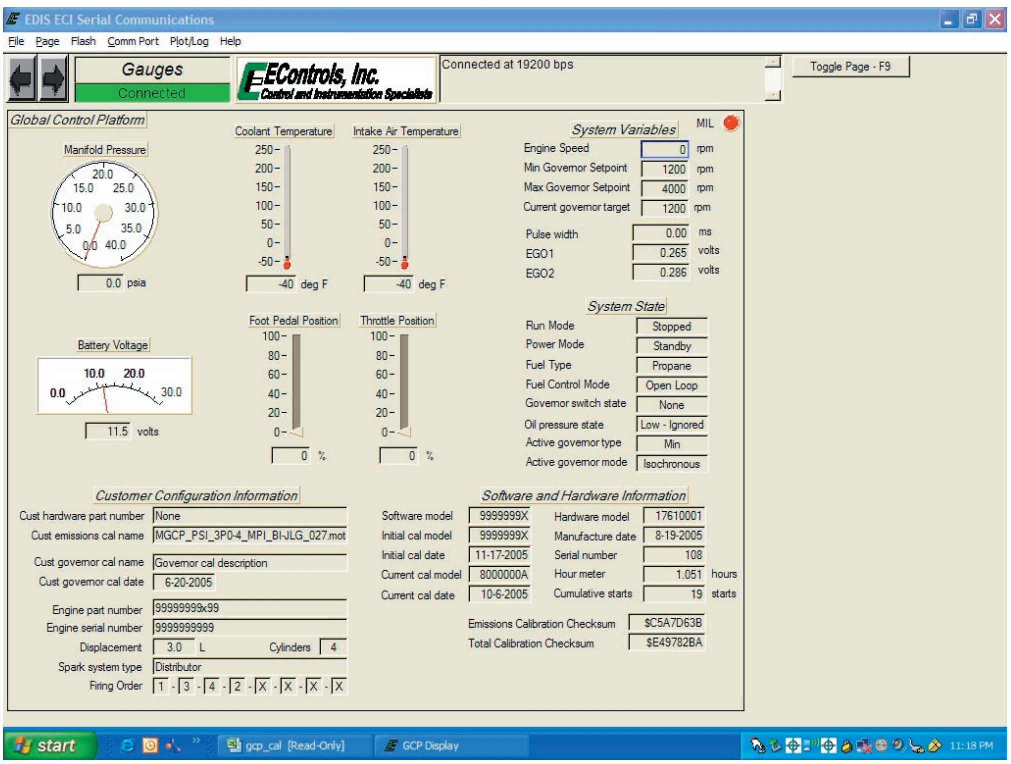
- Connect the system diagnostic cable to the RS232 port on the back of the computer. If you do not have a RS232 port, use the USB to RS232 adapter supplied in the IMPCO ITK test kit. Be sure to install the USB driver to enable the USB adapter for use with your computer.
- Connect the diagnostic cable to the DLC (diagnostic link connector) labeled C016 in the electrical schematic. The DLC is located on the engine harness. The new 8 pin DLC requires the use of the 4 to 8 pin adapter included in the late model ITK test kits.
- Turn the computer ON.
- Start Windows.
- From the start menu select Programs → GCP Display → GCP Display and enter password
- Place the ignition key in the ON position.

Within several seconds the system Gauge screen should now appear and a green banner in the upper left hand will read “Connected”.

DST Service Screens

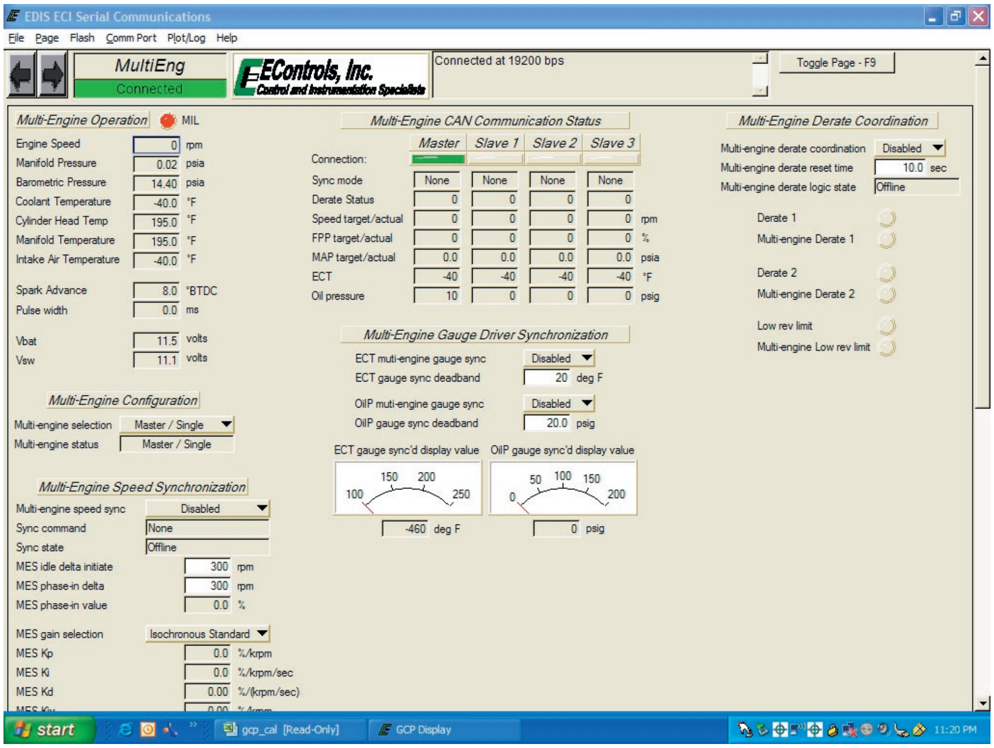
Gauge Screen

Provides system data in large easy to read displays. Displays ECM configuration information for the ECM software, hardware, serial numbers and calibration dates.



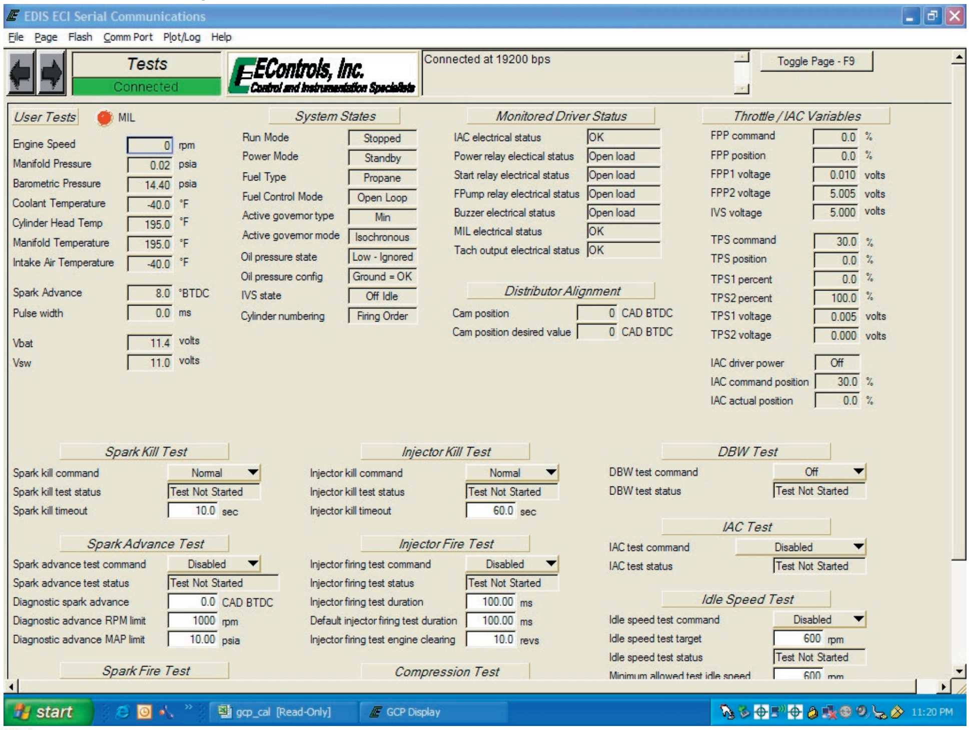
Multi Engine Page

The multi engine page provides a convenient way to access system voltages and sensor inputs for multiple engine installations. It also includes system status on power derate modes.
This screen has limited use for single engine applications.



Test Screen

Provides diagnostic information voltages and sensor outputs and includes diagnostic engine tools such as spark and injector kill controls. Please note that not all features are available for all applications. Disabled item menus are grayed out or rendered inoperative



Spark Kill

The spark kill 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 Kill

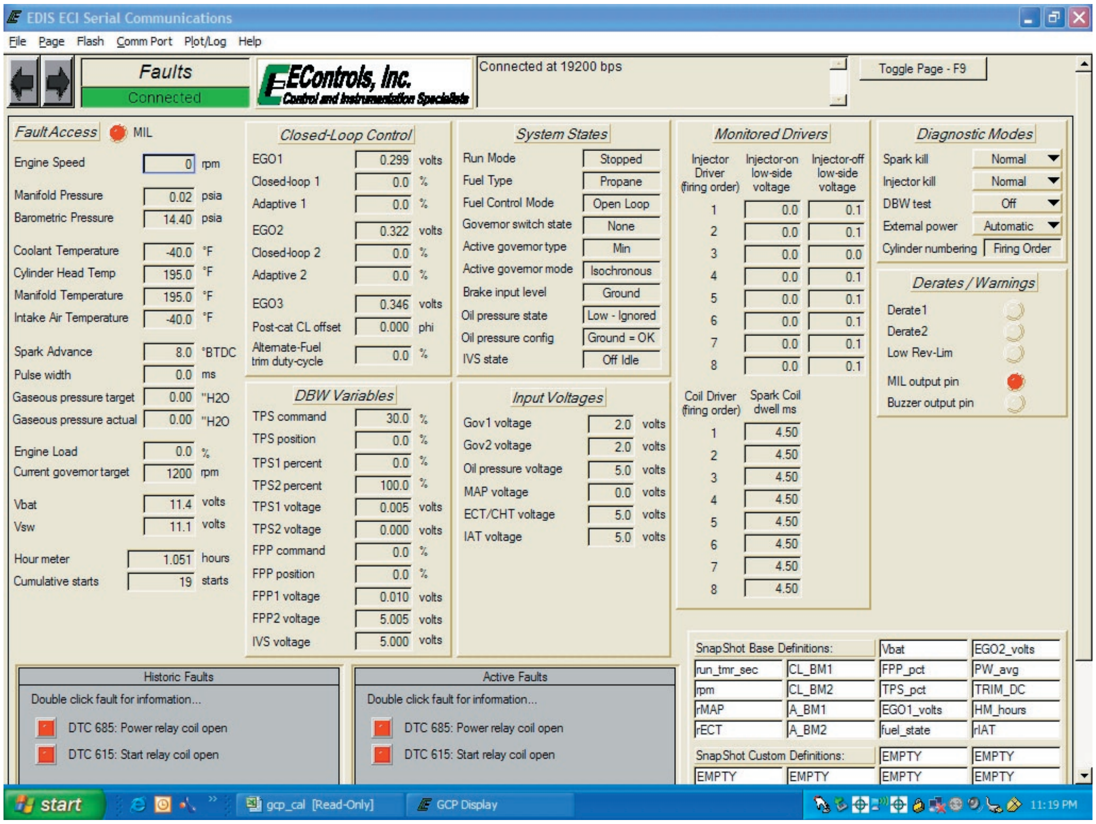
The Injector Kill mode is used to disable individual fuel injectors. If the Injector Kill mode is selected with the engine running below 1000 RPM, the minimum throttle command will lock into the position it was in when the test mode was entered. If the Injector Kill mode is selected with the engine running above 1000 RPM, the throttle will continue to operate normally. To disable an injector, use the mouse to select the desired injector. 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 while each driver is disabled.

DBW Test Mode

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 systems that use DBW control. 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. To select this test mode the engine must be off and the key must be in the ON position

External Power Test

The external power test manually activates relays (relay power, fuel pump, and drive-by wire power) controlled by the ECM while the engine is in the “Stopped” or “Running” states. Reverts to normal operation if “Automatic” state is selected or ignition voltage is cycled from high to low.



Faults Page

Stores DTC codes that may have occurred in the past (Historic Faults) or current set codes (Active Faults). Includes useful system voltages and senor readings used while working with the fuel and emission trouble shooting charts. Shows power derate mode status. To erase a historic DTC code, double click on the code with the left mouse button. Then choose to “erase all codes” or only selected codes in the pop up box.

Plot/Log Menu Functions

The Plot/Log menu allows the user to graphically plot or numerically log variables that have been tagged for plotting/logging. To plot or log variables, a tag must be assigned to each variable of interest. A variable is tagged for plotting/logging through a single right-mouse click in the variable’s vicinity. Once a variable has been tagged for plotting/logging it is highlighted in green. Figure 5 shows an example of variables that have been tagged. A maximum of twenty (20) variables may be tagged for logging and a maximum of ten (10) variables may be tagged for plotting. The maximum achievable sample frequency/minimum period is dependent on the number of variables tagged.

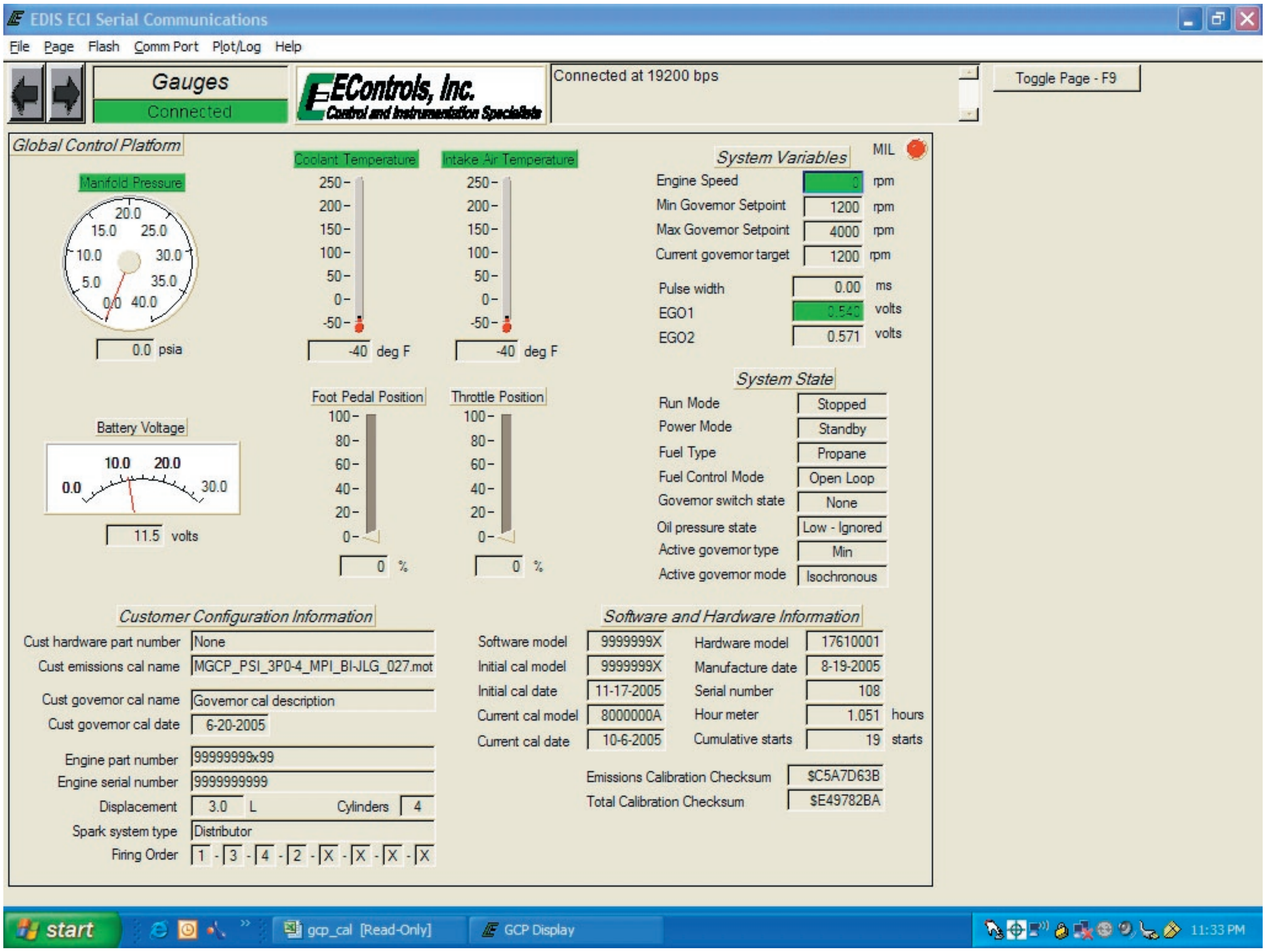


Figure 5: Tagged Variables for Plot/Log

Once the variables have been tagged as highlighted by the green color fill, select the “Plot/Log” function in the top menu bar as shown below in figure 6.

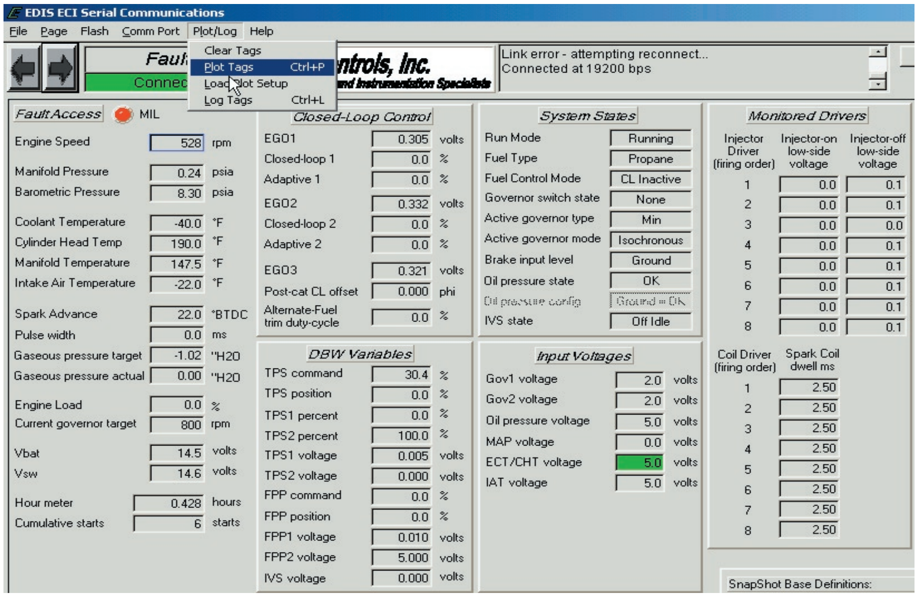


Figure 6

- Select “Plot Tags” to open the snapshot window

Other functions available from the Plot/Log menu include:

- ***Clear Tags***: Releases all plot/log variables.
- ***Plot Tags (Ctrl + P, or P)***: Graphically plot all tagged variables.
- ***Load Plot Setup***: Loads and tags variables for plotting/logging that have been stored in a plot file (.plt).
- ***Log Tags (Ctrl + L)***: Numerically log all variables that have been tagged for plotting/logging

Once the Plot Tags menu item has been selected, tagged variables are graphically plotted in a strip chart interface. An example of a plot is shown in Figure 7. Capabilities of the plotter are outlined in Table 1.

Start/Stop Button	Start or stop plotting of selected variables
Save Button	Save plotted data displayed in the plot to a comma-separated value file (CSV) on the PC hard drive. Format must not be altered if the *Load* function is to be used.
Snapshot Button	Convert the plot into a snapshot that may be panned, zoomed, scrolled, and saved
Close Button	Close the DST Plot interface
Load Setup Button	Load tags from a previously saved plot (.plt) file to allow for similar plots and logs to be generated
Load Plot Button	Load a previously saved plot from the PC into the DST Plot interface
Variable Selector Menu	Selects the active variable for axis scaling

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Single Shot Acquisition Checkbox*	When checked, this does not allow the plot to scroll past the 'Time Interval' thereby preserving plotted data for post-processing.
Exclusive Serial Use Checkbox*	When checked, this allows exclusive serial communication for the plot variables. Other variables on the active page are not updated.
Min Y Value Field*	Specify the minimum Y-axis scaling for the active variable
Max Y Value Field*	Specify the maximum Y-axis scaling for the active variable
Sample Interval (ms) Field*	Define the sample period for recording and display *Frequency (hz.) = 1000/Sample Interval (ms)*
Time Interval (s) Field*	Defines the total sample acquisition time for the plot.
*Accessible only when plotter is not running.	

Table 1

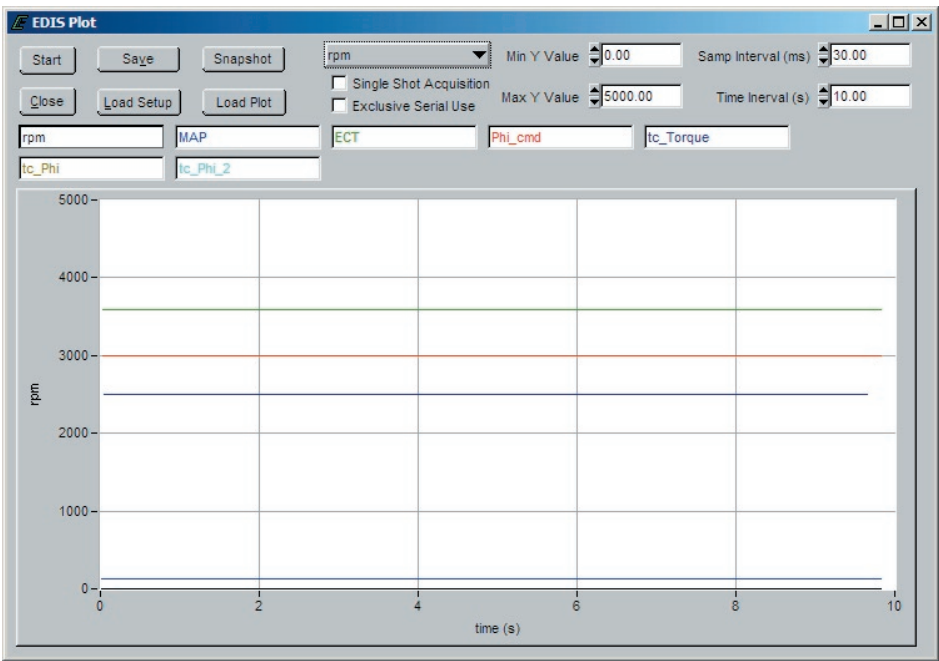


Figure 7 DST Plot

- Click on the start button to start the DST plot function.
- Click on the variable selector button to view selected sensors

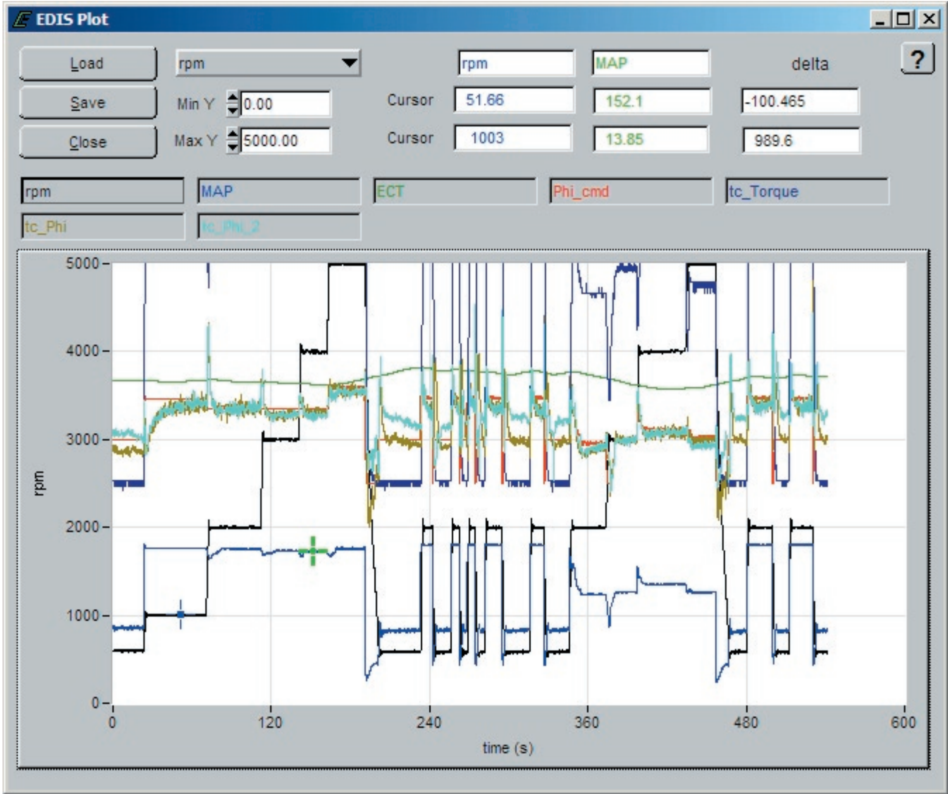
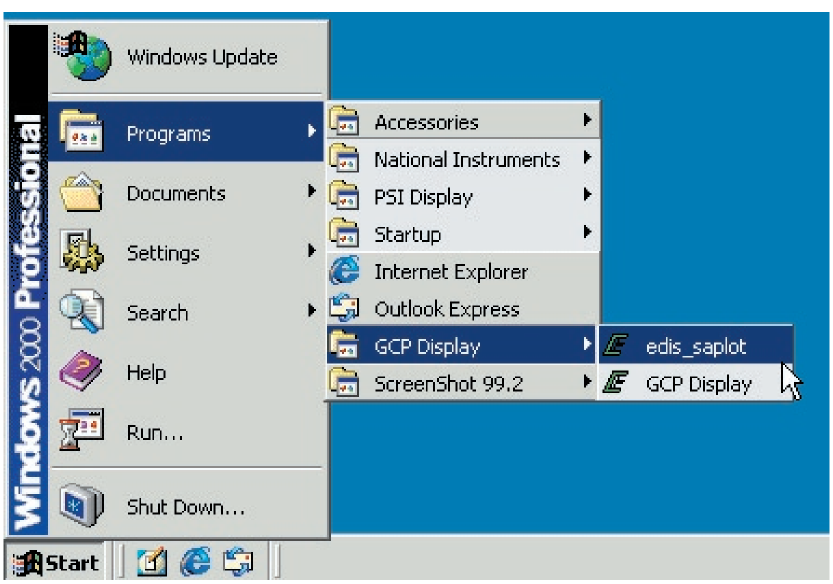


Figure 8: DST Plot Snapshot

- Click on the “Save” button to save the snapshot as a file.

To replay the saved file, open the edis_saplot program from the windows start menu.



- Start Menu → Programs → GCP Display → edis_saplot

DST Plot Interface Functions

A graphic tool incorporated in the plotter is the snapshot function. This function allows data collected in a plot to be transferred into a second window for quick graphical post-processing. The snapshot allows the user to zoom in/out, pan left/right, and move cursors along the signal traces to measure the variable values in virtual real-time. An example of a snapshot is shown in Figure 8. Any CSV file in plot format (.plt) may be loaded into the snapshot. Table 2 outlines the available hot key functions of the snapshot screen.

Snapshot Hot Key Functions

Command	Function
<Single, left-click on trace>	Snap closest cursor to data
<Ctrl + Up/Down Arrows>	Move/pan plot along y axis
<Ctrl + Left/Right Arrows>	Move/pan plot along t axis
<Ctrl+Shift + Up/Down Arrows>	Zoom plot in and out in y axis
<Ctrl+Shift + Left/Right Arrows>	Zoom plot in and out in t axis
<Ctrl + Home>	Resize plot to default settings
<Ctrl + Page Up>	Zoom out by 10%
<Ctrl + Page Down>	Zoom in by 10%
<Page Up>	Toggle to previous cursor
<Page Down>	Toggle to next cursor
<Left/Right Arrow>	Follow selected data along trace
<Up/Down Arrow>	Follow selected data along trace
<Shift + Left/Right Arrow>	Move 10 points along trace
<Shift + Up/Down Arrow>	Move 10 points along trace
<Home>	Go to first visible point on current plot
<End>	Advance to last visible point on current plot
<Shift + Up/Down Arrow>	Toggle between traces/variables

Table 2

DST Logger

Another data capture function incorporated in the software is the DST logger. This tool serves as a PC data logger for any variable available in the ECM through the interface software. Figure 9 shows the interface display for configuring the DST Log. The interface allows the user to create the file's filename, set the sample rate for acquisition, set the time interval for sampling, and display the progress of acquisition. A maximum of twenty (20) variables may be tagged for the log. The amount of data stored is only limited by available PC RAM. The resulting text file may then be viewed by any standard Windows text editor/reader program. To create a log file select the "Log Tags" in the drop down menu as shown in figure 6.

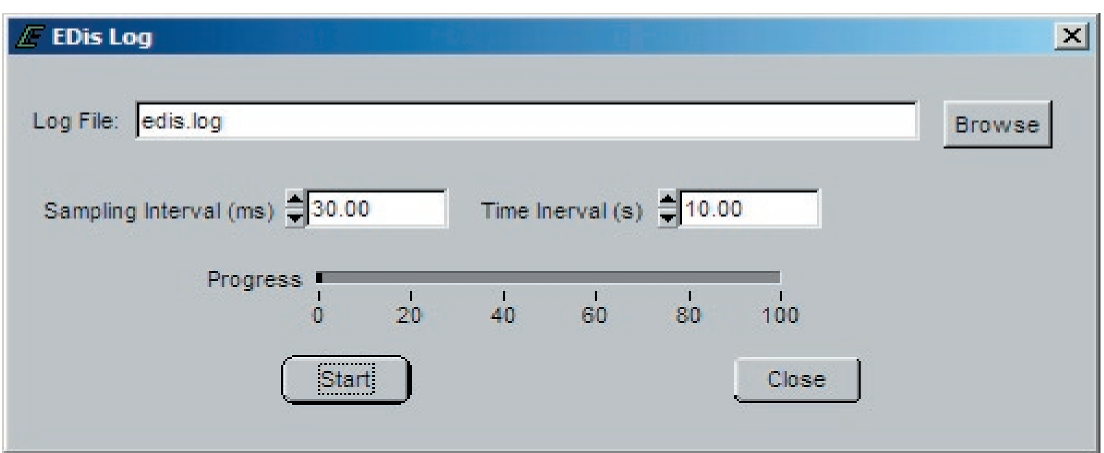


Figure 9: DST Log Interface

Malfunction Indicator Lamp (MIL)

The engine control system has built-in diagnostics for system trouble shooting. The system has a dash mounted malfunction indicator lamp (MIL) that provides indications of an emissions related problem. 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 serves as notification to the operator of a problem related to the emission control system so the driver can arrange for service as soon as possible. It will also display DTC's that have been stored due to a system malfunction.

The MIL 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 illuminate with the vehicle key on/engine off, repair it as soon as possible. Once the engine is in start or run mode, the MIL should turn off. If the lamp remains on while the engine is in the start or run mode a diagnostic trouble code may be set.

Diagnostic Trouble Codes (DTC)

Diagnostic Trouble Codes are set when the ECM (Electronic Control Module) runs a diagnostic self test and the test fails. When a DTC is set, the ECM will illuminate the MIL on the instrument panel and also save the DTC in memory. The ECM will continue to run the self test. If the system continues to fail the test, the lamp will stay illuminated and the DTC is stored as an active DTC. If the self test runs and passes, the DTC will be stored as historic DTC. All DTC's are stored as historic faults until they are cleared. Most DTC's will automatically clear from memory if the DTC does not reset within 50 to 100 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. 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 ECM power fuse (F2) for 15 seconds.

If more than one DTC is detected, start the diagnostic repair with the lowest DTC number set. Diagnose each problem to correction unless directed to do otherwise by the diagnostic chart. The DTC's are numbered in order of importance. Having DTC 112 and DTC122 both concerning the oxygen sensor, it is possible that by repairing DTC 112 first, the problem causing the DTC 122 may also be corrected.

Diagnostic test charts contained in this manual refer to the DST to be connected and in the "System Data Mode". This simply means that the DST is connected and communicating with the PC. In some instances the chart will call out a special test mode. An example of this would be instructions for the DST to be connected and in the DBW (drive by wire) mode. Always be sure to follow the special instructions to avoid a false diagnosis of fuel system components.

DLC Communication Error

The ECM 5 volt reference circuit powers the diagnostic link cable. In the event that the 5 volt reference signal is open or shorted to ground, you will not be able to connect to the system. If you are unable to connect, follow the quick checks listed below:

Be sure you are using the correct password and latest software for the system you are connecting to.

Check the ECM system power and ground circuits. Refer to DTC 562 for the power schematic. Also check for +12 volts switched power at ECM pin 45 with the ignition key on.

Check for power at the DLC connector for + 5 volts between pin 1 (BLK /LT GRN) and pin 2
(LT GRN RED) with the ignition key in the on position.

You may still be able to retrieve a code using the blink code function if none of the above recommendations prove useful. In the event of a 5 volt reference signal malfunction, DTC 642 or DTC 643 should set. If you find one of these codes using the blink code function, follow the DTC diagnostic chart recommendations for that specific DTC.

Blink Code Function

Although the DST is considered a required tool to access the DTC codes, codes may be retrieved without a laptop computer using the blink code function. To enable this function follow the steps below:

- Jump pins 1 and 4 at the DLC connector C016.
- Turn the ignition key to the on position
- The system will now enter the self diagnostic blink code mode. Be ready with pen and paper to write down any codes that may be stored.
- The ECM will flash the MIL indicator with a pause between represented numbers that represent DTC codes. The sequence starts with code 1654. Code 1654 confirms the system has entered the blink code mode. The ECM will flash code 1654 (3) times before displaying the actual DTC code that may be set.

Example:

<u>One short blink</u> (pause) <u>six short blinks</u> (pause) <u>five short blinks</u> (pause) <u>four short blinks.</u>

- If no DTC codes are found, the ECM will continue to flash 1654 only. This means no stored DTC codes were found.

Intermittent Problems

Intermittent fuel system problems can prove to be the most challenging to repair. It is most important to remember when looking to find the cause of these problems, to operate the system in the condition when and where the problem occurs. An example of this would be, if the DST showed a lean fuel mixture at full load, one of the first things to look at would be the fuel pressure. The fuel pressure would need to be monitored while the machine is operating at full load, not at idle because the leaning effect does not occur at idle. Electrical problems should be treated the same way. One excellent tool for finding intermittent electrical problems is the DST plot/log function. Set up the plot for the code that sets. An example of this would be if an intermittent IAT code set, tag the IAT voltage and watch the plot. While watching the plot, agitate the electrical wire connection at the sensor and ECM connector. The resolution of the plot screen is such that you will be able to see any unstable voltages that you would otherwise not see with a standard DVOM.

Caution should be used when pressure washing the under hood of any electrical system. Avoid direct pressure spray on the system electrical connectors. They are splash proof, but if water is sprayed directly at the connector moisture can become trapped behind the connector seal and cause serious system problems.

Extra care must be taken when probing electrical pins and terminals. Do not bend or spread these terminals as this can also be a source of intermittent problems cause by improper handling of these connectors.

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DIAGNOSTIC TROUBLE CODE SECTION
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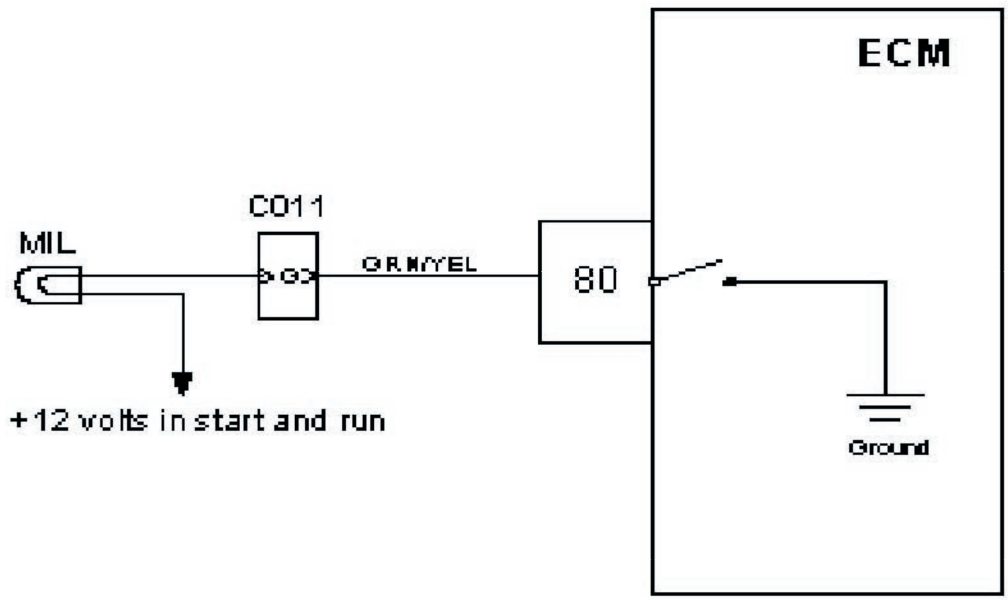
DTC Code to SPN:FMI Code Cross Reference

DTC Code	Description	SPN Code	FMI Code
16	Crank Never Synced at Start	636	8
91	Fuel Pump Low Voltage	94	4
92	Fuel Pump High Voltage	94	3
107	MAP Low Voltage	106	4
108	MAP High Pressure	106	16
111	IAT Higher Than Expected 1	105	15
112	IAT Low Voltage	105	4
113	IAT High Voltage	105	3
116	ECT Higher Than Expected 1	110	15
117	ECT Low Voltage	110	4
118	ECT High Voltage	110	3
121	TPS 1 Lower Than TPS 2	51	1
122	TPS 1 Signal Voltage Low	51	4
123	TPS 1 Signal Voltage High	51	3
127	IAT Higher Than Expected 2	105	0
129	BP Low Pressure	108	1
134	EGO 1 Open/Inactive	724	10
154	EGO 2 Open/Inactive	520208	10
171	Adaptive Learn High Gasoline	520200	0
172	Adaptive Learn Low Gasoline	520200	1
182	Fuel Temp Gasoline Low Voltage	174	4
183	Fuel Temp Gasoline High Voltage	174	3
187	Fuel Temp LPG Low Voltage	520240	4
188	Fuel Temp LPG High Voltage	520240	3
217	ECT Higher Than Expected 2	110	0
219	Max Govern Speed Override	515	15
221	TPS 2 Signal Voltage Low	51	0
222	TPS 2 Signal Low Voltage	520251	4
223	TPS 2 Signal High Voltage	520251	3
261	Injector Driver 1 Open	651	5
262	Injector Driver 1 Shorted	651	6
264	Injector Dirver 2 Open	652	5
265	Injector Driver 2 Shorted	652	6
267	Injector Driver 3 Open	653	5
268	Injector Driver 3 Shorted	653	6
270	Injector Driver 4 Open	654	5
271	Injector Driver 4 Shorted	654	6
336	Crank Sync Noise	636	2
337	Crank Loss	636	4
341	Cam Sync Noise	723	2
342	Cam Sensor Loss	723	4
420	Gasoline Cat Monitor	520211	10

DTC Code	Description	SPN Code	FMI Code
524	Oil Pressure Low	100	1
562	System Voltage Low	168	17
563	System Voltage High	168	15
601	Flash Checksum Invalid	628	13
604	RAM Failure	630	12
606	COP Failure	629	31
642	External 5V Reference Low	1079	4
643	External 5V Reference High	1079	3
685	Power Relay Open	1485	5
686	Power Relay Shorted	1485	4
687	Power Relay Short to Power	1485	3
1111	Fuel Rev Limit	515	16
1112	Sparl Rev Limit	515	0
1151	Closed Loop Multiplier High LPG	520206	0
1152	Closed Loop Multiplier Low LPG	520206	1
1155	Closed Loop Multiplier High Gasoline	520204	0
1156	Closed Loop Multiplier Low Gasoline	520204	1
1161	Adaptive Learn High LPG	520202	0
1162	Adaptive Learn Low LPG	520202	1
1165	LPG Cat Monitor	520213	10
1171	LPG Pressure Higher Than Expected	520260	0
1172	LPG Pressure Lower Than Expected	520260	1
1173	EPR Comm Lost	520260	31
1174	EPR Voltage Supply High	520260	3
1175	EPR Voltage Supply Low	520260	4
1176	EPR Internal Actuator Fault	520260	12
1177	EPR Internal Circuitry Fault	520260	12
1178	EPR Internal Comm Fault	520260	12
1612	RTI 1 loss	629	31
1613	RTI 2 Loss	629	31
1614	RTI 3 Loss	629	31
1615	A/D Loss	629	31
1616	Invalid Interupt	629	31
1625	Shutdown Request	1384	31
1626	CAN Tx Failure	639	12
1627	CAN Rx Failure	639	12
1628	CAN Address Conflict Failure	639	13
1629	Loss of TSC 1	639	31
2111	Unable to Reach Lower TPS	51	7
2112	Unable to Reach Higher TPS	51	7
2135	TPS 1/2 Simulataneous Voltages	51	31
2229	BP Pressure High	108	0

OBD System Check/ MIL (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 exhaust emissions of the vehicle will set a DTC (Diagnostic Trouble Code). The ECM will then provide a path to ground and illuminate the MIL.

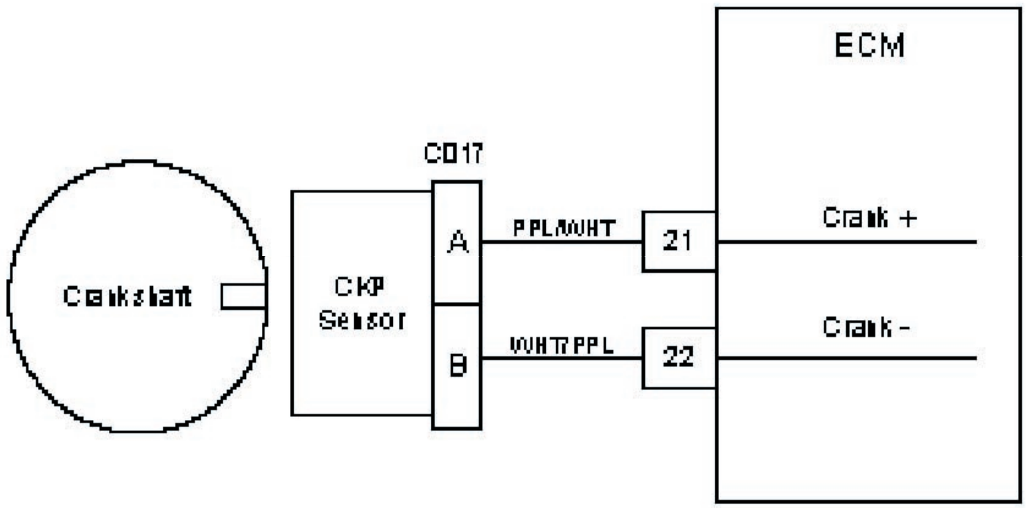
The MIL serves as notification of an emissions related problem. The MIL also has the ability to flash DTC codes in what is referred to the blink code mode. It will display DTC's that have been stored due to a system malfunction. The following DTC charts in this manual will instruct the technician to perform the OBD system check. This simply means to verify the operation of the MIL. The lamp should illuminate when the key is in the ON position, and the engine is not running. This feature verifies that the lamp 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 stays on while the engine is in the start or run mode, a current diagnostic trouble code may be set or a problem may exist with the MIL electrical wiring.

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 side of connector C011 and ECM pin 80 Do you have continuity?		Go to Step (6)	Go to Step (8)
6	• Inspect the MIL lamp socket, connector C011 and ECM pin 80 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 both MIL and ECM side of terminal G in connector C011 • Using a DVOM check for continuity through connector C011 Do you have continuity?		*Go to Step (9)*	Repair open circuit in connector C022
9	• Inspect the MIL lamp socket, connector C011 and ECM terminal 80 for damage, corrosion or contamination Did you find a problem?		Repair the damaged socket or terminal as required. Refer to Wiring Repairs in Engine Electrical.	Repair the wire harness open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
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)		-	-

Step	Action	Value(s)	Yes	No
11	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between ECM terminal 80 and battery voltage • Do you have continuity?		Repair the shorted to ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)

DTC 16-Never Crank Synced At Start SPN/FMI 636:8



Conditions for setting the DTC

- Crankshaft Position sensor
- Check Condition- Engine cranking
- Fault Condition- Cranking RPM above 90 and more than 4 cranking revolutions without sync
- MIL Command-ON

Circuit Description

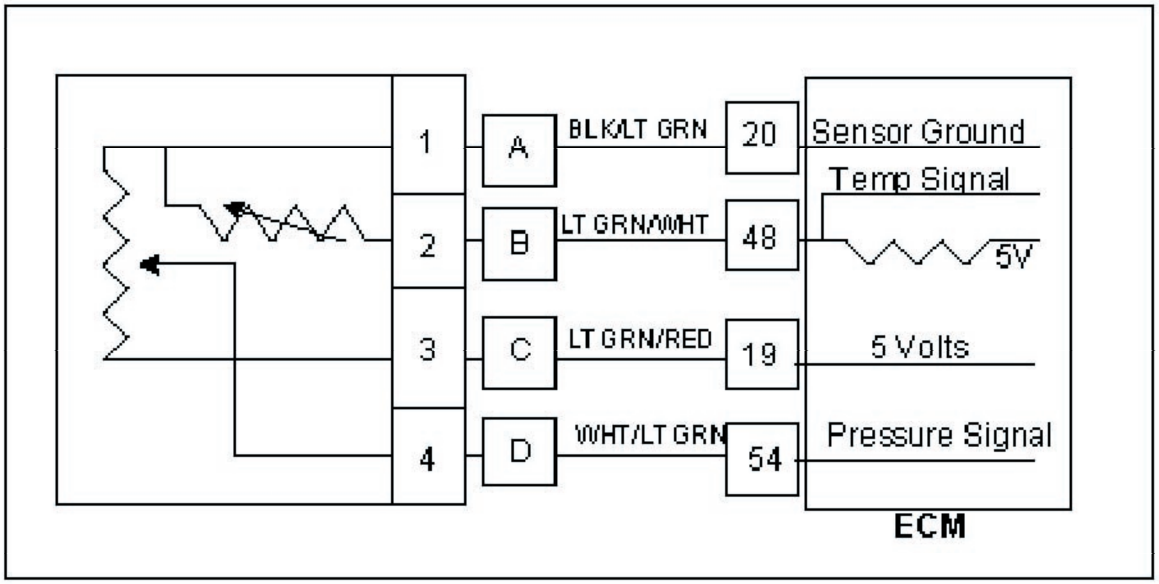
The CKP (crankshaft position sensor) is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize the ignition and fuel systems. This fault will set one or more crank re-sync occur within 800 ms.

DTC 16- Never Crank Synced At Start SPN/FMI 636:8

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 to be sure that the ECM ground terminals C014 and C023 are clean and tight. Are terminals C014 and C023 clean and tight?		Go to Step (3)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key OFF • Disconnect the CKP sensor connector C017 • Using a DVOM check for voltage output directly from the CKP sensor while cranking the engine • Do you have voltage output?	Over .5 volts	Go to Step (4)	Go to Step (11)
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CKP connector pin A and ECM connector pin 21 • 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 B and ECM connector pin 22 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 C017 pins 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 pins 21 and 22 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	• Using a DVOM check for continuity between ECM connector pins 21 and 22 to engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)

Step	Action	Value(s)	Yes	No
9	• Replace CKP sensor Is the replacement complete?		Go to Step (12)	-
10	• Replace ECM • Is the replacement complete?		Go to Step (12)	-
11	• Key OFF • Inspect the pulse wheel and CKP sensor for mechanical damage, corrosion or contamination. Did you find a problem?		Repair the component as necessary. Refer to Engine Repairs in Engine Section	Go to Step (9)
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-16 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 91-Gasoline Fuel Pressure Sensor Low Voltage SPN/FMI 94:4



Conditions for Setting the DTC

- Gasoline fuel pressure sensor voltage
- Fuel pressure sensor voltage less than .2v for 1s
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-disabled for the remainder of key cycle

Circuit Description

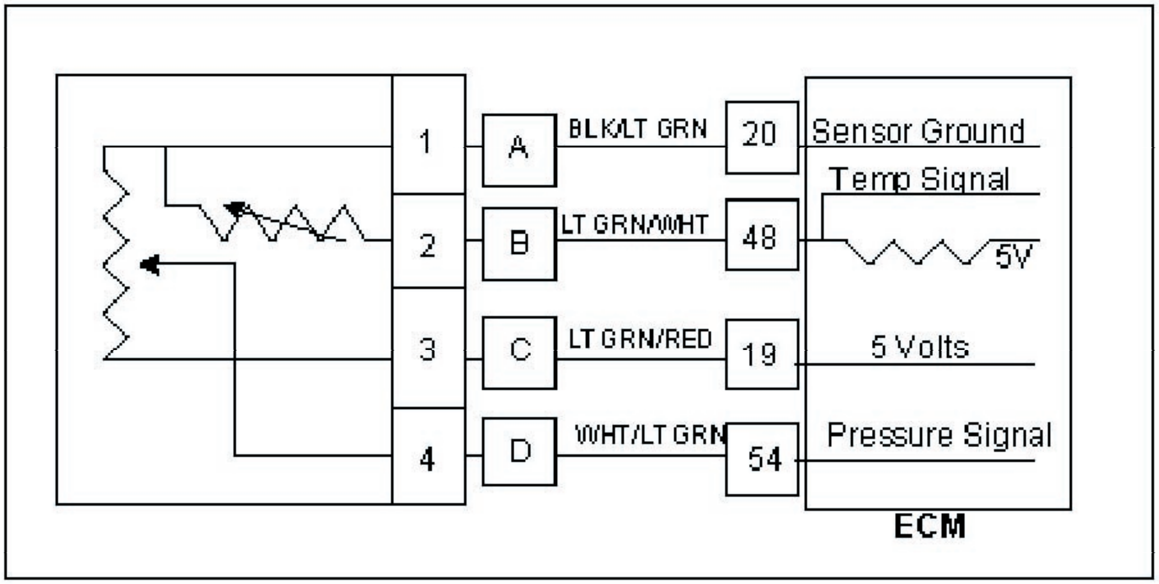
Note: The fuel pressure and temperature sensor is wired via Equipment Manufacturer supplied harness jumper. The terminals A, B, C, D & 19, 20, 48, 54 are engine wiring harness terminals at the fuel sensor interface connector C002 and the ECM header connector C001. You may need to consult additional wiring information supplied by the OEM. The fuel pump pressure sensor voltage is read at less than .2v. This indicates abnormally low fuel pressure or a low voltage fault from the sensor or circuit.

DTC 91- Gasoline Fuel Pressure Sensor Low Voltage SPN/FMI 94:4

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 Using a DVOM, check for voltage at connector C002 terminal D by back probing to ground. Is voltage 0.2v or less with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the gasoline fuel pressure sensor jumper harness connector C002 from the engine wiring harness • Key On • Using a DVOM, check for voltage between connector C002 terminal C and ground. Is voltage 4.5 volts or greater?		Go to Step (4)	Go to step (8)
4	• Inspect fuel pressure and temperature sensor connector and pins for corrosion, contamination or mechanical damage. Check for opens or shorts in OEM supplied jumper harness to sensor 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 C001 • Check for continuity between gasoline pressure sensor connector terminal D and ECM pin 54. 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 fuel pressure sensor connector terminal C and ECM pin 19 Do you have continuity between them?		Go to step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
7	• Check for continuity between fuel pressure sensor connector terminal A and ECM pin 20 Do you have continuity between them?		Go to step (11)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Key Off • Disconnect ECM header connector C001 • Check for continuity between pressure sensor connector C002 terminal C and ECM connector terminal 19. Do you have continuity?		Go to Step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Inspect ECM and gasoline pressure sensor connector (C002) 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 (10)
10	• Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step (12)	-
11	• Replace fuel pressure and temperature sensor Is the replacement complete?		Go to step (12)	-
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-91 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 92-Gasoline Fuel Pressure Sensor High Voltage SPN/FMI 94:3



Conditions for Setting the DTC

- Gasoline fuel pressure sensor voltage
- Fuel pressure sensor voltage greater than 4.8v for 1s
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-disabled for the remainder of key cycle

Circuit Description

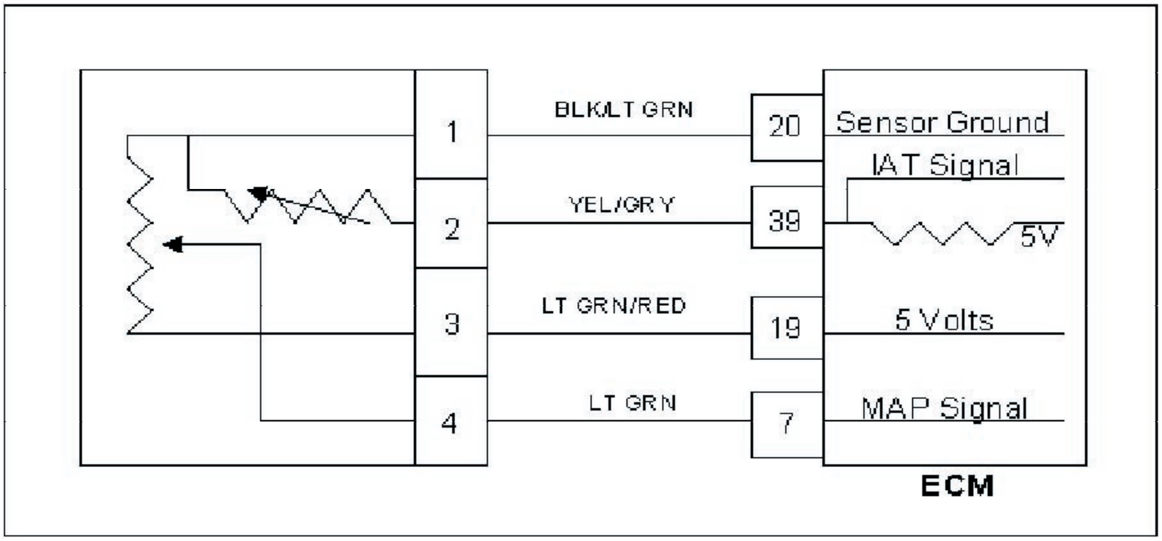
Note: The fuel pressure and temperature sensor is wired via Equipment Manufacturer supplied harness jumper. The terminals A, B, C, D & 19, 20, 48, 54 are engine wiring harness terminals at the fuel sensor interface connector C002 and the ECM header connector C001. You may need to consult additional wiring information supplied by the OEM. The fuel pressure sensor voltage is read at greater than 4.8v. This indicates abnormally high fuel pressure or a high voltage fault from the sensor or circuit.

DTC 92- Gasoline Fuel Pressure Sensor High Voltage SPN/FMI 94:3

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 Using a DVOM, check for voltage at connector C002 terminal D by back probing to ground. Is voltage 4.8v or higher with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the gasoline fuel pressure sensor jumper harness connector C002 from the engine wiring harness • Key On • Using a DVOM, check for voltage between connector C002 terminals C and A. Is voltage 4.5 volts or greater?		Go to Step (4)	Go to step (8)
4	• Inspect fuel pressure and temperature sensor connector and pins for corrosion, contamination or mechanical damage. Check for opens or shorts in OEM supplied jumper harness to sensor 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 C001 • Check for continuity between gasoline pressure sensor connector terminal D and ECM pin 54. 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 fuel pressure sensor connector terminal C and ECM pin 19 Do you have continuity between them?		Go to step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
7	• Check for continuity between fuel pressure sensor connector terminal A and ECM pin 20 Do you have continuity between them?		Go to step (11)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Key Off • Disconnect ECM header connector C001 • Check for continuity between pressure sensor connector C002 terminal A and ECM connector terminal 20. Do you have continuity?		Go to Step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Inspect ECM and gasoline pressure sensor connector (C002) 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 (10)
10	• Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step (12)	-
11	• Replace fuel pressure and temperature sensor Is the replacement complete?		Go to step (12)	-
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-92 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 107- MAP Low Voltage SPN/FMI 106:4



Conditions for Setting the DTC

- Manifold Absolute Pressure Sensor
- Check Condition-Engine cranking or running
- Fault Condition-MAP voltage less than 0.05 with throttle position greater than 2% and engine RPM less than 7000.
- MIL-ON
- Adaptive-Disabled for the remainder of key on cycle
- 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. The pressure reading is used in conjunction with other inputs to estimate 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.

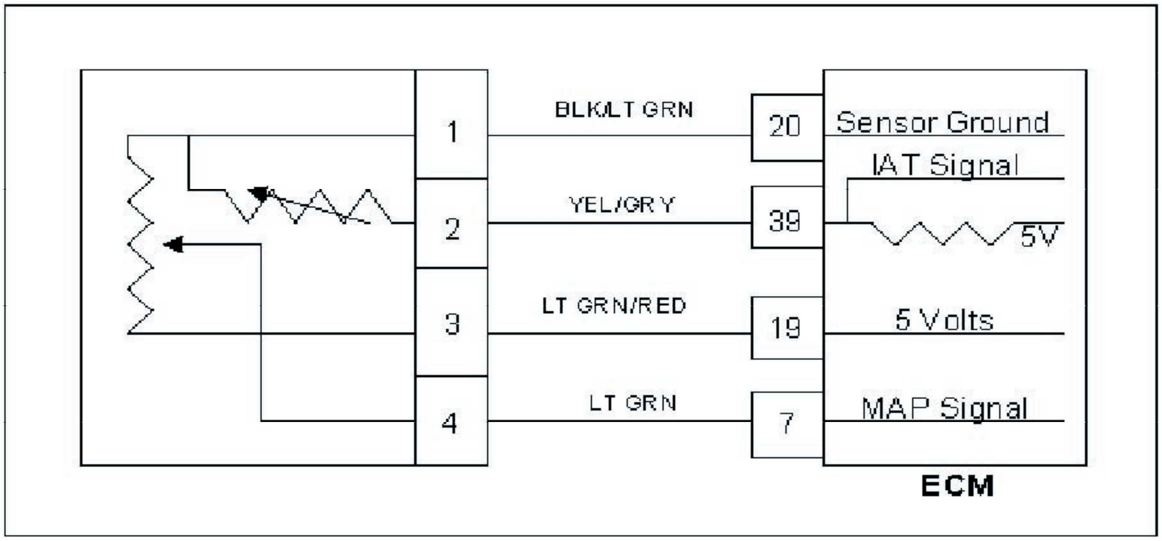
DTC 107- MAP Low Voltage SPN/FMI 106:4

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 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 connector C007 from the wiring harness • Jump 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 C001 • Check for continuity between TMAP sensor connector signal pin 4 and ECM MAP signal pin 7. 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 19 Do you have continuity between them?		Go to step (7)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
7	• Check for continuity between TMAP sensor connector ground pin 1 and ECM sensor ground pin 20 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 19. 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 7 Do you have continuity between them?		Go to Step (14)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
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 (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-107 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 108-MAP High Pressure SPN/FMI 106:16



Conditions for Setting the DTC

- Barometric pressure check
- Check condition-engine running and greater than 1800 RPM
- Fault Condition-MAP greater than 17 psia withTPS less than 10% and RPM greater than 1800
- MIL-On for active fault and for 4 seconds after active fault
- Adaptive-disabled for the remainder of key cycle

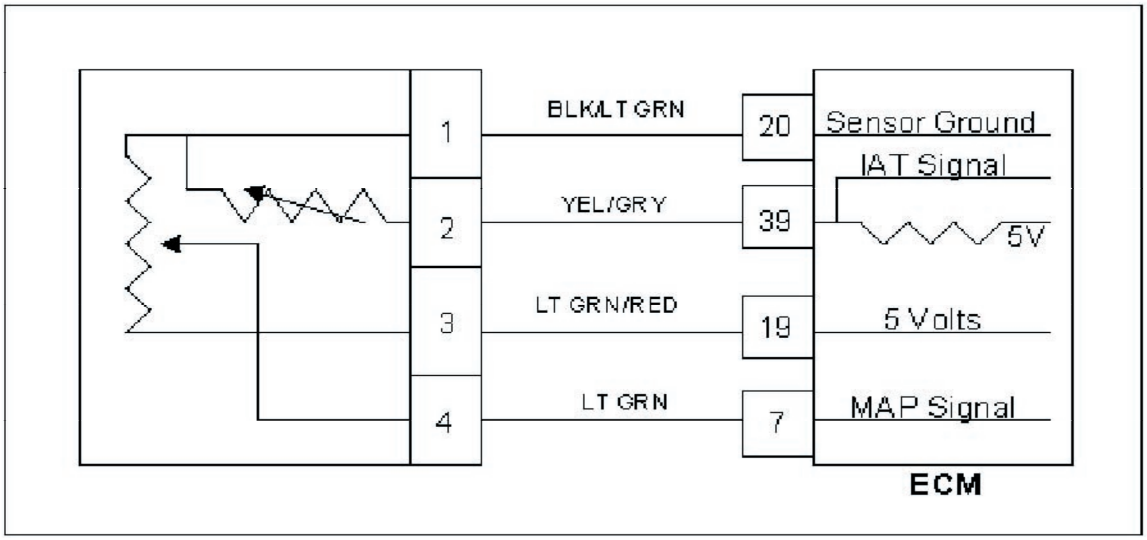
Circuit Description

The MAP (Manifold Absolute Pressure) is estimated from the TMAP sensor. The MAP pressure value is used for fuel, airflow and spark calculations. This fault will set in the event the MAP value is greater than 17 psia when the TPS is less than 10% with engine speed greater than 1800.

DTC 108- MAP High Pressure SPN/FMI 106:16

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 at full operating temperature. • DST (Diagnostic Scan Tool) connected in System Data Mode Does DST display MAP pressure of 17.0 psia or greater with the engine running above 1800 RPM?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the TMAP sensor connector C007 • Key ON Does the DST display MAP pressure less than 0.05 psia?		Go to step (4)	Go to step (6)
4	• Probe TMAP connector ground 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 vacuum 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 20. 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 the TMAP mechanical connection problem been corrected?		System OK	Go to OBD System Check

DTC 111-IAT Higher Than Expected 1 SPN/FMI 105:15



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 200 degrees F. and engine RPM greater than 1300 for more than 60 seconds
- MIL-On
- Adaptive-Disabled during active fault
- 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 200 degrees F. and engine rpm is greater than 1300 for more than 60 seconds. Power derate level one will be enforced during this fault limiting the maximum throttle position to50%.

Diagnostic Aid

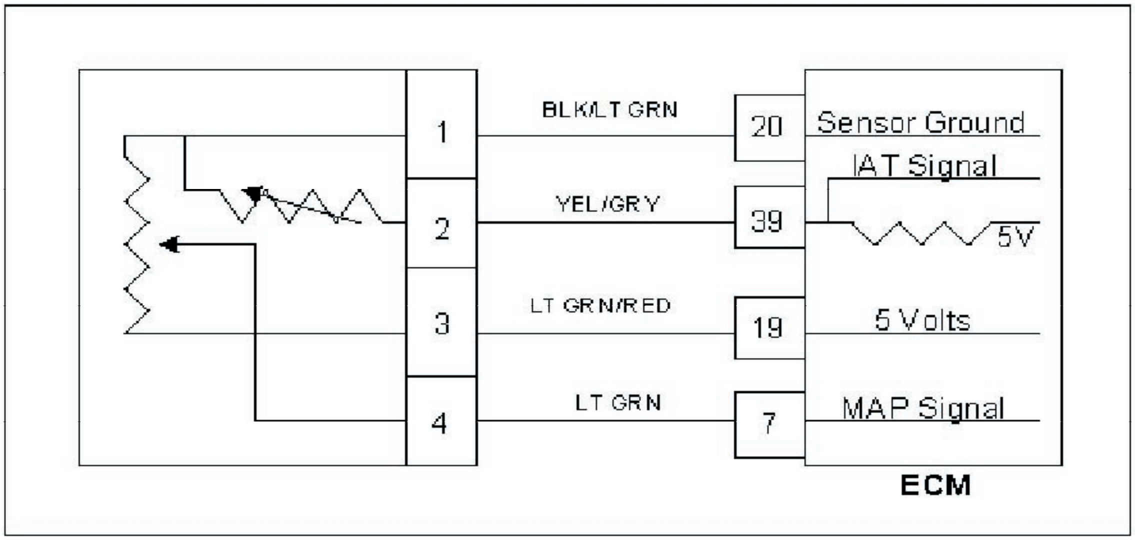
* This fault will set when inlet air is much hotter than normal. The most common cause of high inlet air temperature is a problem with the inlet air system. Ensure that the air inlet is not obstructed, modified or damaged.
* Inspect the air inlet system for cracks or breaks that may allow unwanted under hood air in to the air inlet system.

DTC 111-IAT Higher Than Expected 1 SPN/FMI 105:15

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 112-IAT Low Voltage SPN/FMI 105:4



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition Engine Cranking or Running
- Fault Condition-IAT Sensor Voltage less than 0.05 for greater than 1 second
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault

Circuit Description

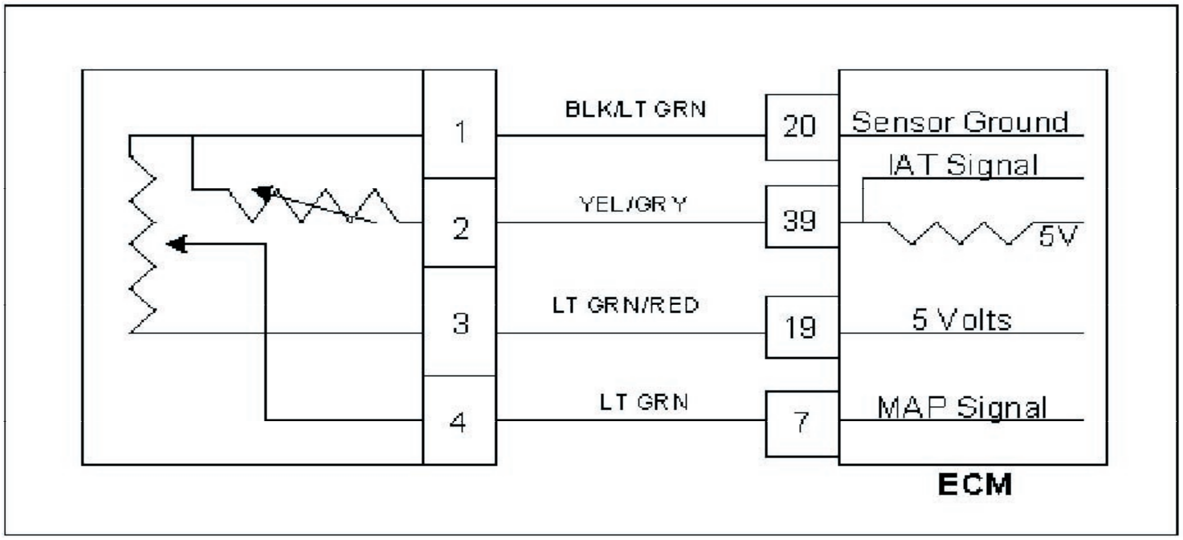
The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used 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 for 1 second 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 SPN/FMI 105:4

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 connector C007 • 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 C001 • 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)	_

Step	Action	Value(s)	Yes	No
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 High Voltage SPN/FMI 105:3



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-IAT Sensor Voltage greater than 4.95 for more than 1 second
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault

Circuit Description

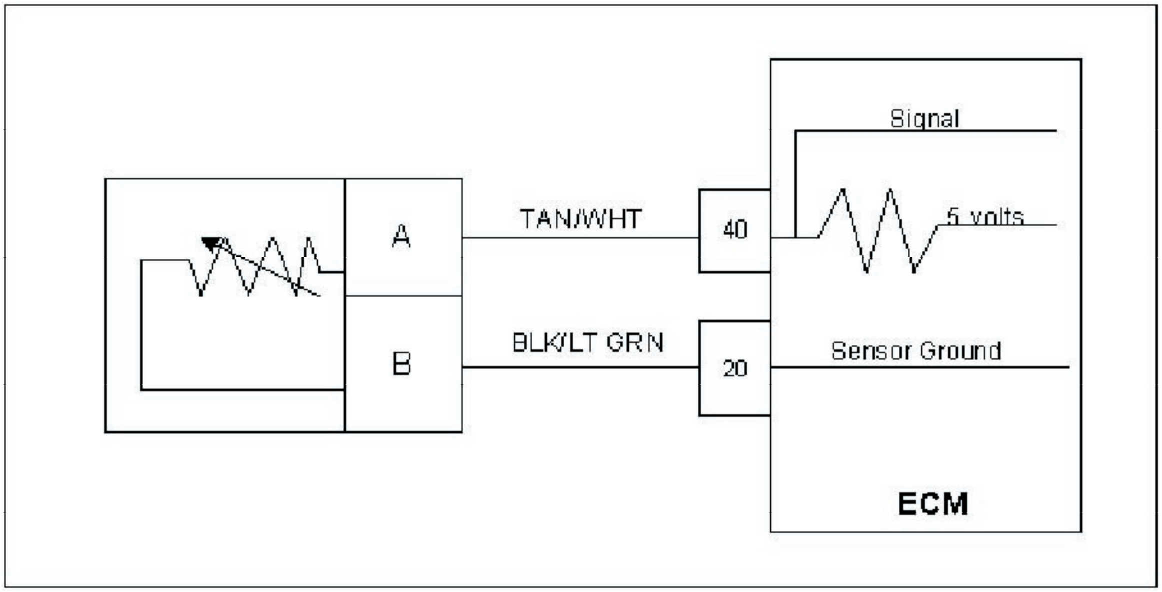
The TMAP is a combined IAT (Intake Air Temperature) and MAP (Manifold Absolute Pressure) sensor. A temperature sensitive resistor is used in the TMAP located in the intake manifold of the engine. It is used to monitor incoming air temperature, and the output in conjunction with other sensors is used 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 greater than 4.95 volts for more than 1 second anytime the engine is running. The ECM will use a default value for the IAT sensor in the event of this fault.

DTC 113- IAT VOLTAGE HIGH SPN/FMI 105:3

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 C007 and jump 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 C001. • Check for continuity between TMAP sensor connector signal pin 2 and ECM IAT signal pin 39 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 20 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 connector for damage corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical	Go to Step (5)

Step	Action	Value(s)	Yes	No
10	• Re-check wire harness and TMAP sensor connectors for damage corrosion or contamination 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-113 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 116-ECT Higher Than Expected 1 SPN/FMI 110:15



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-Engine Coolant Temperature reading or estimate greater than 220 degrees F. for greater than 60 seconds
- MIL-On
- Power derate (level 1)
- Adaptive-Disabled during active fault

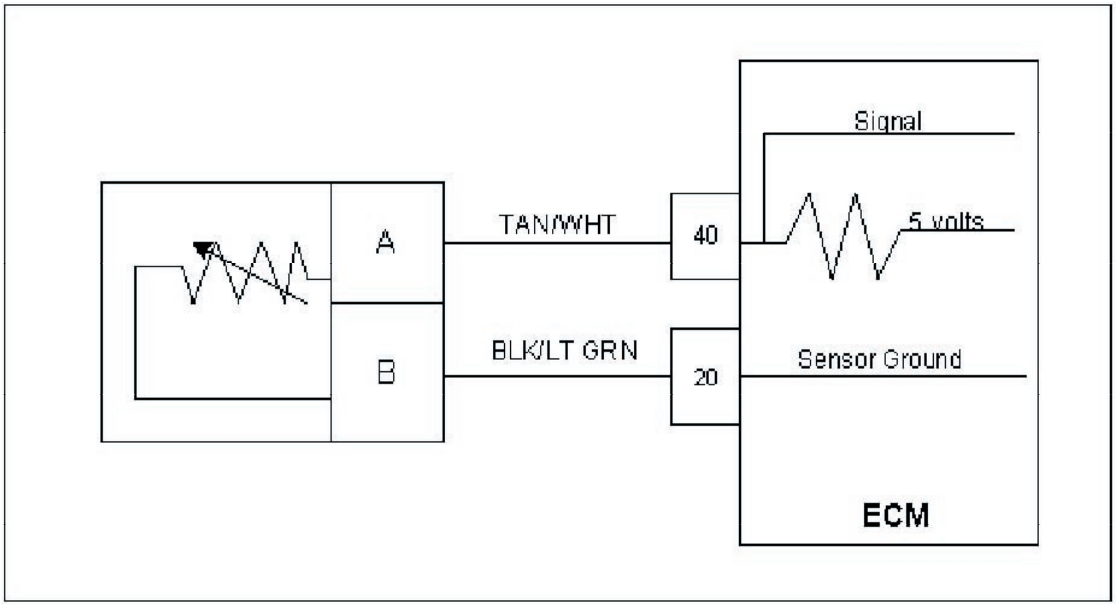
Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant. sensor that is located in the coolant passage. The ECT is used for engine airflow calculation, fuel enrichment, ignition timing control and to enable certain other temperature dependant operations. This code set is designed to help prevent engine damage from overheating. 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 set when the coolant exceeds 225 degrees F. for more than 60 seconds with the engine speed over 1200 rpm. Power derate level one will be enforced during this fault limiting the maximum throttle position to 50%.

DTC 116- ECT HIGHER THAN EXPECTED 1 SPN/FMI 110:15

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 1200 rpm for at least 60 seconds Does DST display ECT temperature of 225 degrees F. or greater with the engine running over 1200 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 DTC117 ECT Low Voltage		-	-

DTC 117-ECT Low Voltage SPN/FMI 110:4



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

Circuit Description

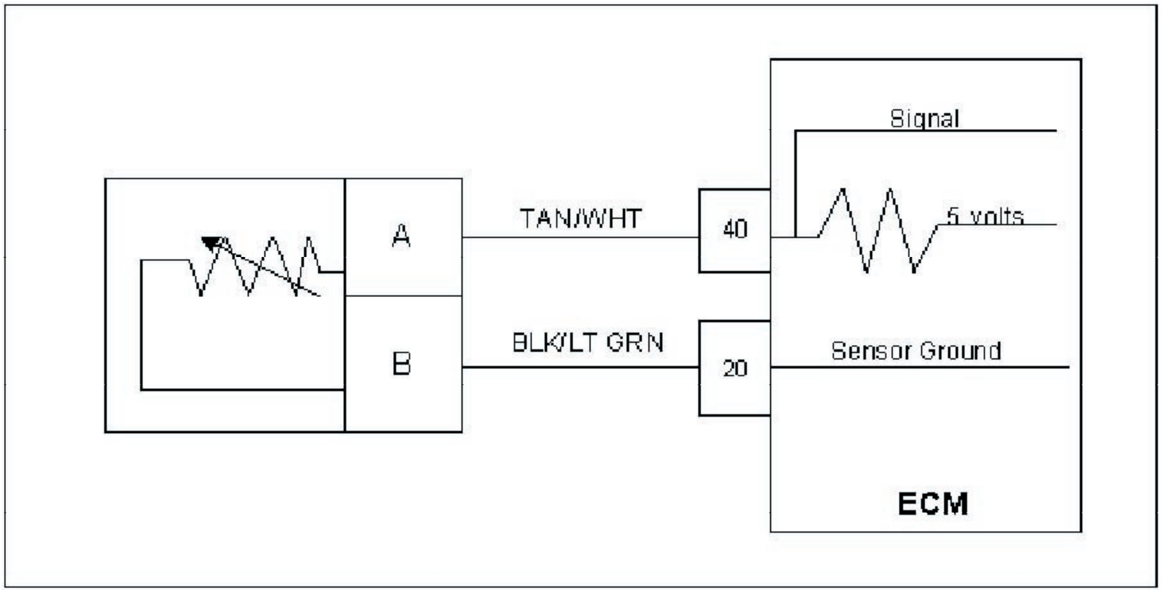
The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant passage. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm. This fault will set if the signal voltage is less than 0.05 volts anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

Temp (deg F)	Ohms
242.4	101
231.9	131
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 117- ECT VOLTAGE LOW SPN/FMI 110:4

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-117 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 118-ECTHigh Voltage SPN/FMI 110:3



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-ECT sensor voltage exceeds 4.95 volts for greater than 1 second
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault

Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant passage. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm. This fault will set if the signal voltage is greater than 4.95 volts for one second anytime the engine is running. The ECM will use a default value for the ECT sensor in the event of this fault.

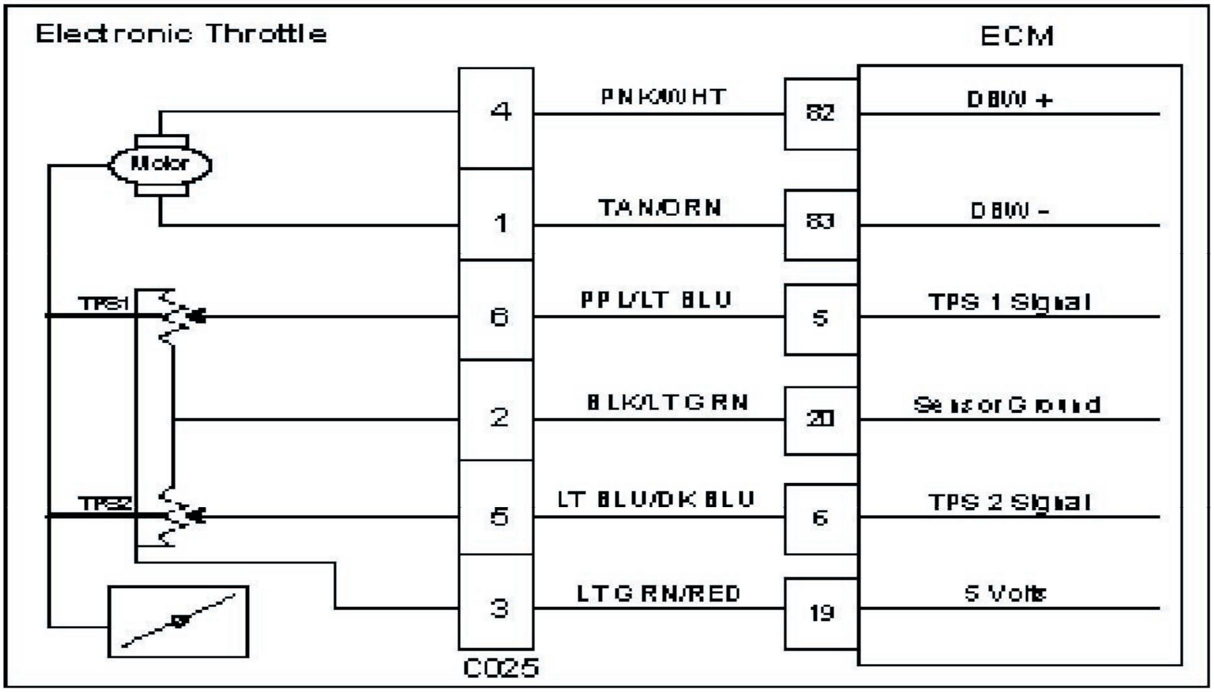
Temp (deg F)	Ohms
242.4	101
231.9	131
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-5.7	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

DTC 118- ECT VOLTAGE HIGH SPN/FMI 110:3

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 connector C008 and Jump 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 118 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 A and B 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 C001 • Inspect ECM connector pins 20 and 40 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 20 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 20 and 40 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)

Step	Action	Value(s)	Yes	No
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 40 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 20 and 40 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-118 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 121-TPS 1 Lower Than TPS 2 SPN/FMI 51:1



Conditions for Setting the DTC

- Throttle Position Sensor 1 & 2
- Check Condition-Key On
- Fault Condition-TPS 1 20% lower than TPS 2
- MIL-On for remainder of key on cycle
- Power Derate 1

Circuit description

There are two Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS 1 will read low voltage when closed and TPS 2 will read high voltage when closed. The TPS 1 and TPS 2 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.

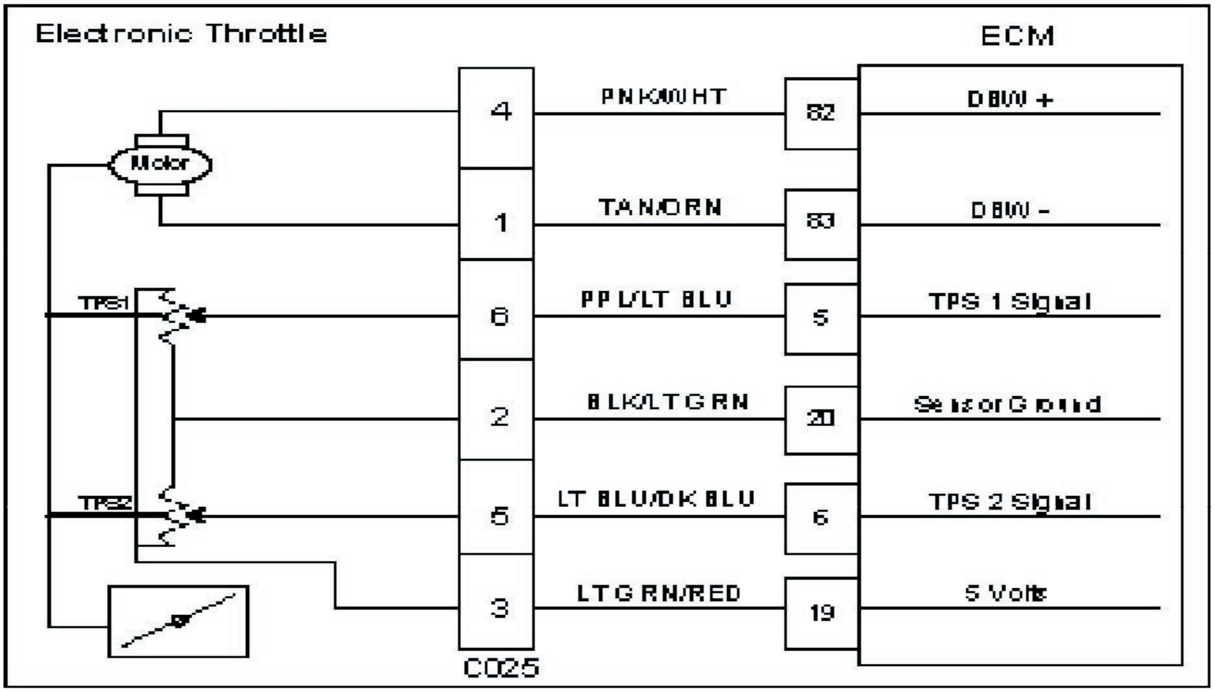
This fault will set if TPS 1 is 20% (or more) lower than TPS 2. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. Power derate 1 will be enforced limiting the throttle to 50% maximum. Low rev limit and forced idle will also be enforced during this fault.

DTC 121 TPS 1 Lower Than TPS 2 SPN/FMI 51:1

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, Engine OFF • DST (Diagnostic Scan Tool) connected in System Data Mode Does the DST display more than a 20% difference between TPS 1 and TPS 2 voltage?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect electronic throttle connector C025 • Key ON • Change DST mode to DBW (drive by wire) test mode Is the voltage for TPS 1 less than 0.1 volts?		Go to Step (5)	Go to Step (4)
4	• Key OFF • Disconnect ECM wiring harness connector C001 • Key ON • Using a DVOM check for voltage between ECM connector TPS 1 signal pin 5 and engine ground Do you have voltage?		Repair the TPS 1 circuit shorted to voltage as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (9)
5	• Jump TPS 1 signal pin 6 to the 5 volt reference pin 3 at connector C025 Does DST display TPS 1 voltage over 4.95 volts		Go to Step (6)	Go to Step (8)
6	• Inspect wire terminals at throttle connector for damage corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace the electronic Throttle Is the replacement complete?		Go to Step (12)	-
8	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between throttle connector TPS 1 signal pin 6 and ECM connector TPS 1 signal pin5 Do you have continuity between them?		Go to Step (9)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Using a DVOM check for continuity between throttle connector signal ground pin 2 and ECM connector signal ground pin 20 Do you have continuity between them?		Go to Step (10)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
10	• Inspect ECM connector terminals for damage corrosion or contamination. Any problems found?		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 (12)	-
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate 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-TPS 1 Signal Voltage Low SPN/FMI 51:4



Conditions for Setting the DTC

- Throttle Position Sensor 1
- Check Condition-Cranking or Running
- Fault Condition-TPS sensor voltage less than 0.20 for more than .50 seconds
- MIL-On during active fault
- Power Derate 1

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 lower voltage when closed and TPS2 will read higher 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. The TPS is not serviceable and in the event of a failure the electronic throttle assembly must be replaced.

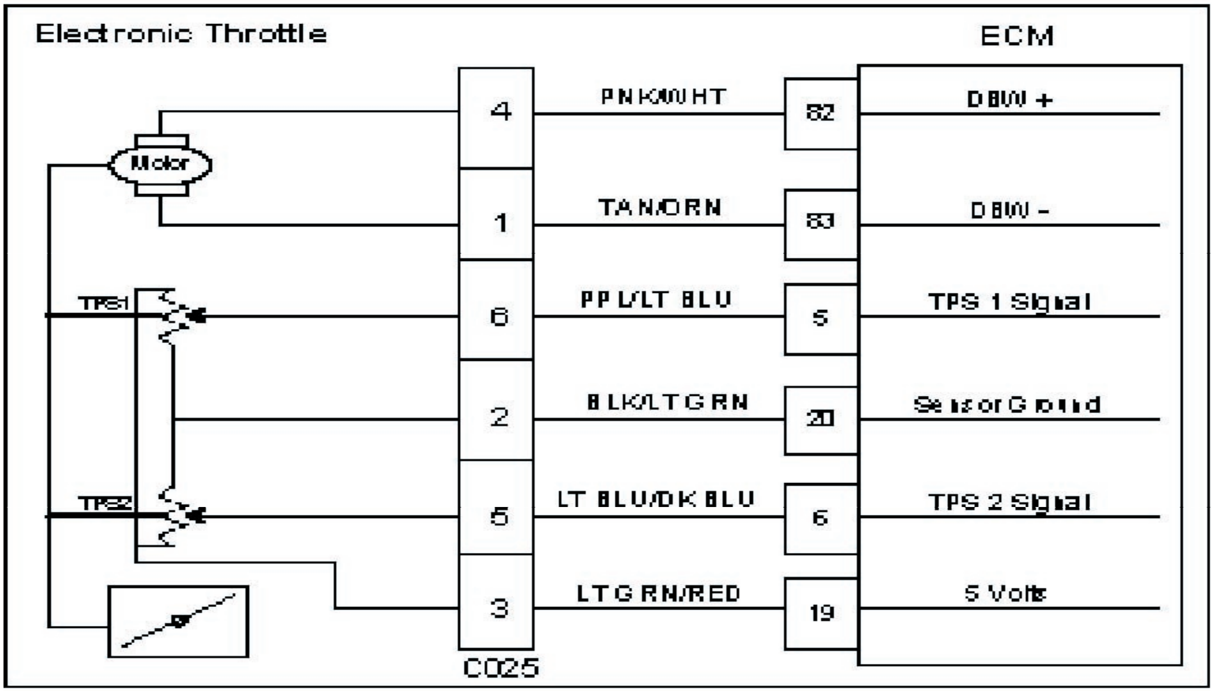
This fault will set if the TPS 1 voltage is less than 0.20 volts for more than .50 seconds. The MIL command in ON and power derate level 1 will be enforced limiting maximum throttle to 50%.

DTC 122 TPS 1 Signal Voltage Low SPN/FMI 51:4

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 0.20 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 0.20 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect the electronic throttle connector C025 • Jump the 5 volt reference circuit pin 3 and TPS 1 signal circuit pin 6 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 C001 Using a DVOM check continuity between TPS 1 connector C025 signal pin 6 and ECM connector TPS 1 signal pin 5 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
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 electronic throttle Is the replacement complete?		Go to Step (9)	-

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the 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-TPS 1 Signal Voltage High SPN/FMI 51:3



Conditions for Setting the DTC

- Throttle Position Sensor 1
- Check Condition-Cranking or Running
- Fault Condition-TPS sensor voltage exceeds 4.80 volts for more than .50 seconds
- MIL-On during active fault
- Power derate level 1

Circuit Description

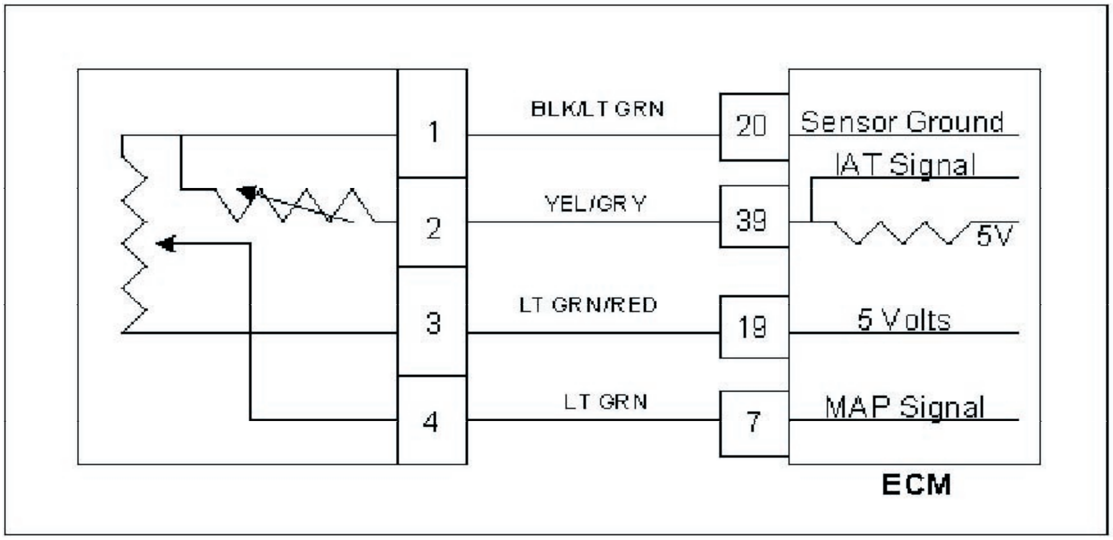
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read lower voltage when closed and TPS2 will read higher voltage when closed. The TPS1 and TPS2 percentages are calculated from these 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. The TPS is not serviceable and in the event of a failure the electronic throttle assembly must be replaced.
This fault will set if the TPS 1 voltage exceeds 4.80 volts for more than .50 seconds. The MIL command in ON and power derate level 1 will be enforced limiting maximum throttle to 50%.

DTC 123 TPS 1 Signal Voltage High SPN/FMI 51:3

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 electronic throttle connector C025 • 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 C001 • Key ON • Using a DVOM check for voltage between TPS 1 signal at the ECM connector pin 5 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 20 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 electronic 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 (9)
9	• Replace the electronic throttle Is the replacement complete?		Go to Step (11)	-
10	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between the electronic throttle connector C025 sensor ground pin 2 and ECM connector TPS 1 sensor ground pin 20 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-123 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 127-IAT Higher Than Expected 2 SPN/FMI 105:0



Conditions for Setting the DTC

- Intake Air Temperature
- Check Condition-Engine Running
- Fault Condition-Intake Air Temperature greater than 200 degrees F. for more than 120 seconds with engine speed greater than 1300 RPM
- MIL-On for active fault and for 15 seconds after active fault
- 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.

This fault will set if the Intake Air Temperature is greater than 210 degrees F. for more than 120 seconds with engine RPM greater than 1400. The MIL light command is on during this active fault and the engine will shut down.

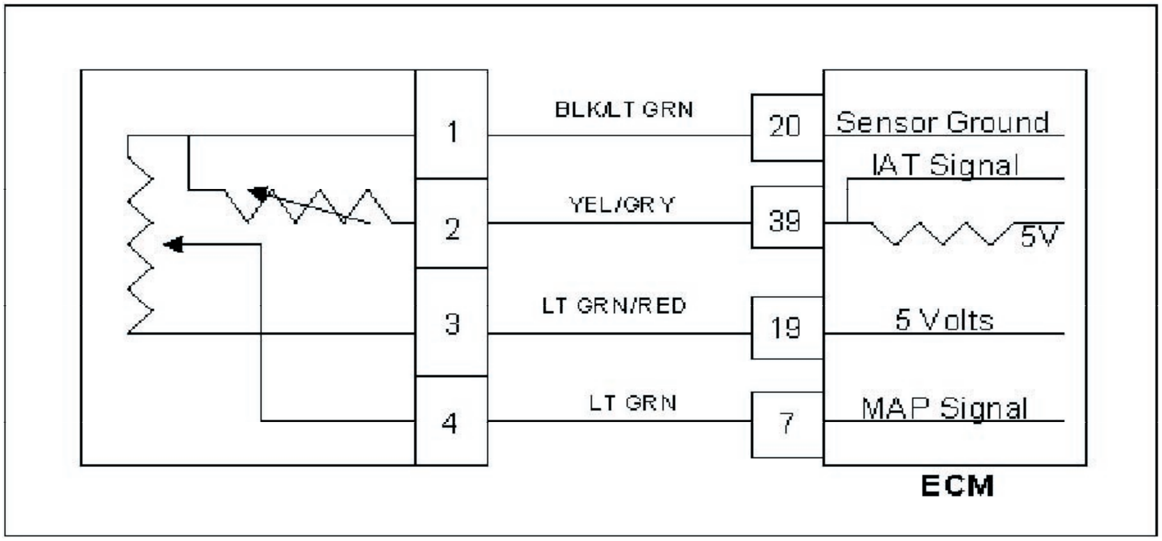
DTC 127-IAT Higher Than Expected 2 SPN/FMI 105:0

Diagnostic Aid

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 129-BP Low Pressure SPN/FMI 108:1



Conditions for Setting the DTC

- Barometric pressure check
- Check condition-engine off and 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 the remainder of key cycle

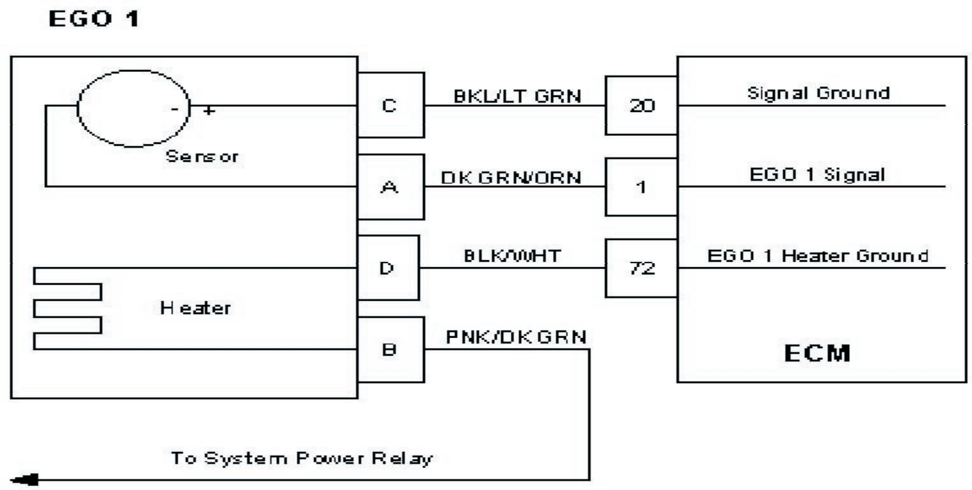
Circuit Description

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 operating range.

DTC 129- BP Low Pressure SPN/FMI 108:1

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 Does DST display MAP pressure of 8.3 PSIA or less?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Replace TMAP sensor. Is the repair complete?		Go to Step (4)	-
4	• 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-129 check for any stored codes. Does the engine operate normally with no stored codes?		System Ok	*Go to OBD System Check*

DTC 134-EGO 1 Open/Lazy SPN/FMI 724:10



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check condition- Engine running
- Fault condition- EGO 1 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 EGO 1 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.

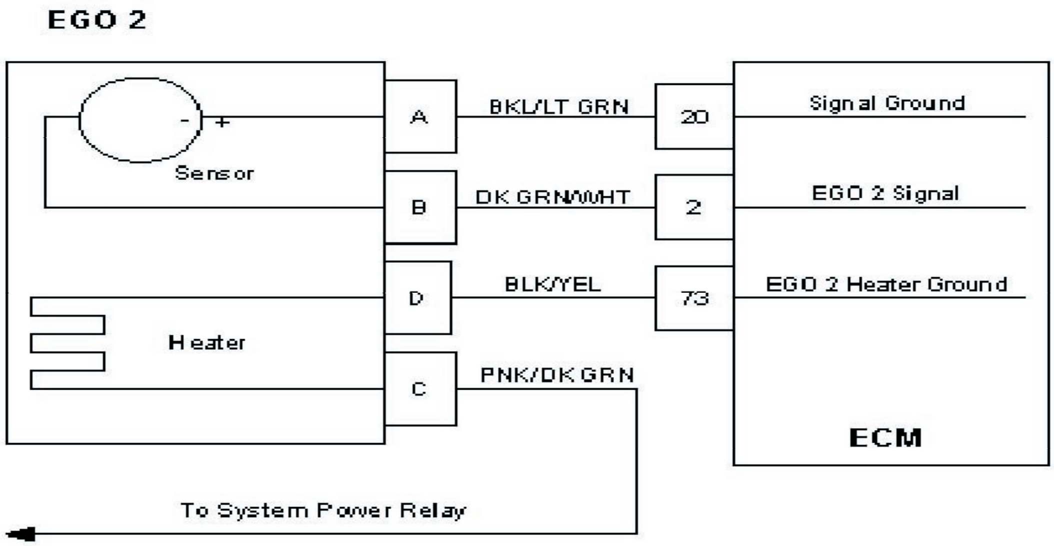
This fault will set if EGO 1 is cold, non-responsive, or inactive for more than 120 seconds.

DTC 134-EGO 1 Open/Inactive SPN/FMI 724:10

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 EGO 1 voltage fixed between 0.4 and 0.5 volts after at least 2 minutes of idle run time?		Go to Step (3)	Intermittent problem. See Electrical Section Intermittent Electrical Diagnosis
3	• Key OFF • Disconnect EGO 1 connector C006 • Key ON • Using a DVOM check for voltage between EGO 1 connector pins B and D **(Check must be made within 30 seconds or before power relay shuts down)** Do you have voltage?		*Go to step (8)*	*Go To Step (4)*
4	• Key OFF • Using a DVOM check for voltage between EGO 1 connector pin B and engine ground • Key ON **(Check must be made within 30 seconds or before power relay shuts down)** Do you have voltage?	System Voltage	*Go to step (5)*	*Repair system power relay open circuit*
5	• Disconnect ECM connector C001 • Using a DVOM check for continuity between EGO 1 connector pin D and ECM connector pin 72 Do you have continuity?		*Go to step (6)*	*Repair open heater ground circuit*
6	• Inspect wire harness connector C006 pins A and D and C001 pins 1 and 72 for damage, corrosion or contamination Did You find a problem?		Correct the problem as required see Electrical Section wire harness repair	Go to step (7)

Step	Action	Value(s)	Yes	No
7	• Replace ECM Is the replacement complete?		Go to step (11)	-
8	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between EGO 1 pin A and ECM connector pin 1 Do you have continuity?		Go to step (9)	*Repair open EGO 1 circuit*
9	• Using a DVOM check for continuity between EGO 1 pin C and ECM connector pin 20 Do you have continuity?		Go to step (10)	*Repair open EGO 1 signal ground*
10	• Replace EGO 1 sensor Is the replacement complete?		Go to step (11)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and 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 154-EGO 2 Open/Inactive SPN/FMI 520208:10



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check condition- Engine running
- Fault condition- EGO 2 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

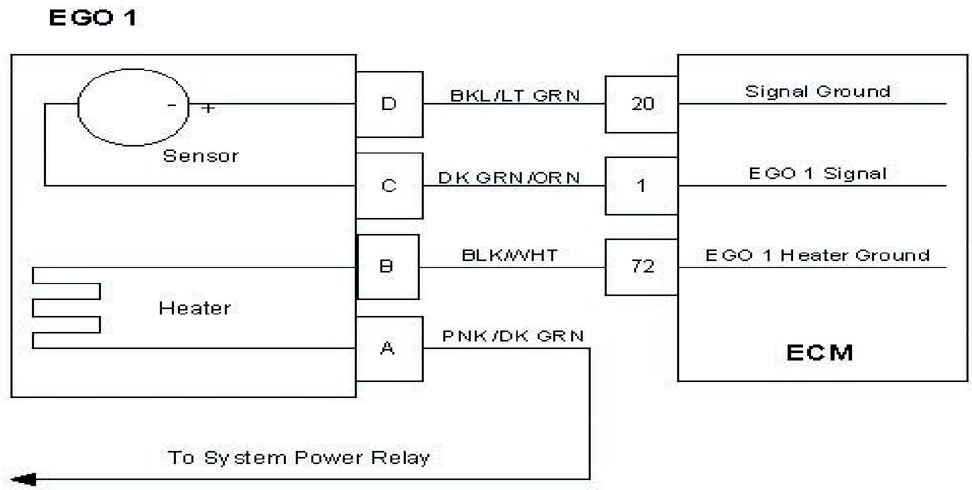
The EGO 2 sensor is used to monitor the efficiency of the catalytic converter. The ECM compares the EGO 1 and EGO 2 voltage signals to determine this. This fault will set if EGO 2 is cold, non-responsive, or inactive for more than 120 seconds.

DTC 154-EGO 2 Open/Inactive SPN/FMI 520208:10

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 EGO 2 voltage fixed between 0.4 and 0.5 volts after at least 2 minutes of idle run time?		Go to Step (3)	Intermittent problem. See Electrical Section Intermittent Electrical Diagnosis
3	• Key OFF • Disconnect EGO 2 connector C005 • Key ON • Using a DVOM check for voltage between EGO 2 connector pins C and D **(Check must be made within 30 seconds or before power relay shuts down)** Do you have voltage?		Go to step (8)	Go To Step (4)
4	• Key OFF • Using a DVOM check for voltage between EGO 2 connector pin C and engine ground • Key ON **(Check must be made within 30 seconds or before power relay shuts down)** Do you have voltage?	System Voltage	Go to step (5)	Repair system power relay open circuit
5	• Disconnect ECM connector C001 • Using a DVOM check for continuity between EGO 2 connector pin D and ECM connector pin 73 Do you have continuity?		Go to step (6)	Repair open heater ground circuit
6	• Inspect wire harness connector C005 pins C and D and C001 pins 2 and 73 for damage, corrosion or contamination Did You find a problem?		Correct the problem as required see Electrical Section wire harness repair	Go to step (7)

Step	Action	Value(s)	Yes	No
7	• Replace ECM Is the replacement complete?		Go to step (11)	-
8	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between EGO 2 connector pin B and ECM connector pin 2 Do you have continuity?		Go to step (9)	Repair open EGO 2 circuit
9	• Using a DVOM check for continuity between EGO 2 pin A and ECM connector pin 20 Do you have continuity?		Go to step (10)	Repair open EGO 2 signal ground
10	• Replace EGO 2 sensor Is the replacement complete?		Go to step (11)	-
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and 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-154 check for any stored codes. Does the engine operate normally with no stored codes?		System Ok	Go to OBD System Check

DTC 171-Adaptive Learn High Gasoline SPN/FMI 520200:0



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

Circuit Description

The EGO 1 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 Aid

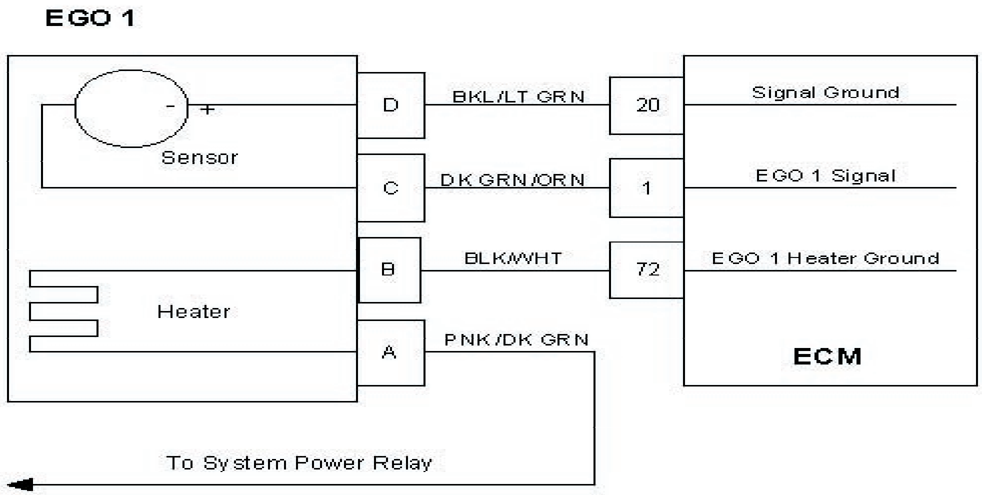
Check for other DTC codes that may be set. Correct those starting with the lowest code set number before proceeding with the diagnostic chart.
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause 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 the 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 Check ECM grounds.

DTC 171 Adaptive Learn High Gasoline SPN/FMI 520200:0

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 EGO 1 sensor installed securely and the wire leads not contacting the exhaust manifold or ignition wires • ECM grounds must be clean and tight. Refer to Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to 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. Always repair existing codes starting with the lowest numerical code set first. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (8)	Go to step (4)
4	• Disconnect EGO1 connector C006 • Using a DVOM check for voltage between EGO 1 connector pins A and B • Key ON (**CHECK MUST BE MADE WITHIN 30 SECONDS OR BEFORE POWER RELAY SHUTS DOWN)** Do you have voltage?	System voltage	Go to Step (5)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Key OFF • Disconnect EGO 1 sensor wire harness connector C006 • Disconnect ECM wire harness connector C001 • Key ON • Using a high impedance DVOM check for continuity between EGO 1 connector signal pin C and engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Using a high impedance DVOM check for continuity between EGO 1 connector signal ground pin D and EGO 1 signal pin C • Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace EGO 1 sensor Is the replacement complete?		Go to Step (8)	-

Step	Action	Value(s)	Yes	No
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-171 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 172-Adaptive Learn Low Gasoline SPN/FMI 520200:1



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

Circuit Description

The EGO 1 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.

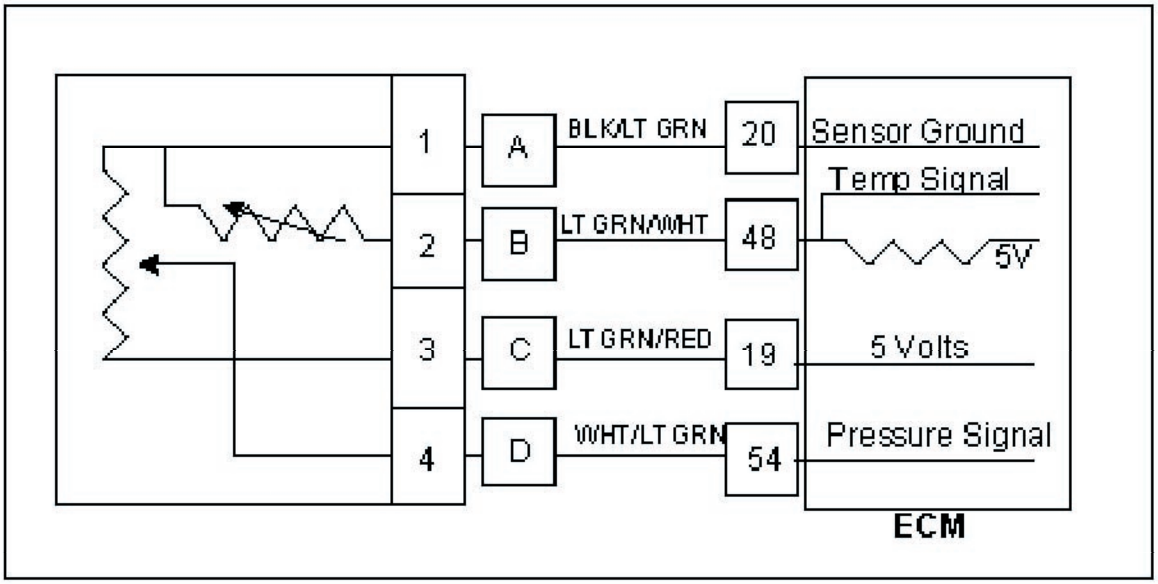
Diagnostic Aid

Check for other DTC codes that may be set. Correct those starting with the lowest code set number before proceeding with the diagnostic chart
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 cooler than it actually is. This could also cause a rich exhaust condition.

DTC 172 Adaptive Learn Low Gasoline SPN/FMI 520200:1

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 EGO 1 sensor installed securely and the wire leads not contacting the exhaust manifold or ignition wires • ECM grounds for being clean and tight. Refer to Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to Fuel System Diagnostics Was a repair made?		Go to Step (6)	Go to Step (4)
3	• Diagnose any other DTC codes before proceeding with this chart. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (6)	Go to step (4)
4	• Key OFF • Disconnect EGO 1 sensor wire harness connector • Disconnect ECM wire harness connector C001 • Key ON • Using a DVOM check for voltage at EGO 1 connector C006 signal pin C 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 EGO 1 sensor Is the replacement complete?		Go to Step (6)	-
6	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-172 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 182-Gasoline Fuel Temperature Sensor Low Voltage SPN/FMI 174:4



Conditions for Setting the DTC

- Gasoline fuel temperature sensor voltage
- Fuel temperature sensor voltage greater than 0.05v for 1s
- MIL-On for active fault and for 2 seconds after active fault

Circuit Description

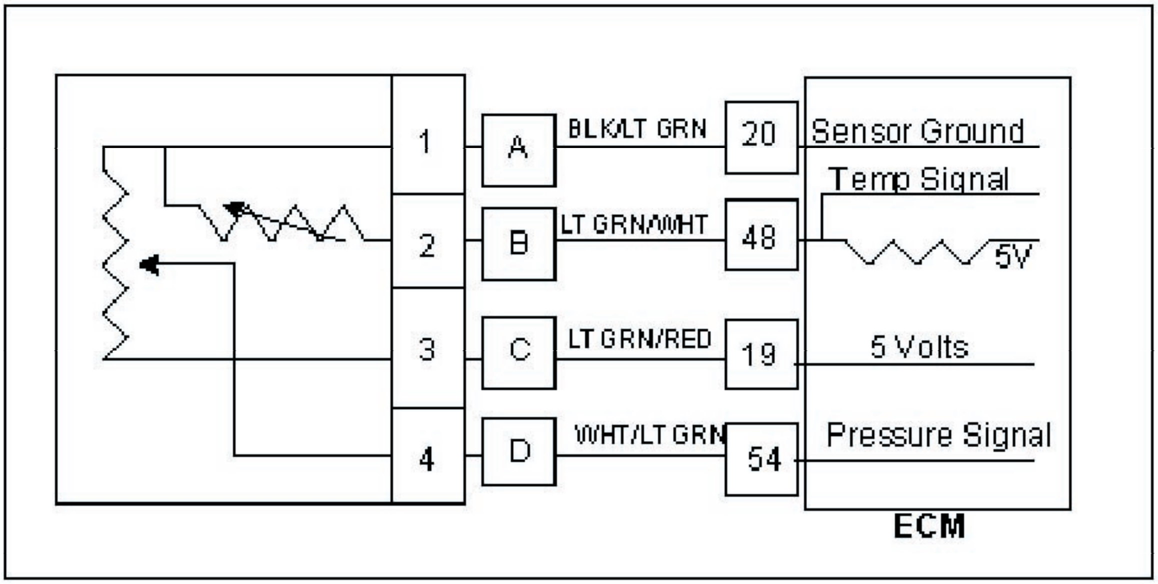
Note: The fuel pressure and temperature sensor is wired via Equipment Manufacturer supplied harness jumper. The terminals A, B, C, D & 19, 20, 48, 54 are engine wiring harness terminals at the fuel sensor interface connector C002 and the ECM header connector C001. You may need to consult additional wiring information supplied by the OEM. The gasoline fuel temperature sensor voltage is read at less than 0.05v. This indicates a low voltage fault from the sensor or circuit.

DTC 182- Gasoline Fuel Temperature Sensor Low Voltage SPN/FMI 174:4

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 • Check voltage for AUX_PU3 raw on the Raw Volts Page Is voltage 0.050 volts or lower?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the gasoline fuel pressure sensor jumper harness connector C002 from the engine wiring harness • Key On • Using a DVOM, check for voltage between connector C002 terminal B and engine ground. Is voltage 4.95 volts or higher?		Go to Step (4)	Go to step (8)
4	• Using a DVOM check for voltage between fuel pressure sensor connector C002 terminals A & B. Is voltage of 4.95 volts or higher		Go to Step (5)	Go to Step (7)
5	• Jumper fuel pressure sensor connector C002 terminals A & B together. Is voltage for AUX_PU3 raw .050 volts or less?		Go to Step (6)	Go to Step 7
6	• Inspect fuel pressure and temperature sensor connector and pins for corrosion, contamination or mechanical damage. Check for opens or shorts in OEM supplied jumper harness to sensor Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (11)
7	• Key OFF • Disconnect ECM connector C001 • Check for continuity between gasoline pressure sensor connector terminal A and ECM pin 20. Do you have continuity between them?		Go to Step (8)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
8	• Check for continuity between fuel pressure sensor connector terminal B and ECM pin 48 Do you have continuity between them?		Go to step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Inspect ECM and gasoline pressure sensor connector (C002) 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 (10)
10	• Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step (12)	-
11	• Replace fuel pressure and temperature sensor Is the replacement complete?		Go to step (12)	-
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-91 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 183-Gasoline Fuel Temperature Sensor High Voltage SPN/FMI 174:3



Conditions for Setting the DTC

- Gasoline fuel temperature sensor voltage
- Fuel temperature sensor voltage greater than 4.95v for 1s
- MIL-On for active fault and for 2 seconds after active fault

Circuit Description

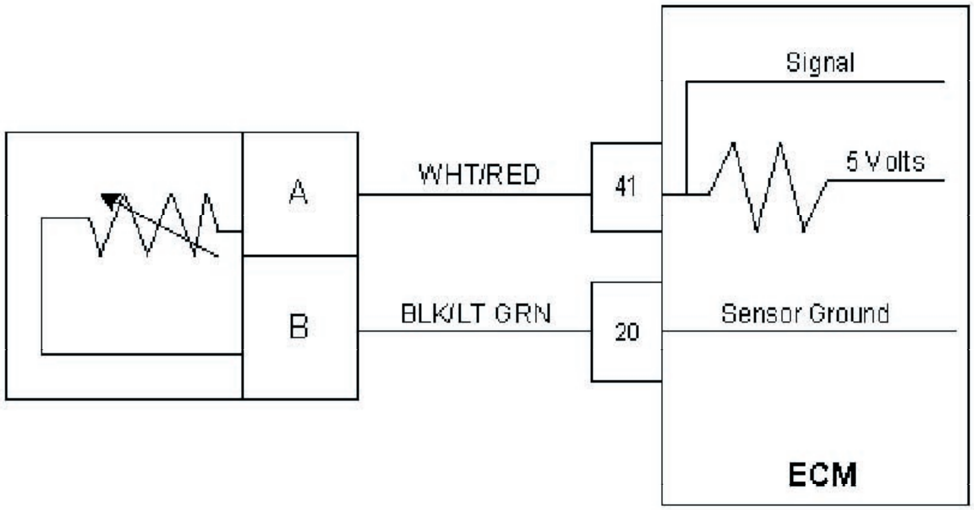
Note: The fuel pressure and temperature sensor is wired via Equipment Manufacturer supplied harness jumper. The terminals A, B, C, D & 19, 20, 48, 54 are engine wiring harness terminals at the fuel sensor interface connector C002 and the ECM header connector C001. You may need to consult additional wiring information supplied by the OEM. The fuel temperature sensor voltage is read at greater than 4.95v. This indicates a high voltage fault from the sensor or circuit.

DTC 183- Gasoline Fuel Temperature Sensor High Voltage SPN/FMI 174:3

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 • Check voltage for AUX_PU3 raw on the Raw Volts Page Is voltage 4.95 volts or higher?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect the gasoline fuel pressure sensor jumper harness connector C002 from the engine wiring harness • Key On • Using a DVOM, check for voltage between connector C002 terminal B and engine ground. Is voltage 4.95 volts or higher?		Go to Step (4)	Go to step (8)
4	• Using a DVOM check for voltage between fuel pressure sensor connector C002 terminals A & B. Is voltage of 4.95 volts or higher		Go to Step (5)	Go to Step (7)
5	• Jumper fuel pressure sensor connector C002 terminals A & B together. Is voltage for AUX_PU3 raw .050 volts or less?		Go to Step (6)	Go to Step (7)
6	• Inspect fuel pressure and temperature sensor connector and pins for corrosion, contamination or mechanical damage. Check for opens or shorts in OEM supplied jumper harness to sensor Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (11)

Step	Action	Value(s)	Yes	No
7	• Key OFF • Disconnect ECM connector C001 • Check for continuity between gasoline pressure sensor connector terminal A and ECM pin 20. Do you have continuity between them?		Go to Step (8)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Check for continuity between fuel pressure sensor connector terminal B and ECM pin 48 Do you have continuity between them?		Go to step (9)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Inspect ECM and gasoline pressure sensor connector (C002) 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 (10)
10	• Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?		Go to step (12)	-
11	• Replace fuel pressure and temperature sensor Is the replacement complete?		Go to step (12)	-
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-91 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 187-LPG Fuel Temperature Sesnor Voltage Low SPN/FMI 520240:4



Temperature Sensor Temperature Degrees F.	Resistance Tolerance ± 10% Ohms
-40	99318
-20	48300
0	24705
20	13214
40	7357
60	4259
70	3284
80	2554
100	1582
120	1008
140	660.6
160	444.1
170	367.3
180	305.5
190	255.4
200	214.6
220	153.7

Conditions for Setting the DTC

- Fuel Temperature
- Check Condition-Engine Running
- Fault Condition-FT sensor voltage less than 0.050 volts
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault and for the remainder of the key cycle

Circuit Description

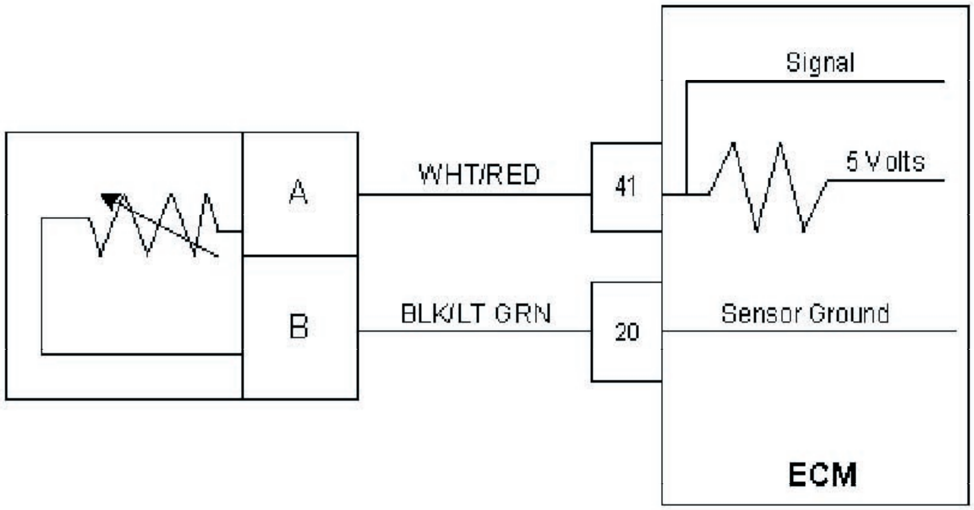
The FT (Fuel Temperature) sensor is a temperature sensitive resistor located near the fuel outlet of the electronic pressure regulator. It is used to help determine fuel charge density for accurate fuel mixture control. The ECM provides a voltage divider circuit so that when the sensor is cool the signal reads a higher voltage, and lower when warm. This fault will set if the signal voltage is less than 0.050 volts anytime the engine is running.

DTC 187- LPG Fuel Temperature Sensor Voltage Low
SPN/FMI 520240:4

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 FT voltage of 0.050 or less?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the FT wire harness connector C003 • Key ON Does the DST display FT voltage of 4.9 volts or greater?		Go to step (4)	Go to step (5)
4	Replace FT sensor. Is the replacement complete?		Go to Step (8)	_
5	• Key OFF • Disconnect ECM wire harness connector C001 • Check for continuity between FT sensor connector signal pin A and FT sensor ground pin B Do you have continuity between them?	__	Repair the shorted circuit as Repairs in Engine Electrical.	Go to step (6)
6	• Check for continuity between FT 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)	_

Step	Action	Value(s)	Yes	No
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-187 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 188-LPG Fuel Temperature Sensor Voltage High SPN/FMI 520240:3



Temperature Sensor Temperature Degrees F.	Resistance Tolerance ± 10% Ohms
-40	99318
-20	48300
0	24705
20	13214
40	7357
60	4259
70	3284
80	2554
100	1582
120	1008
140	660.6
160	444.1
170	367.3
180	305.5
190	255.4
200	214.6
220	153.7

Conditions for Setting the DTC

- Fuel Temperature
- Check Condition-Engine Running
- Fault Condition-FT sensor voltage exceeds 4.950
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault and for the remainder of the key cycle

Circuit Description

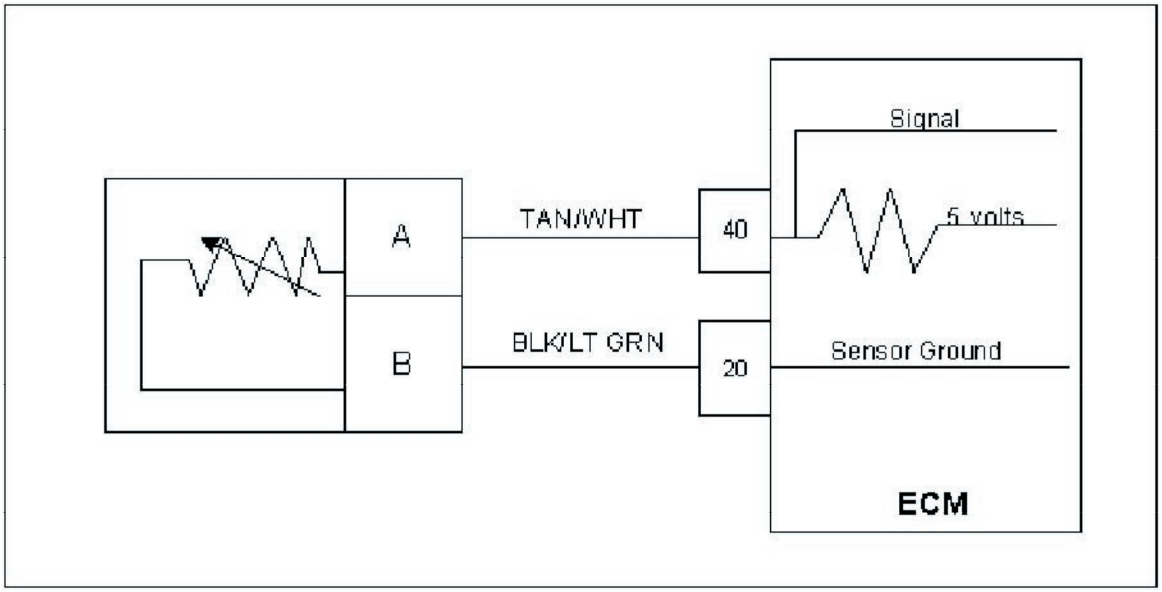
The FT (Fuel Temperature) sensor is a temperature sensitive resistor located near the fuel outlet of the electronic pressure regulator. It is used to help determine fuel charge density for accurate fuel mixture control. The ECM provides a voltage divider circuit so that when the sensor is cool the signal reads a higher voltage, and lower when warm. This fault will set if the signal voltage is greater than 4.950 volts anytime the engine is running.

DTC 188- FT Voltage High
SPN/FMI 520240:3

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 FT voltage of 4.95 or greater?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the FT sensor connector C003 and jump connector terminals A and B together • Key On Does the DST display FT 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 FT sensor and compare the resistance reading to the chart Is the resistance value correct?	See temperature vs. resistance chart in the DTC 188 circuit description	Go to Step (6)	Go to step (5)
5	• Replace FT sensor Is the replacement complete?		Go to Step (14)	-
6	• Inspect the FT sensor 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 20 and 41 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	• Jump the FT signal pin A at the FT connector C003 to engine ground Does DST display FT voltage of 0.05 or less?		Go to Step (9)	Go to Step (12)
9	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between FT sensor ground pin B and ECM connector pin 20 Do you have continuity between them?		Go to Step (10)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
10	• Inspect ECM connector pins 20 and 41 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 C001 • Using a DVOM check for continuity between FT connector signal pin A and ECM connector terminal 41 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 20 and 41 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-188 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 217-ECT Higher Than Expected 2 SPN/FMI 110:0



Conditions for Setting the DTC

- Engine Coolant Temperature
- Check Condition-Engine Running
- Fault Condition-Engine Coolant temperature reading or estimate greater than 235 deg. F for more than 60 seconds with the engine speed greater than 600 rpm
- MIL-On
- Engine Shut Down

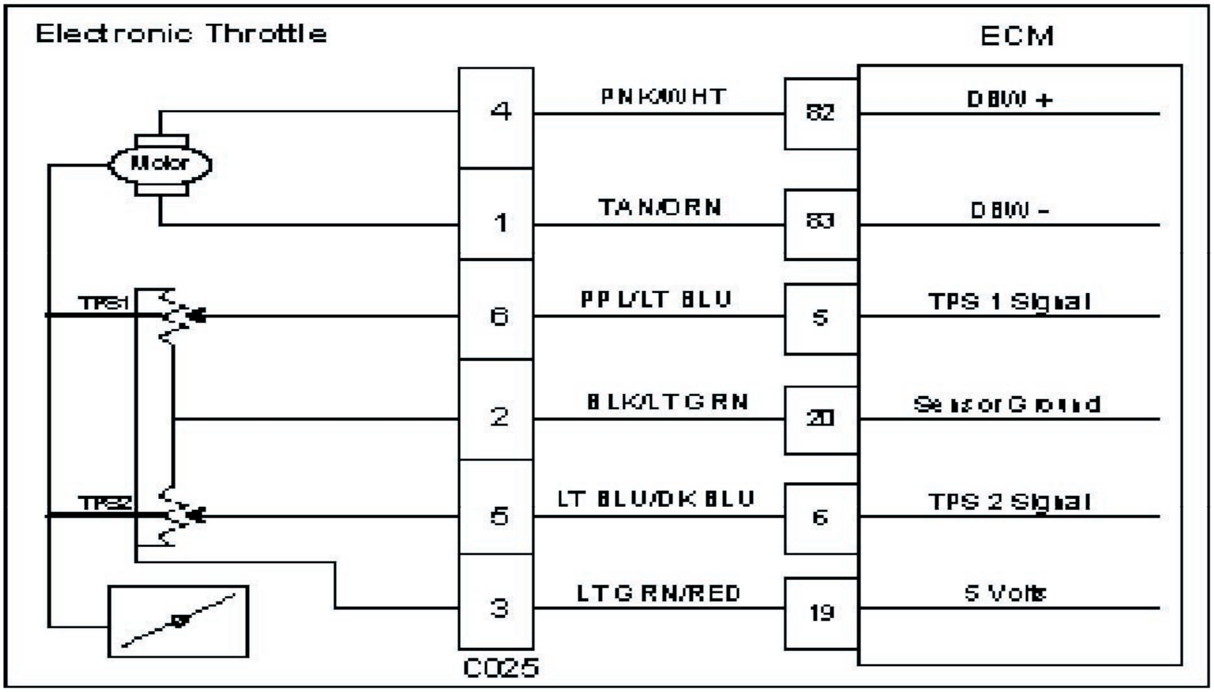
Circuit Description

The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant passage. The ECT is used for engine airflow calculation, fuel enrichment, ignition timing control and to enable certain other temperature dependant operations. This code set is designed to help prevent engine damage from overheating. 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 set when the coolant exceeds 250 degrees F. for more than 60 seconds with the engine speed over 1000 rpm. The engine will then shut down.

DTC 217 ECT Higher than expected 2 SPN/FMI 110:0

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 • Operate the engine to attempt to recreate the failure running the engine above 1000 rpm for at least 60 seconds • Does DST display ECT temperature of 250 degrees F. or greater with the engine running over 1000 rpm, and then shut down?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Verify with a temperature gauge that the engine coolant is over 250 degrees F. Does the temperature gauge indicate 250 degrees F. or greater?		Repair Cooling system.	Go to step (4)
4	Verify ECT circuit function. Follow diagnostic test procedure for DTC-117 ECT Low Voltage		-	-

DTC 219-Max Govern Speed Override SPN/FMI 515:15



Conditions for Setting the DTC

- Max Govern Speed Override
- Check Condition- Engine Running
- Fault Condition- Engine RPM greater than 3200 for 2 seconds continuously
- MIL- On during active fault

Circuit description

This fault will set anytime the engine RPM exceeds 3500 for 2 seconds or more continuously. The MIL command is ON during this active fault.

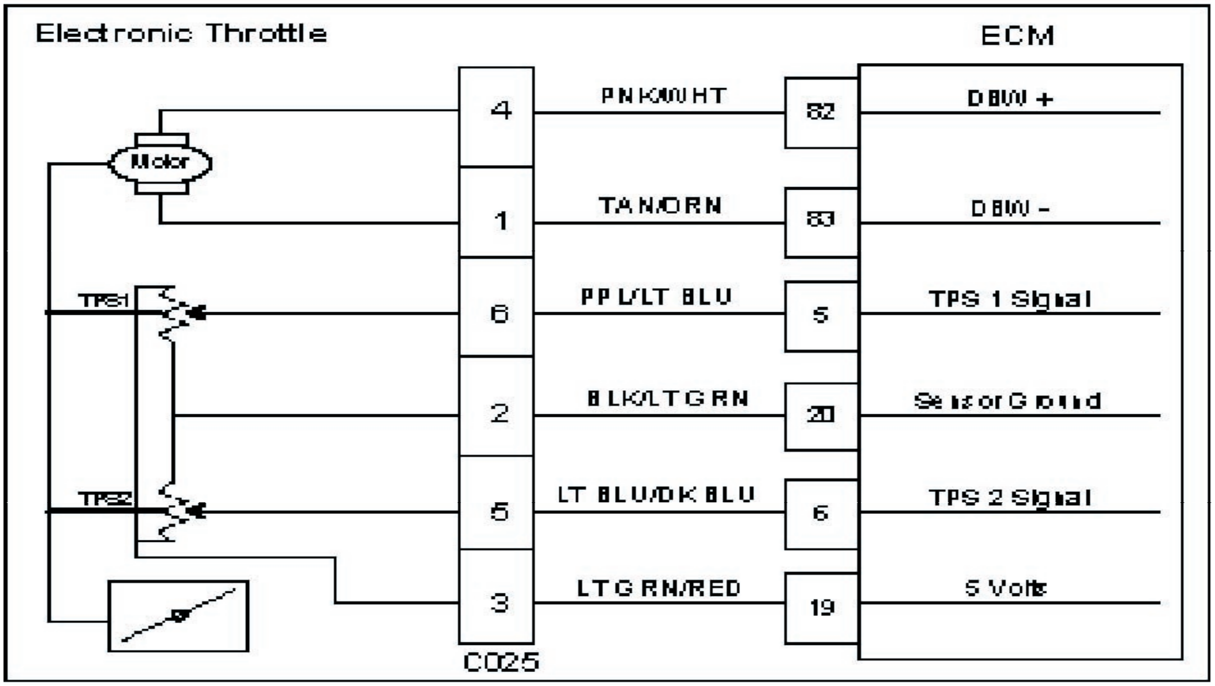
Diagnostic Aid

Always check for other stored DTC codes before using the following DTC chart for this code set. Repair any existing codes starting with the lowest numerical code first.

DTC 219- Max Govern Speed Override SPN/FMI 515:15

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 connected Are any other DTC codes present with DTC 219?		Go to Step (3)	Go to Step (4)
3	• Diagnose and repair any other DTC codes stored 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 the 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 section Has the mechanical operation of the throttle been corrected?		Go to step (9)	-
8	• Check engine for large manifold vacuum leaks. Refer to Symptom Diagnostic section 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-219 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 221-TPS 1 Higher Than TPS 2 SPN/FMI 51:0



Conditions for Setting the DTC

- Throttle Position Sensor 1 & 2
- Check Condition-Key On
- Fault Condition-TPS 1 20% higher than TPS2
- MIL-On for remainder of key on cycle
- Engine Shutdown

Circuit Description

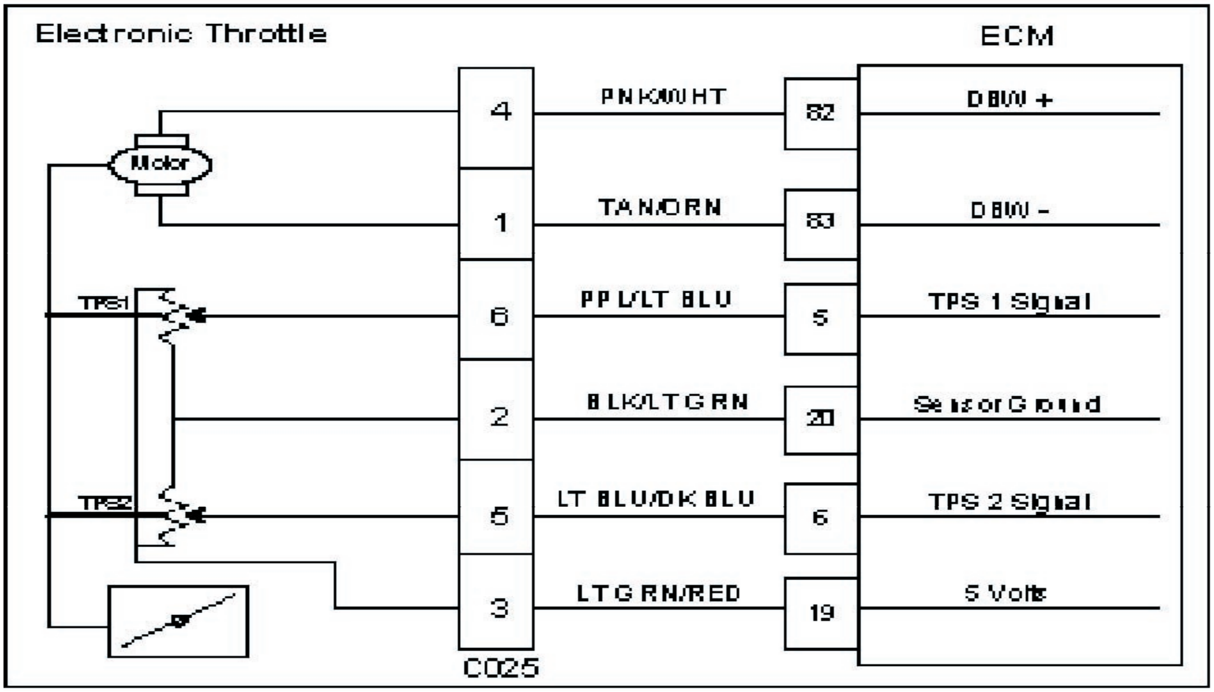
There are two Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS 1 will read lower voltage when closed and TPS 2 will read higher voltage when closed. The TPS 1 and TPS 2 percentages are calculated from 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. The TPS is not serviceable and in the event of a failure the electronic throttle assembly must be replaced. This fault will set if TPS 1 is 20% (or more) higher than TPS 2. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. The MIL command is ON and Power derate 1 will be enforced limiting the throttle to 50% maximum

DTC 221 TPS 1 Higher Than TPS 2 SPN/FMI 51:0

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 more than a 20% difference between TPS 1 and TPS 2?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect electronic throttle connector C025 • Key ON • Change DST mode to DBW (drive by wire) test mode Is the voltage for TPS 1 less than 0.1 volts?		Go to Step (5)	Go to Step (4)
4	• Key OFF • Disconnect ECM wiring harness connector C001 • Key ON • Using a DVOM check for voltage between ECM connector TPS 1 signal pin 5 and engine ground Do you have voltage?		Repair the TPS 1 circuit shorted to voltage as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (9)
5	• Jump TPS 1 signal pin 6 to the 5 volt reference pin 3 at connector C025 Does DST display TPS 1 voltage over 4.95 volts		Go to Step (6)	Go to Step (8)
6	• Inspect wire terminals at throttle connector for damage corrosion or contamination Any problems found?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace the electronic Throttle Is the replacement complete?		Go to Step (12)	-
8	• Key OFF • Disconnect ECM wire harness connector C001 • Using a DVOM check for continuity between throttle connector TPS 1 signal pin 6 and ECM connector TPS 1 signal pin5 Do you have continuity between them?		Go to Step (9)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
9	• Using a DVOM check for continuity between throttle connector signal ground pin 2 and ECM connector signal ground pin 20 Do you have continuity between them?		Go to Step (10)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
10	• Inspect ECM connector terminals for damage corrosion or contamination. Any problems found?		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 (12)	-
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate 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?		System OK	Go to OBD System Check

DTC 222-TPS 2 Signal Voltage Low SPN/FMI 520251:4



Conditions for Setting the DTC

- Throttle Position Sensor 2
- Check Condition-Cranking or Running
- Fault Condition-TPS 2 sensor voltage less than 0.200 volts for more than .500 seconds
- MIL-ON during active fault
- Engine Shutdown

Circuit Description

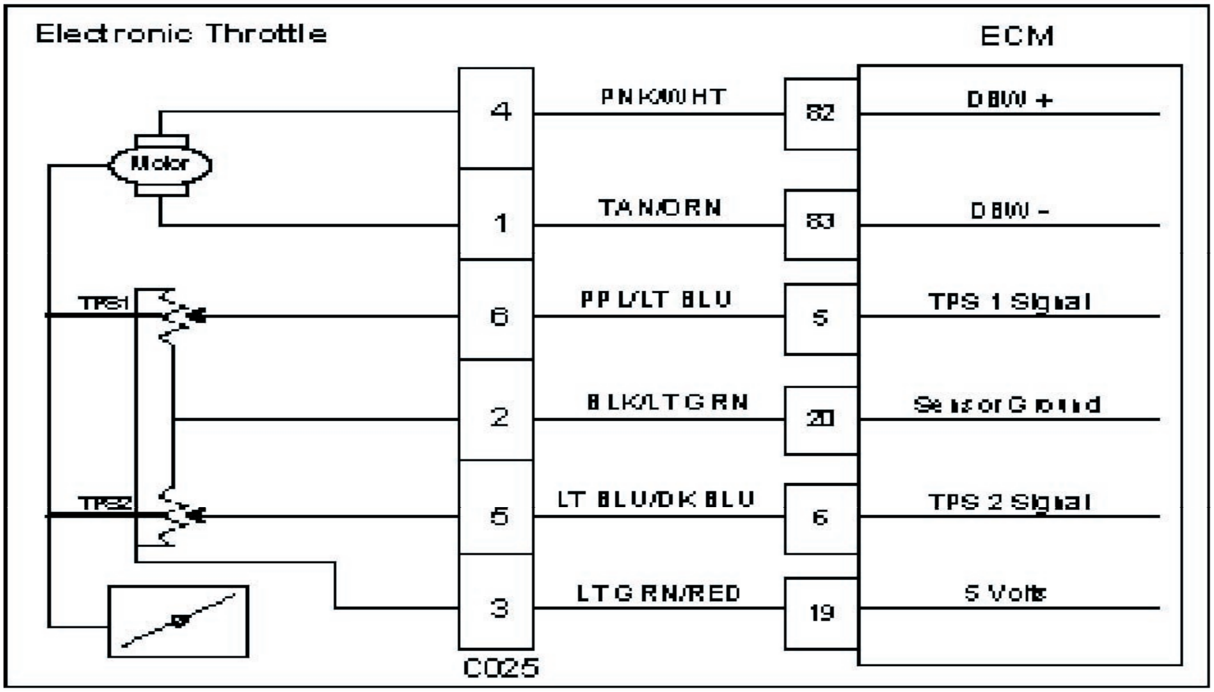
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read lower voltage when closed and TPS2 will read higher voltage when closed. The TPS1 and TPS2 percentages are calculated from these 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. The TPS is not serviceable and in the event of a failure the electronic throttle assembly must be replaced.

This fault will set if the TPS 2 voltage is less than 0.200 volts for more than .500 seconds. The MIL command is ON and power derate level 1 will be enforced limiting maximum throttle to 50%.

DTC 222 TPS 2 Signal Voltage Low SPN/FMI 520251:4

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 2 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 2 voltage Does TPS 2 voltage ever fall below 0.2 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect electronic throttle connector C025 • Jumper the 5 volt reference circuit pin 3 and TPS 2 signal circuit pin 5 together at the throttle connector • Key ON Does DST display TPS 2 voltage of 4.0 volts or greater?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector C001 Using a DVOM check continuity between TPS 2 connector signal pin 5 and ECM connector TPS 2 Signal pin 6 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
6	• Replace ECM Is the replacement complete?		Go to Step (9)	-
7	• Inspect the electronic 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 electronic throttle 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-222 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 223-TPS 2 Signal Voltage High SPN/FMI 520251:3



Conditions for Setting the DTC

- Throttle Position Sensor 2
- Check Condition-Cranking or Running
- Fault Condition-TPS 2 sensor exceeds 4.80 volts for more than .50 seconds
- MIL-On during active fault
- Engine Shutdown

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 lower voltage when closed and TPS2 will read higher 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. The TPS is not serviceable and in the event of a failure the electronic throttle assembly must be replaced.

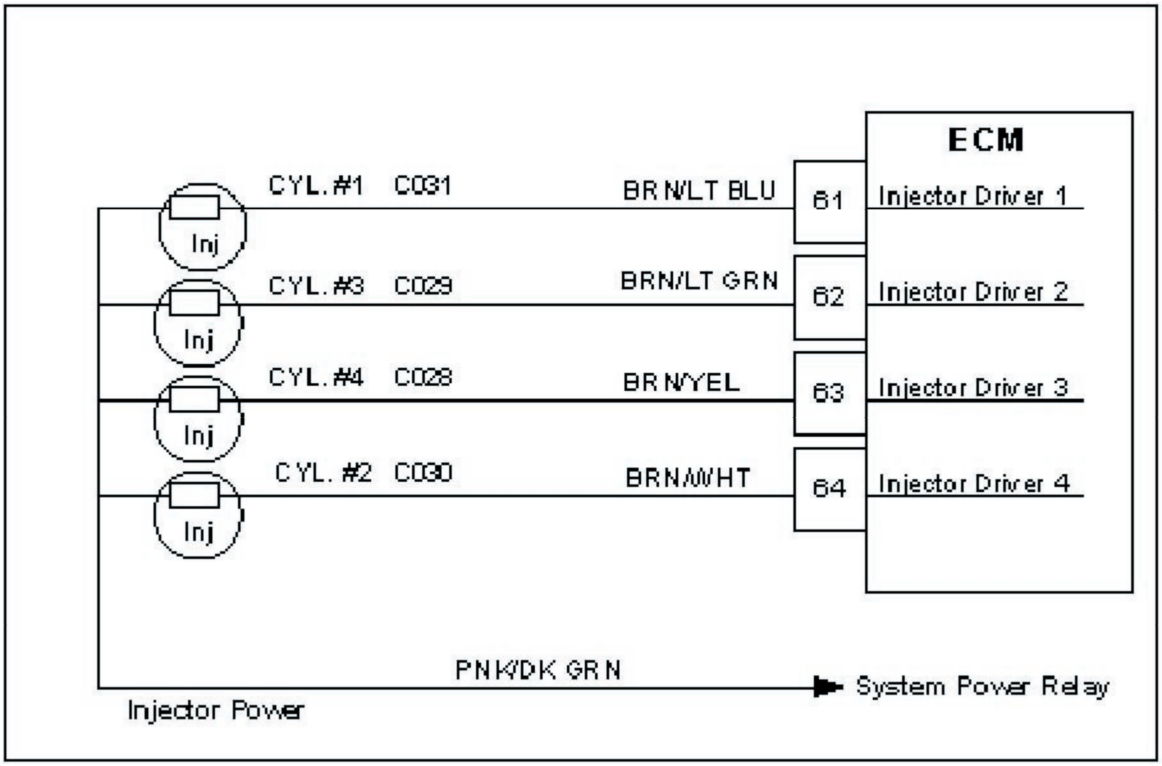
This fault will set if the TPS 2 voltage is greater than 4.80 volts for more than .50 seconds. The MIL command is ON and power derate level 1 will be enforced limiting maximum throttle to 50%.

DTC 223 TPS 2 Signal Voltage High SPN/FMI 520251:3

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 2 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 2 voltage Does TPS 2 voltage ever exceed 4.8 volts?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Key OFF • Disconnect electronic throttle connector C025 • Key ON Does DST display TPS 2 voltage less than 0.2 volts?		Go to Step (7)	Go to Step (5)
5	• Key OFF • Disconnect ECM wire harness connector C001 • Key ON • Using a DVOM check for voltage between electronic throttle connector TPS 2 signal pin 5 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	• Probe sensor ground circuit at the ECM side of the wire harness pin 20 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 electronic throttle wire harness connector and 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 electronic throttle Is the replacement complete?		Go to Step (11)	-
10	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between throttle connector C025 sensor ground pin 2 and ECM connector sensor ground pin 20 Do have continuity between them?		Go to Step (6)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.

Step	Action	Value(s)	Yes	No
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-223 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 261 Injector Driver 1 (Cyl #1) Open SPN/FMI 651:5



Conditions for Setting the DTC

- Injector loop open or driver circuit short
- Check Condition-key on and engine running
- Fault Condition-System voltage greater than 9 volts and injector low side less than 4 volts for 10 injector firings
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key-on cycle
- Closed Loop-Disabled during active fault

Circuit Description

This fault will set if the ECM detects low feedback voltage at the injector driver circuit while the injector drive circuit is in the off-state and battery voltage is greater than 9 volts.

Diagnostic Aid

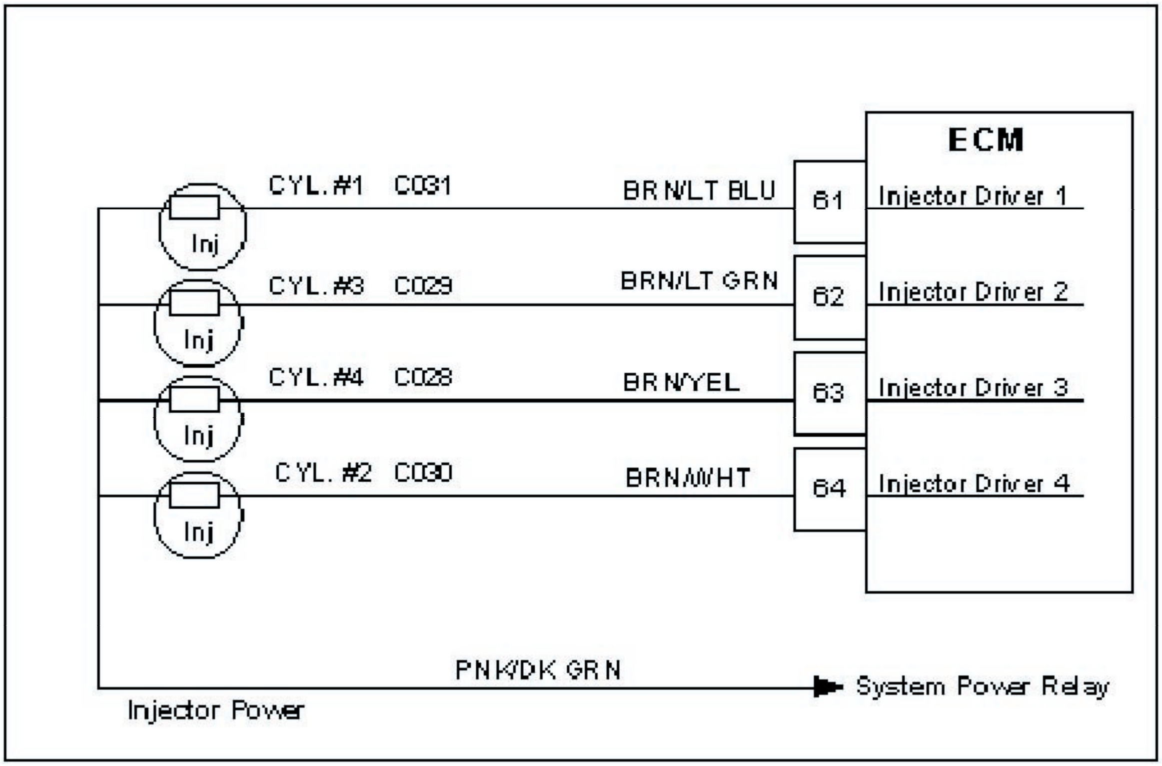
The injector driver numbers shown above are called out in respect to the engine firing order. It is important to know the engine firing order when locating a specific injector at the engine block. Refer to engine firing order in the engine section of this manual.

DTC 261 Injector Driver 1 (Cyl #1) Open SPN/FMI 651:5

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 DTC 261 Does DTC 261 reset with the engine idling?		Go to step (3)	Intermittent problem. Go to Intermittent electrical section
3	• Key Off • Disconnect the wire harness connector C031 at the number 1 injector. • Using a high impedance DVOM, measure the resistance between the (2) pins on the injector at an ambient temperature of 58 to 88 degrees F. Does the DVOM display a resistance value of 16 Ohms or less?	16 ohms or less	Go to step (5)	Go to step (4)
4	• Replace the Fuel Injector Is the replacement complete?		Go to Step (11)	_
5	• Measure the resistance between C031 injector driver BRN/LT BLU wire and battery ground. Does the DVOM display a resistance of 5.0 Ohms or less?	__	Go to Step (6)	Go to step (9)
6	• Disconnect ECM connector C001 • Measure the resistance between the injector driver wire BRN/LT BLU and battery ground. Does the DVOM display a resistance of 5.0 Ohms or less?	5.0 Ohms	Repair the shorted injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (9)
7	• Disconnect ECM wire harness connector C001 • Using a DVOM measure the resistance between the injector driver wire BRN/LT BLU and ECM connector pin 61 • Does the DVOM display a resistance of 5.0 Ohms or less between them?	5.0 Ohms	Go to Step (8)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Check the injector connector and ECM connector terminals for damage, corrosion or contamination. Any problems found?		Repair the open injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (10)

Step	Action	Value(s)	Yes	No
9	• Disconnect ECM wire harness connector C001 • Using a DVOM measure the resistance between the injector connector C031 BRN/ LT BLU wire and ECM pin 61 Does the DVOM display a resistance of 5.0 Ohms or less?		Go to Step (8)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Replace ECM. Refer to ECM replacement in the Engine Controls Section. 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-261 check for any stored codes. • Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 262 Injector Driver 1 (Cyl #1) Shorted SPN/FMI 651:6



Conditions for Setting the DTC

- Injector coil shorted
- Check Condition-key on and engine running
- Fault Condition-Battery voltage at ECM less than16 volts and injector on state low side greater than 4 volts for 10 injector firings
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key-on cycle
- Closed Loop-Disabled during active fault

Circuit Description

This fault will set if the ECM detects high feedback voltage at the injector while the injector drive circuit is in the off-state with system battery voltage less than 16 volts.

Diagnostic Aid

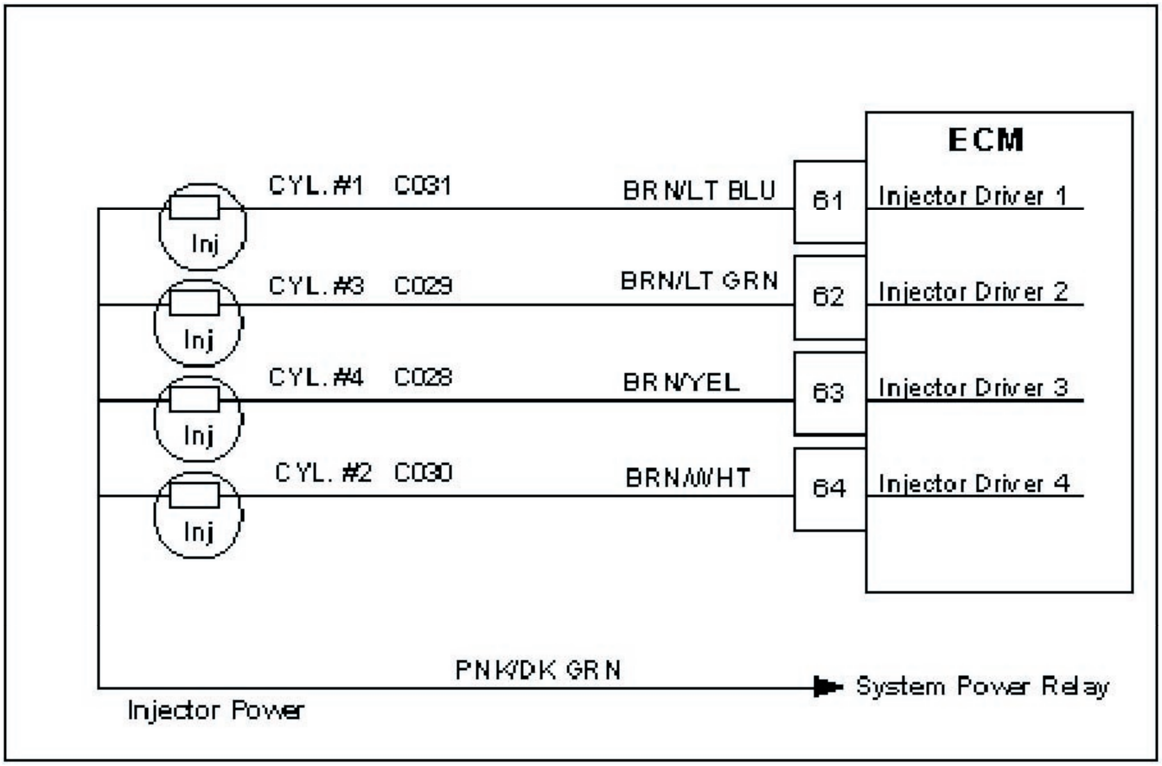
The injector driver numbers shown above are called out in respect to the engine firing order. It is important to know the engine firing order when locating a specific injector at the engine block. Refer to engine firing order in the engine section of this manual.

DTC 262 Injector Driver 1 (Cyl #1) Shorted SPN/FMI 651:6

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 DTC 262 Does DTC 262 reset with the engine idling?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the harness connector C031 from the cylinder number 1 injector. • Using a high impedance DVOM, measure the resistance between the (2) pins of the injector Does the DVOM display a resistance value of 5 ohms or more?		Go to step (5)	Go to step (4)
4	• Replace the Fuel Injector Is the replacement complete?		Go to Step (8)	_
5	• Disconnect the ECM wire harness connector C001 • Key ON • Using a DVOM check for voltage between the ECM connector pin 61 and engine ground Does the DVOM display voltage?		Repair the shorted to voltage injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace Fuel Injector Is the replacement complete?		Go to Step (8)	-
7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	Go to step (9)	_

Step	Action	Value(s)	Yes	No
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 DTC262 check for any stored codes. • Does the vehicle engine normally with no stored codes?		System OK	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 DTC262 check for any stored codes. • Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 264 Injector Driver 2 (Cyl #3) Open SPN/FMI 652:5



Conditions for Setting the DTC

- Injector coil open or driver circuit short
- Check Condition-key on and engine running
- Fault Condition-Battery voltage at ECM greater than 9 volts and injector low side less than 4 volts for 10 injector firings
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key-on cycle
- Closed Loop-Disabled during active fault

Circuit Description

This fault will set if the ECM detects low feedback voltage on the internal injector while the injector drive circuit is in the off-state and battery voltage is greater than 9 volts.

Diagnostic Aid

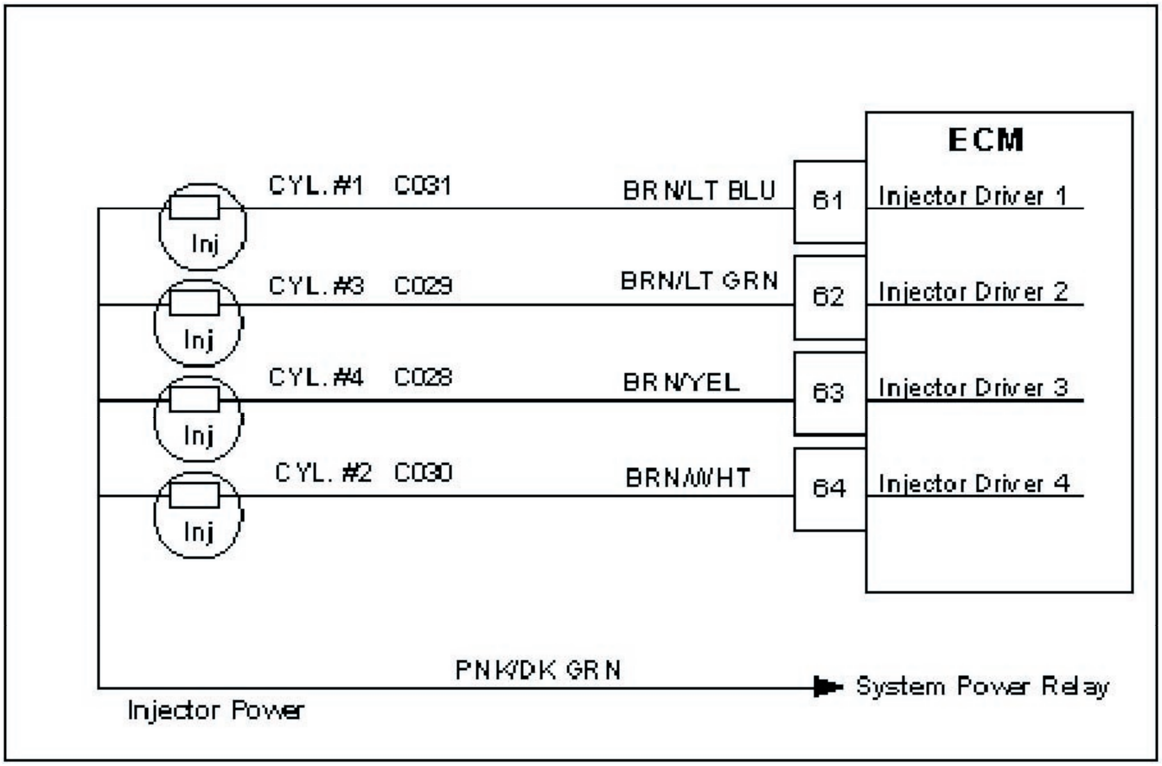
The injector driver numbers shown above are called out in respect to the engine firing order. It is important to know the engine firing order when locating a specific injector at the engine block. Refer to engine firing order in the engine section of this manual.

DTC 264 Injector Driver 2 (Cyl #3) Open SPN/FMI 652:5

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 DTC 264 Does DTC 264 reset with the engine idling?		Go to step (3)	Intermittent problem. Go to Intermittent electrical section
3	• Key Off • Disconnect the wire harness connector C029 at the cylinder number 3 injector. • Using a high impedance DVOM, measure the resistance between the (2) pins on the injector at an ambient temperature of 58 to 88 degrees F. Does the DVOM display a resistance value of 16 Ohms or less?	16 ohms or less	Go to step (5)	Go to step (4)
4	• Replace the Fuel Injector Is the replacement complete?		Go to Step (11)	_
5	• Measure the resistance between C029 injector driver BRN/ LT GRN wire and battery ground. Does the DVOM display a resistance of 5.0 Ohms or less?	__	Go to Step (6)	Go to step (9)
6	• Disconnect ECM connector C001 • Measure the resistance between the injector driver wire BRN/ LT GRN and battery ground. Does the DVOM display a resistance of 5.0 Ohms or less?	5.0 Ohms	Repair the shorted injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (9)
7	• Disconnect ECM wire harness connector C001 • Using a DVOM measure the resistance between the injector driver wire BRN/ LT GRN and ECM connector pin 62 • Does the DVOM display a resistance of 5.0 Ohms or less between them?	5.0 Ohms	Go to Step (8)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Check the injector connector and ECM connector terminals for damage, corrosion or contamination. Any problems found?		Repair the open injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (10)

Step	Action	Value(s)	Yes	No
9	• Disconnect ECM wire harness connector C001 • Using a DVOM measure the resistance between the injector connector C029 BRN/ LT GRN wire and ECM pin 62 Does the DVOM display a resistance of 5.0 Ohms or less?		Go to Step (8)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Replace ECM. Refer to ECM replacement in the Engine Controls Section. 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-264 check for any stored codes. • Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 265 Injector Driver 2 (Cyl #3) Shorted SPN/FMI 652:6



Conditions for Setting the DTC

- Injector coil shorted
- Check Condition-key on and engine running
- Fault Condition-Battery voltage at ECM less than 16 volts and injector on state low side greater than 4 volts for 10 injector firings
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key-on cycle
- Closed Loop-Disabled during active fault

Circuit Description

This fault will set if the ECM detects high feedback voltage at the injector while the injector drive circuit is in the off-state with system battery voltage less than 16 volts.

Diagnostic Aid

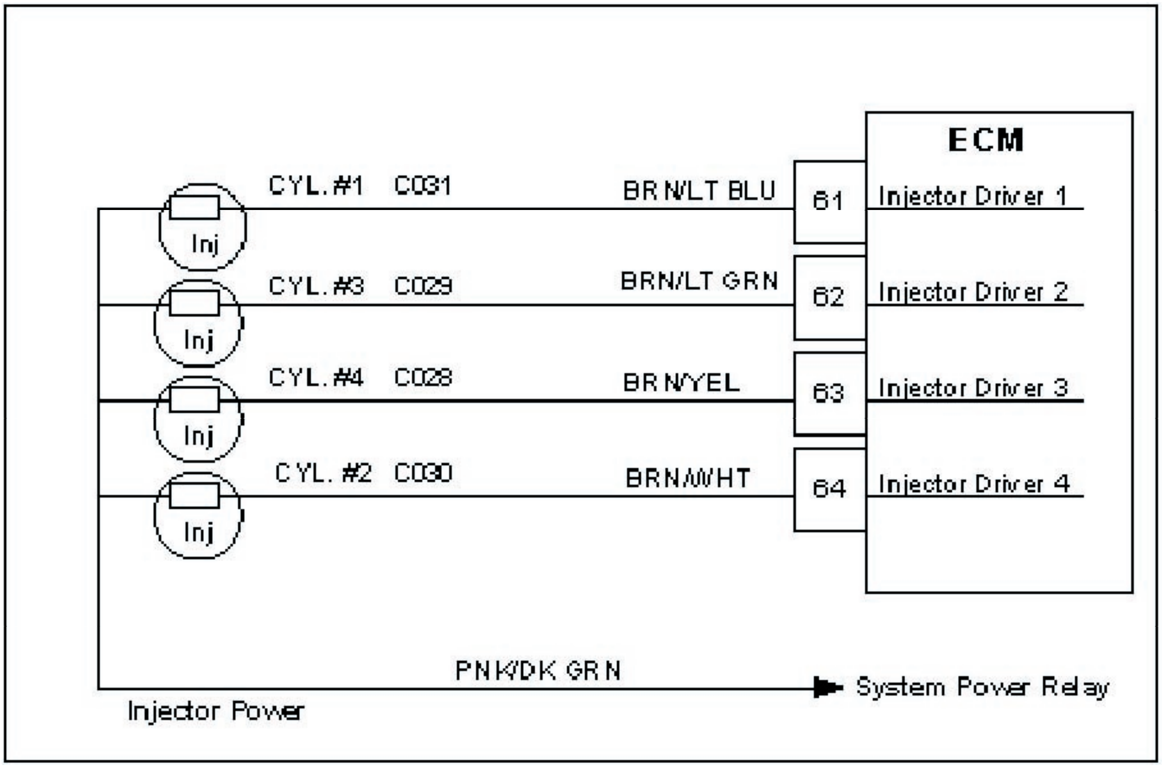
The injector driver numbers shown above are called out in respect to the engine firing order. It is important to know the engine firing order when locating a specific injector at the engine block. Refer to engine firing order in the engine section of this manual.

DTC 265 Injector Driver 2 (Cyl #3) Shorted SPN/FMI 652:6

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 DTC 265 Does DTC 265 reset with the engine idling?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the harness connector C029 from the cylinder number 3 injector. • Using a high impedance DVOM, measure the resistance between the (2) pins of the injector Does the DVOM display a resistance value of 5 ohms or more?		Go to step (5)	Go to step (4)
4	• Replace the Fuel Injector Is the replacement complete?		Go to Step (8)	_
5	• Disconnect the ECM wire harness connector C001 • Key ON • Using a DVOM check for voltage between the ECM connector pin 62 and engine ground Does the DVOM display voltage?		Repair the shorted to voltage injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace Fuel Injector Is the replacement complete?		Go to Step (8)	-
7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	Go to step (9)	_

Step	Action	Value(s)	Yes	No
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 DTC265 check for any stored codes. • Does the vehicle engine normally with no stored codes?		System OK	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 DTC265 check for any stored codes. • Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 267 Injector Driver 3 (Cyl #4) Open SPN/FMI 653:5



Conditions for Setting the DTC

- Injector coil open or driver circuit short
- Check Condition-key on and engine running
- Fault Condition-Battery voltage at ECM greater than 9 volts and injector low side less than 4 volts for 10 injector firings
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key-on cycle
- Closed Loop-Disabled during active fault

Circuit Description

This fault will set if the ECM detects low feedback voltage on the internal injector while the injector drive circuit is in the off-state and battery voltage is greater than 9 volts.

Diagnostic Aid

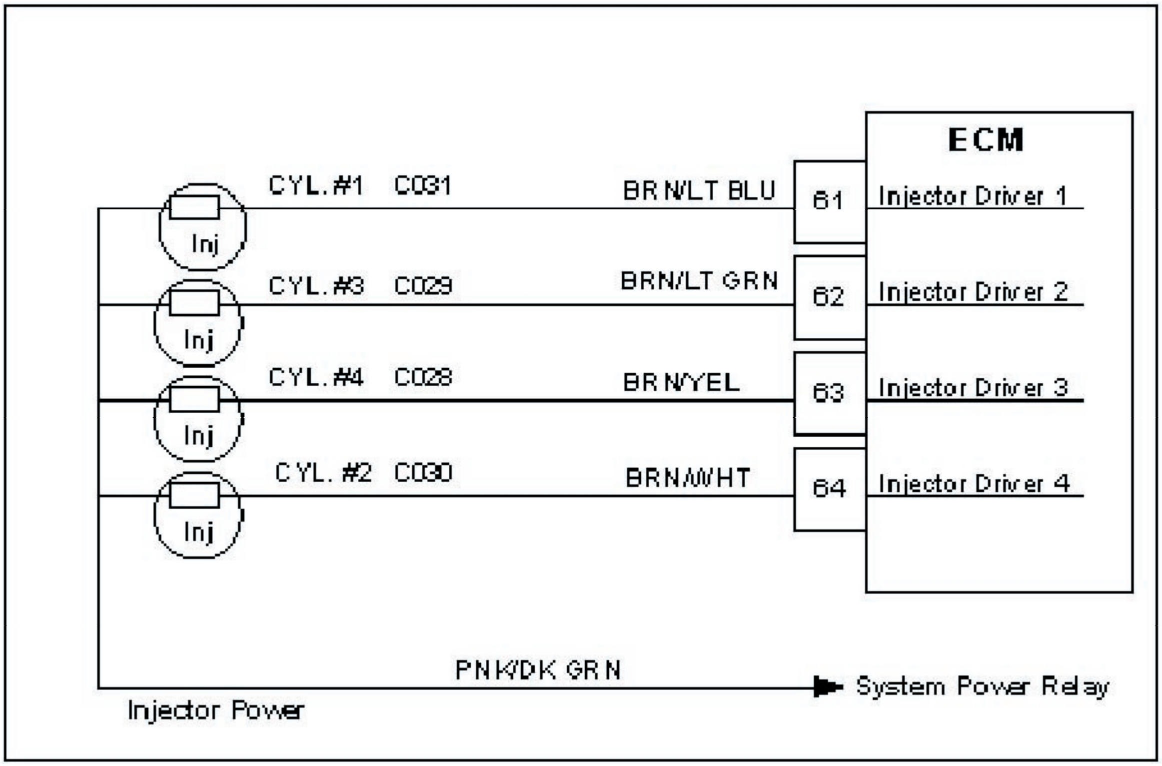
The injector driver numbers shown above are called out in respect to the engine firing order. It is important to know the engine firing order when locating a specific injector at the engine block. Refer to engine firing order in the engine section of this manual.

DTC 267 Injector Driver 3 (Cyl #4) Open SPN/FMI 653:5

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 DTC 267 Does DTC 267 reset with the engine idling?		Go to step (3)	Intermittent problem. Go to Intermittent electrical section
3	• Key Off • Disconnect the wire harness connector C028 at the cylinder number 4 injector. • Using a high impedance DVOM, measure the resistance between the (2) pins on the injector at an ambient temperature of 58 to 88 degrees F. Does the DVOM display a resistance value of 16 Ohms or less?	16 ohms or less	Go to step (5)	Go to step (4)
4	• Replace the Fuel Injector Is the replacement complete?		Go to Step (11)	_
5	• Measure the resistance between C028 injector driver BRN/YEL wire and battery ground. Does the DVOM display a resistance of 5.0 Ohms or less?	__	Go to Step (6)	Go to step (9)
6	• Disconnect ECM connector C001 • Measure the resistance between the injector driver wire BRN/YEL and battery ground. Does the DVOM display a resistance of 5.0 Ohms or less?	5.0 Ohms	Repair the shorted injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (9)
7	• Disconnect ECM wire harness connector C001 • Using a DVOM measure the resistance between the injector driver wire BRN/YEL and ECM connector pin 63 • Does the DVOM display a resistance of 5.0 Ohms or less between them?	5.0 Ohms	Go to Step (8)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Check the injector connector and ECM connector terminals for damage, corrosion or contamination. Any problems found?		Repair the open injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (10)

Step	Action	Value(s)	Yes	No
9	• Disconnect ECM wire harness connector C001 • Using a DVOM measure the resistance between the injector connector C028 BRN/YEL wire and ECM pin 63 Does the DVOM display a resistance of 5.0 Ohms or less?		Go to Step (8)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Replace ECM. Refer to ECM replacement in the Engine Controls Section. 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-267 check for any stored codes. • Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 268 Injector Driver 3 (Cyl #4) Shorted SPN/FMI 653:6



Conditions for Setting the DTC

- Injector coil shorted
- Check Condition-key on and engine running
- Fault Condition-Battery voltage at ECM less than 16 volts and injector on state low side greater than 4 volts for 10 injector firings
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key-on cycle
- Closed Loop-Disabled during active fault

Circuit Description

This fault will set if the ECM detects high feedback voltage at the injector while the injector drive circuit is in the off-state with system battery voltage less than 16 volts.

Diagnostic Aid

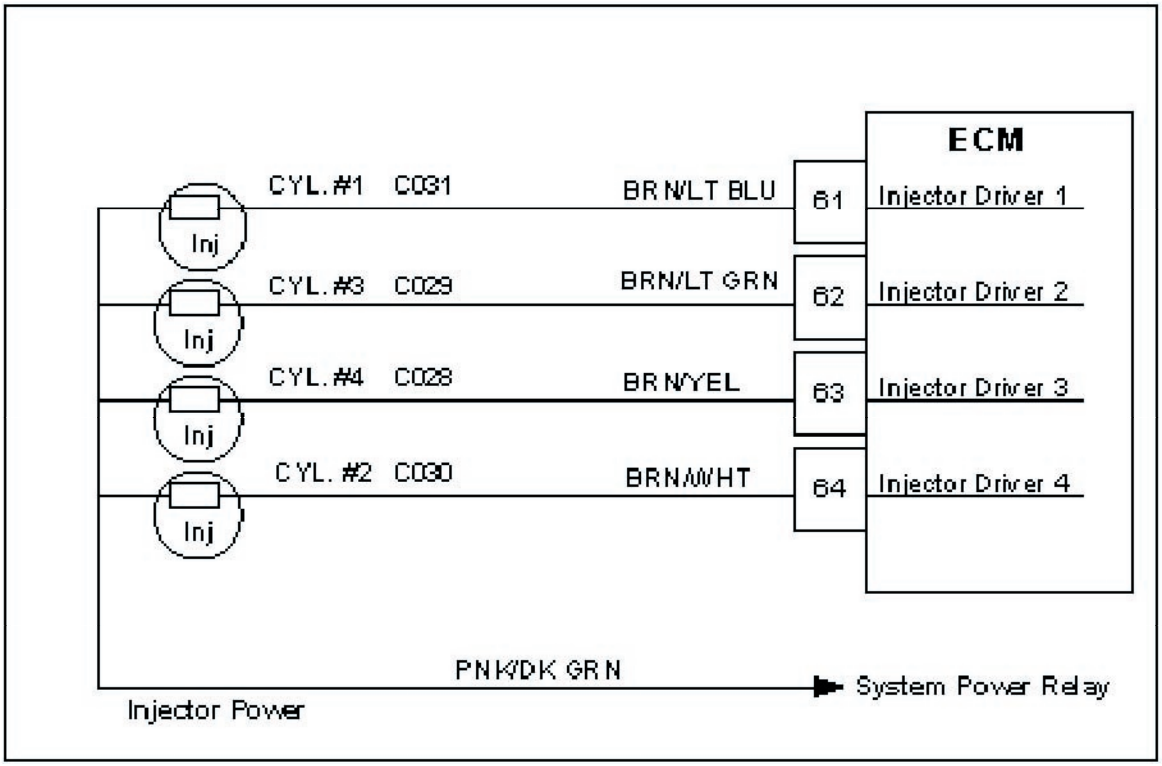
The injector driver numbers shown above are called out in respect to the engine firing order. It is important to know the engine firing order when locating a specific injector at the engine block. Refer to engine firing order in the engine section of this manual.

DTC 268 Injector Driver 3 (Cyl #4) Shorted SPN/FMI 653:6

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 DTC 268 Does DTC 268 reset with the engine idling?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the harness connector C028 from the cylinder number 4 injector. • Using a high impedance DVOM, measure the resistance between the (2) pins of the injector Does the DVOM display a resistance value of 5 ohms or more?		Go to step (5)	Go to step (4)
4	• Replace the Fuel Injector Is the replacement complete?		Go to Step (8)	_
5	• Disconnect the ECM wire harness connector C001 • Key ON • Using a DVOM check for voltage between the ECM connector pin 63 and engine ground Does the DVOM display voltage?		Repair the shorted to voltage injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace Fuel Injector Is the replacement complete?		Go to Step (8)	-
7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	Go to step (9)	_
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 DTC268 check for any stored codes. • Does the vehicle engine normally with no stored codes?		System OK	Go to Step (7)

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC268 check for any stored codes. • Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 270 Injector Driver 4 (Cyl #2) Open SPN/FMI 654:5



Conditions for Setting the DTC

- Injector coil open or driver circuit short
- Check Condition-key on and engine running
- Fault Condition-Battery voltage at ECM greater than 9 volts and injector low side less than 4 volts for 10 injector firings
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key-on cycle
- Closed Loop-Disabled during active fault

Circuit Description

This fault will set if the ECM detects low feedback voltage on the internal injector while the injector drive circuit is in the off-state and battery voltage is greater than 9 volts.

Diagnostic Aid

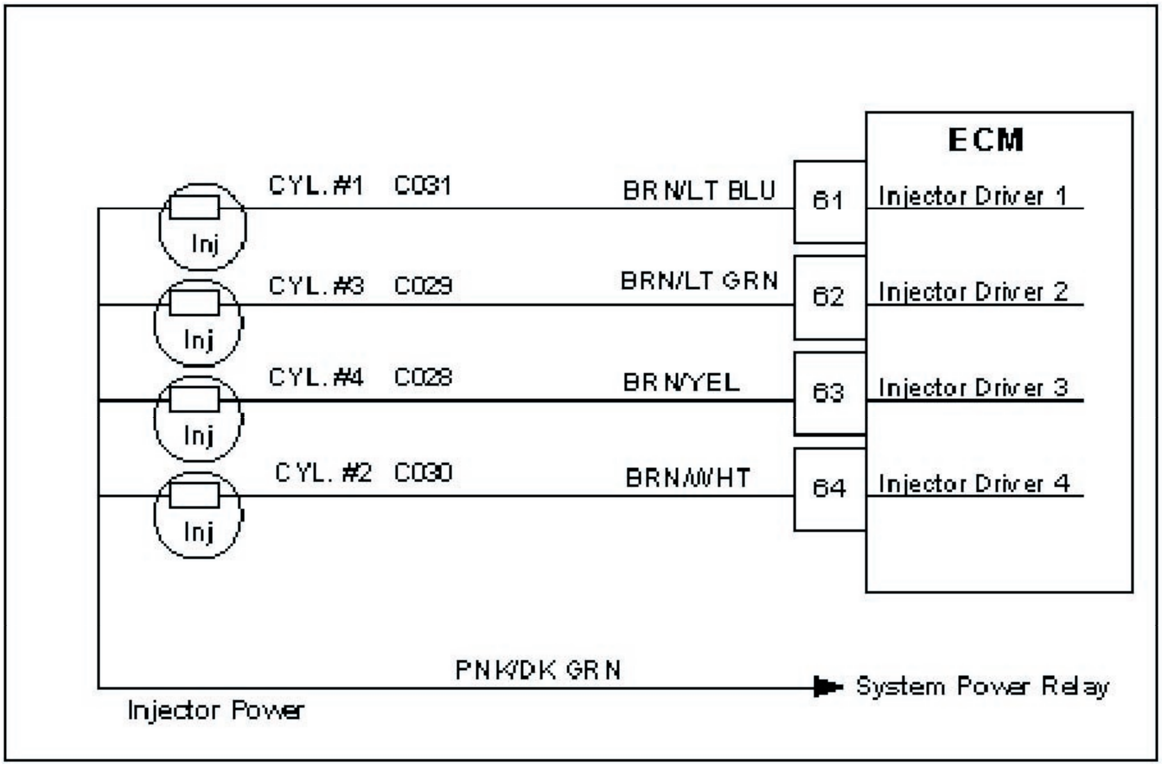
The injector driver numbers shown above are called out in respect to the engine firing order. It is important to know the engine firing order when locating a specific injector at the engine block. Refer to engine firing order in the engine section of this manual.

DTC 270 Injector Driver 4 (Cyl #2) Open SPN/FMI 654:5

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 DTC 270 Does DTC 270 reset with the engine idling?		Go to step (3)	Intermittent problem. Go to Intermittent electrical section
3	• Key Off • Disconnect the wire harness connector C030 at the Cylinder number 2 injector. • Using a high impedance DVOM, measure the resistance between the (2) pins on the injector at an ambient temperature of 58 to 88 degrees F. Does the DVOM display a resistance value of 16 Ohms or less?	16 ohms or less	Go to step (5)	Go to step (4)
4	• Replace the Fuel Injector Is the replacement complete?		Go to Step (11)	_
5	• Measure the resistance between C030 injector driver BRN/WHT wire and battery ground. Does the DVOM display a resistance of 5.0 Ohms or less?	—	Go to Step (6)	Go to step (9)
6	• Disconnect ECM connector C001 • Measure the resistance between the injector driver wire BRN/WHT and battery ground. Does the DVOM display a resistance of 5.0 Ohms or less?	5.0 Ohms	Repair the shorted injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (9)
7	• Disconnect ECM wire harness connector C001 • Using a DVOM measure the resistance between the injector driver wire BRN/WHT and ECM connector pin 64 • Does the DVOM display a resistance of 5.0 Ohms or less between them?	5.0 Ohms	Go to Step (8)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
8	• Check the injector connector and ECM connector terminals for damage, corrosion or contamination. Any problems found?		Repair the open injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (10)

Step	Action	Value(s)	Yes	No
9	• Disconnect ECM wire harness connector C001 • Using a DVOM measure the resistance between the injector connector C030 BRN/WHT wire and ECM pin 64 Does the DVOM display a resistance of 5.0 Ohms or less?		Go to Step (8)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
10	• Replace ECM. Refer to ECM replacement in the Engine Controls Section. 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-270 check for any stored codes. • Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 271 Injector Driver 4 (Cyl #2) Shorted SPN/FMI 654:6



Conditions for Setting the DTC

- Injector coil shorted
- Check Condition-key on and engine running
- Fault Condition-Battery voltage at ECM less than 16 volts and injector on state low side greater than 4 volts for 10 injector firings
- MIL-On for active fault and for 5 seconds after active fault
- Adaptive-Disabled for remainder of key-on cycle
- Closed Loop-Disabled during active fault

Circuit Description

This fault will set if the ECM detects high feedback voltage at the injector while the injector drive circuit is in the off-state with system battery voltage less than 16 volts.

Diagnostic Aid

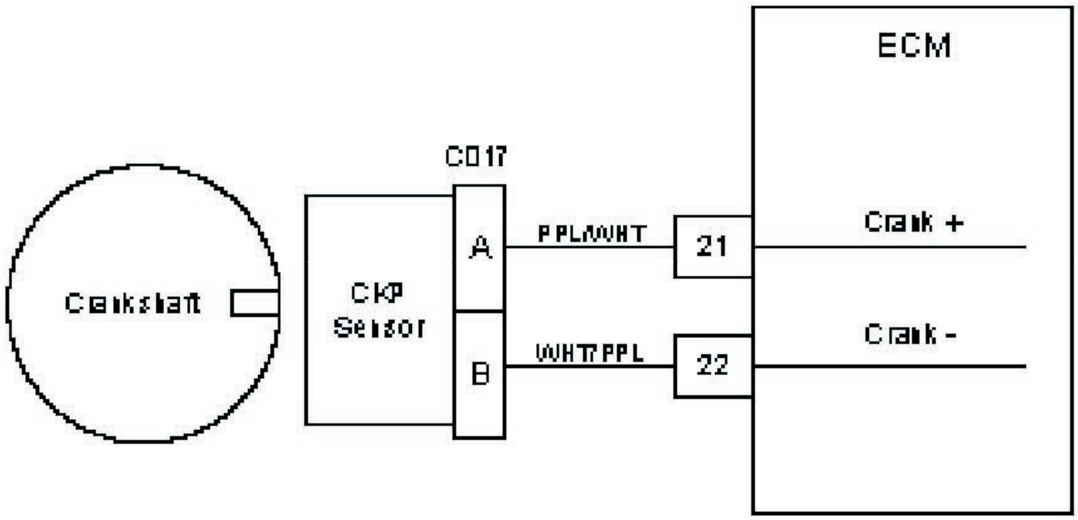
The injector driver numbers shown above are called out in respect to the engine firing order. It is important to know the engine firing order when locating a specific injector at the engine block. Refer to engine firing order in the engine section of this manual.

DTC 271 Injector Driver 4 (Cyl #2) Shorted SPN/FMI 654:6

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 DTC 271 Does DTC 271 reset with the engine idling?		Go to step (3)	Intermittent problem Go to Intermittent section
3	• Key Off • Disconnect the harness connector C030 from the cylinder number 2 injector. • Using a high impedance DVOM, measure the resistance between the (2) pins of the injector Does the DVOM display a resistance value of 5 ohms or more?		Go to step (5)	Go to step (4)
4	• Replace the Fuel Injector Is the replacement complete?		Go to Step (8)	_
5	• Disconnect the ECM wire harness connector C001 • Key ON • Using a DVOM check for voltage between the ECM connector pin 64 and engine ground Does the DVOM display voltage?		Repair the shorted to voltage injector driver circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Replace Fuel Injector Is the replacement complete?		Go to Step (8)	-
7	Replace ECM. Refer to ECM replacement in the Engine Controls Section. Is the replacement complete?	_	Go to step (9)	_
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 DTC271 check for any stored codes. • Does the vehicle engine normally with no stored codes?		System OK	Go to Step (7)

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC271 check for any stored codes. • Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 336-Crank Sync Noise SPN/FMI 636:2



Conditions for setting the DTC

- Crankshaft Position sensor
- Check Condition- Engine cranking or running
- Fault Condition- one or more invalid crank re-sync within 800 ms
- MIL Command-ON

Circuit Description

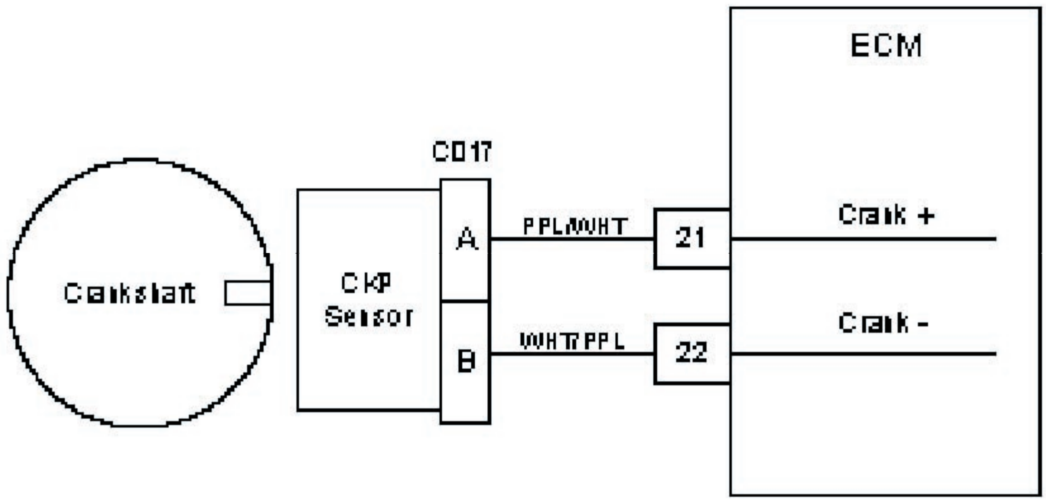
The CKP (crankshaft position sensor) is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize the ignition and fuel systems. This fault will set one or more crank re-sync occur within 800 ms.

DTC 336- Crank Sync Noise SPN/FMI 636:2

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	• Check to be sure that the ECM ground terminals C014 and C023 are clean and tight. Are terminals C014 and C023 clean and tight?		Go to Step (3)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key OFF • Disconnect the CKP sensor connector C017 • Using a DVOM check for voltage output directly from the CKP sensor while cranking the engine • Do you have voltage output?	Over .5 volts	Go to Step (4)	Go to Step (11)
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CKP connector pin A and ECM connector pin 21 • 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 B and ECM connector pin 22 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 C017 pins 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 pins 21 and 22 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	• Using a DVOM check for continuity between ECM connector pins 21 and 22 to engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
9	• Replace CKP sensor Is the replacement complete?		Go to Step (12)	-
10	• Replace ECM • Is the replacement complete?		Go to Step (12)	-

Step	Action	Value(s)	Yes	No
11	• Key OFF • Inspect the pulse wheel and CKP sensor for mechanical damage, corrosion or contamination. Did you find a problem?		Repair the component as necessary. Refer to Engine Repairs in Engine Section	Go to Step (9)
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-336 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 337-Crank Loss SPN/FMI 636:4



Conditions for setting the DTC

- Crankshaft Position sensor
- Check Condition- Engine cranking or running
- Fault Condition- Three or more cam pulses without crank activity
- MIL Command-ON

Circuit Description

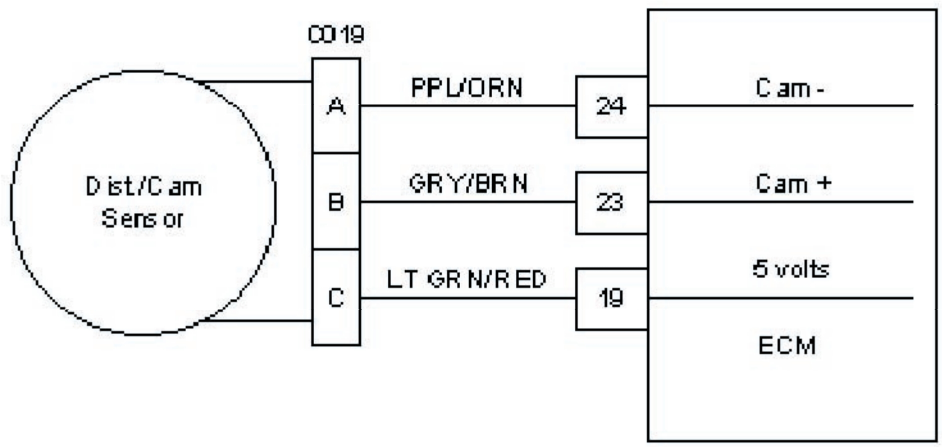
The CKP (crankshaft position sensor) is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize the ignition and fuel systems. This fault will set if three or more cam pulse signals are present without any crankshaft signal.

DTC 337- Crank Loss SPN/FMI 636:4

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 to be sure that the ECM ground terminals C014 and C023 are clean and tight. Are terminals C014 and C023 clean and tight?		Go to Step (3)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
3	• Key OFF • Disconnect the CKP sensor connector C017 • Using a DVOM check for voltage output directly from the CKP sensor while cranking the engine • Do you have voltage output?	Over .5 volts	Go to Step (4)	Go to Step (11)
4	• Key OFF • Disconnect ECM connector C001 • Using a DVOM check for continuity between CKP connector pin A and ECM connector pin 21 • 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 B and ECM connector pin 22 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 C017 pins 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 pins 21 and 22 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	• Using a DVOM check for continuity between ECM connector pins 21 and 22 to engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (10)
9	• Replace CKP sensor Is the replacement complete?		Go to Step (12)	-
10	• Replace ECM • Is the replacement complete?		Go to Step (12)	-

Step	Action	Value(s)	Yes	No
11	• Key OFF • Inspect the pulse wheel and CKP sensor for mechanical damage, corrosion or contamination. Did you find a problem?		Repair the component as necessary. Refer to Engine Repairs in Engine Section	Go to Step (9)
12	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-337 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 341-Camshaft Sync Noise SPN/FMI 723:2



Conditions for Setting the DTC

- Camshaft position sensor
- Check Condition-Cranking or Running
- Fault Condition- 1 invalid cam re-sync in 700ms or less
- MIL-On

Circuit Description

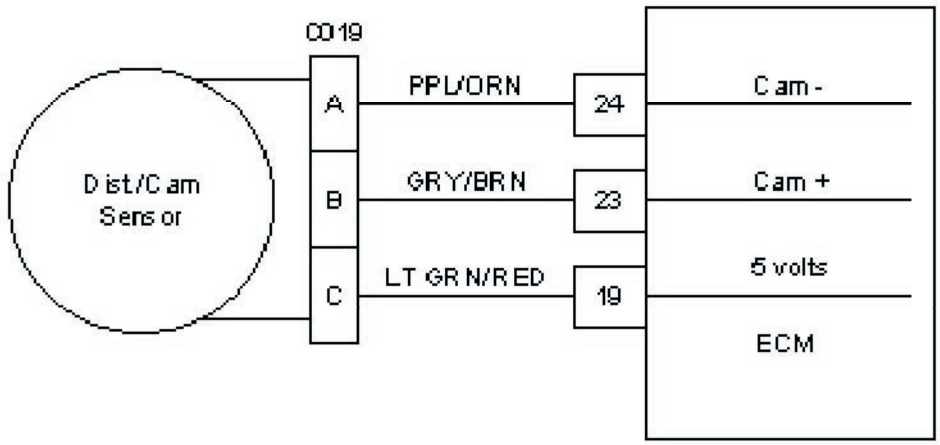
The CMP (Camshaft Position Sensor) is used to synchronize the fuel and ignition systems. This fault will set if the ECM detects erroneous pulses from the camshaft position sensor causing invalid cam re-sync.

DTC 341- Camshaft Sensor Noise SPN/FMI 723:2

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	• Check that the ECM ground terminals C014 and C023 are clean and tight Are the ground terminals C014 and C023 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 C019 • 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 24 • 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 25 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 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 19, 24 and 25 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 Is the replacement complete?		Go to Step (10)	-
9	• Replace ECM • Is the replacement complete?		Go to Step (11)	-

Step	Action	Value(s)	Yes	No
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-341 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-341 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 342-Camshaft Sensor Loss SPN/FMI 723:4



Conditions for Setting the DTC

- CMP (Camshaft Position Sensor)
- Check Condition-Engine Cranking or Running
- Fault Condition-No cam pulse in 2 cycles with engine speed above 100 RPM
- MIL-On

Circuit Description

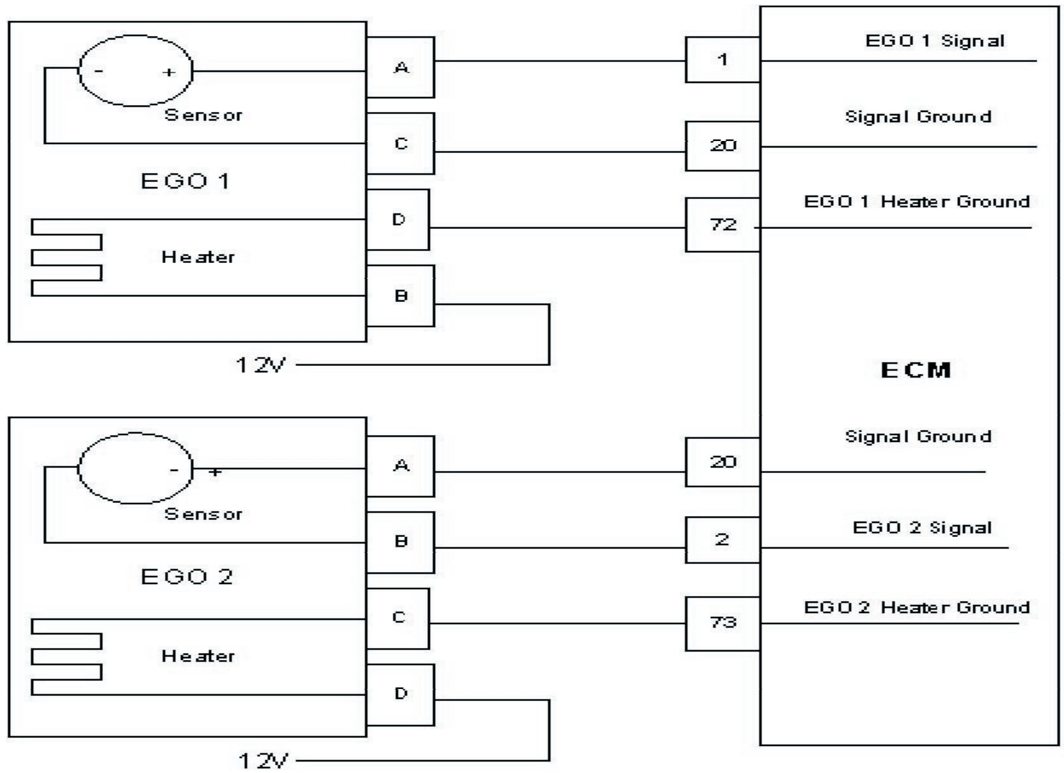
The CMP (Camshaft Position Sensor) is used to synchronize the fuel and ignition systems. This fault will set if the ECM does not detect a cam pulse in 2 engine cycles whenever the engine is cranking or running. The engine may not run with this fault present.

DTC 342-Camshaft Sensor Loss SPN/FMI 723:4

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 C014 and C023 are clean and tight Are the ground terminals C014 and C023 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 C019 • 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 24 • 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 25 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 C019 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 24,25 and 19 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 Is the replacement complete?		Go to Step (10)	-
9	• Replace ECM • Is the replacement complete?		Go to Step (11)	-

Step	Action	Value(s)	Yes	No
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-342 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-342 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 420 Gasoline Catalyst Monitor SPN/FMI 520211:10



Conditions for Setting the DTC

- Catalyst Function
- Check condition- Engine running
- Fault condition- EGO 1 signal = EGO 2 signal for 100 updates
- MIL- On during active fault and for 1 second after active fault
- Adaptive- Disabled during active fault

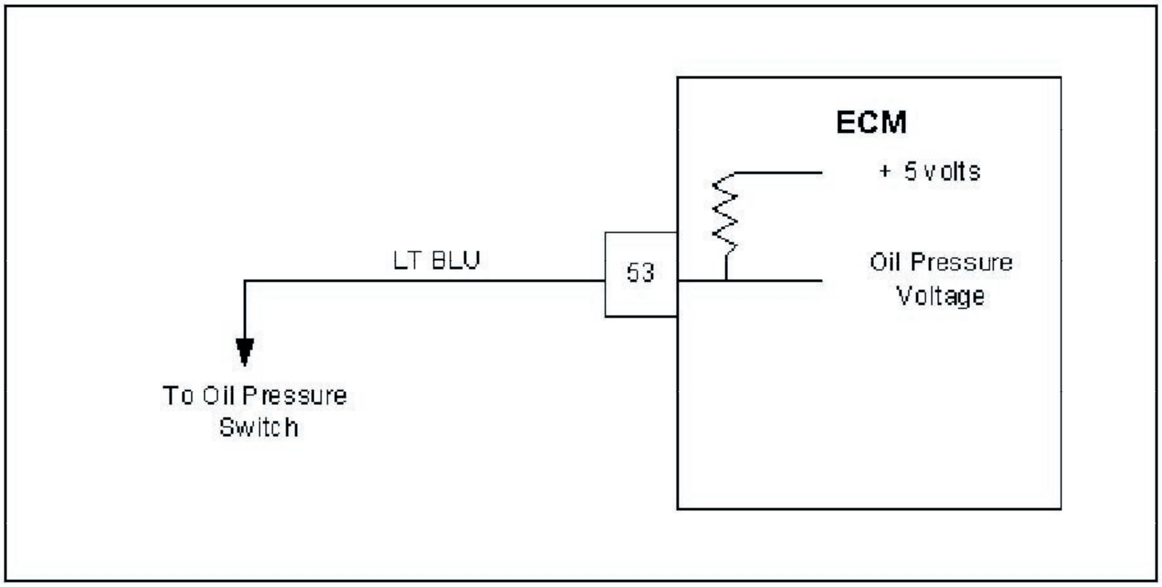
Circuit Description

The ECM uses EGO 1 and EGO 2 sensor signals to diagnose problems with the catalyst muffler. When the signals for EGO 1 & EGO 2 are similar it may indicate a problem with the catalyst.

Diagnostic Aids

Always diagnose any other troubles, stored along with DTC 420 first. Check for and eliminate any exhaust leaks prior to replacing catalyst muffler. Look for exhaust leaks at the catalyst muffler inlet and tail pipes. Clear this trouble code after repairing exhaust leaks, and recheck for code.

DTC 524-Oil Pressure Low SPN/FMI 100:1



Conditions for Setting the DTC

- Engine Oil Pressure low
- Check Condition-Engine running for 30 seconds with RPM greater than 600
- Fault Condition- closed circuit/voltage low less than 2.5 volts
- MIL-On during active fault and for 3 seconds after active fault
- Engine Shut Down

Circuit Description

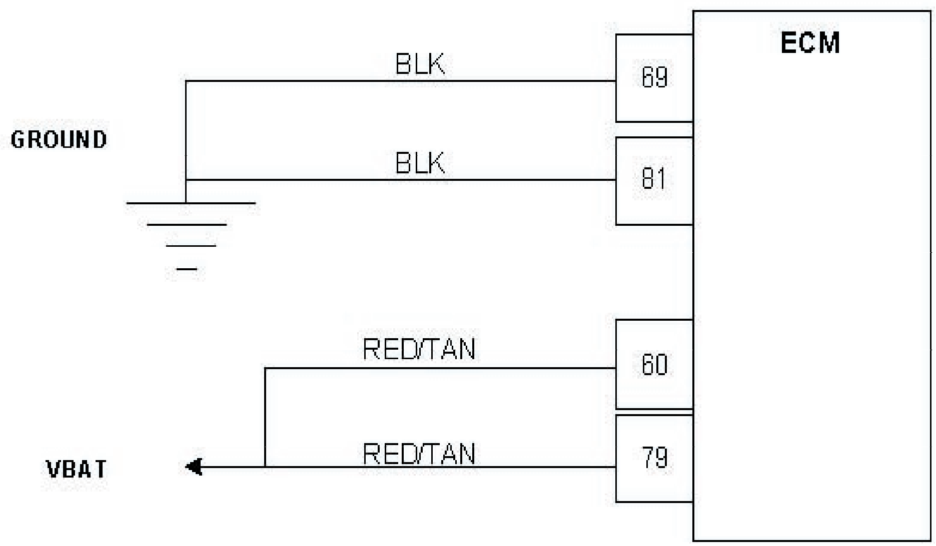
The Oil Pressure Switch is used to communicate a low oil pressure condition to the ECM. Engine damage can occur if the engine is operated with low oil pressure. The ECM uses an analog voltage input with an internal 5 volt reference. If the oil pressure circuit is grounded, the input voltage will be near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

DTC 524- Oil Pressure Low SPN/FMI 100:1

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	• 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 above 2 psi?		Go to Step (3)	Repair faulty Oiling System
3	• Key On, Engine Running DST connected in System Data Mode • Clear DTC 524 • 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 600 RPM Does DTC 524 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 • Clear DTC 524 • Start engine, let idle for at least one minute with ECT over 160 degrees F. • Increase engine speed above 600 RPM Does DTC 524 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 engine ground. • Do you have continuity between them?		Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
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)	-

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-524 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 562-System Voltage Low SPN/FMI 168:17



Conditions for Setting the DTC

- System Voltage to ECM
- Check Condition-Key on with engine speed greater than 1500 RPM
- Fault Condition-Battery voltage at ECM less than 9.0 volts for more than 5 seconds
- MIL-On for active fault and for 10 seconds after active fault
- Adaptive-Disabled and for the for remainder of key ON cycle

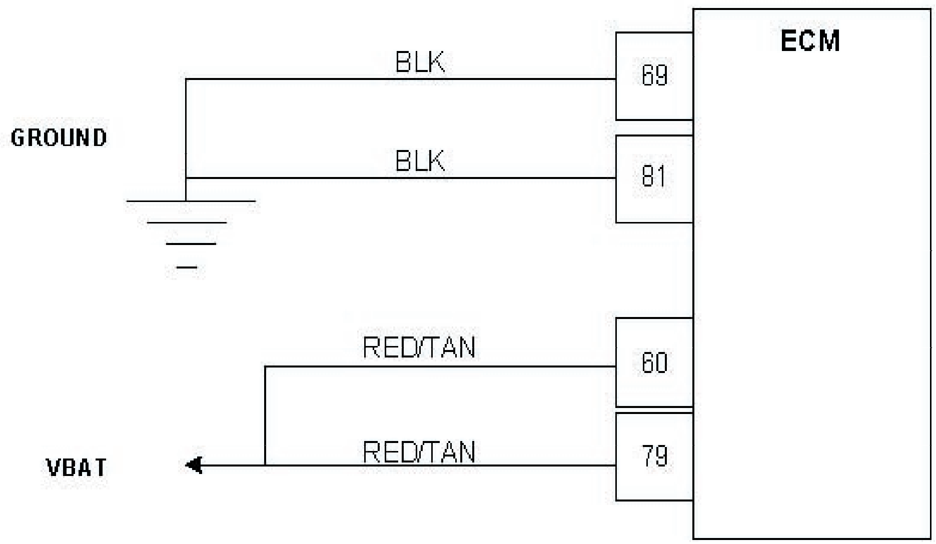
Circuit Description

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 during this fault for the remainder of the key cycle.

DTC 562- System Voltage Low SPN/FMI 168:17

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	• Check the voltage at ECM connector C001 pins 60 and 79 • 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	• Check the voltage at ECM connector pins 69 and 81 • Measure voltage with DVOM between each pin and battery positive 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-562 check for any stored codes. Does the engine operate normally with no stored codes?	-	System OK	Go to OBD System Check

DTC 563-System Voltage High SPN/FMI 168:15



Conditions for Setting the DTC

- System Voltage to ECM
- Check Condition-Cranking or Running
- Fault Condition-System 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 cycle

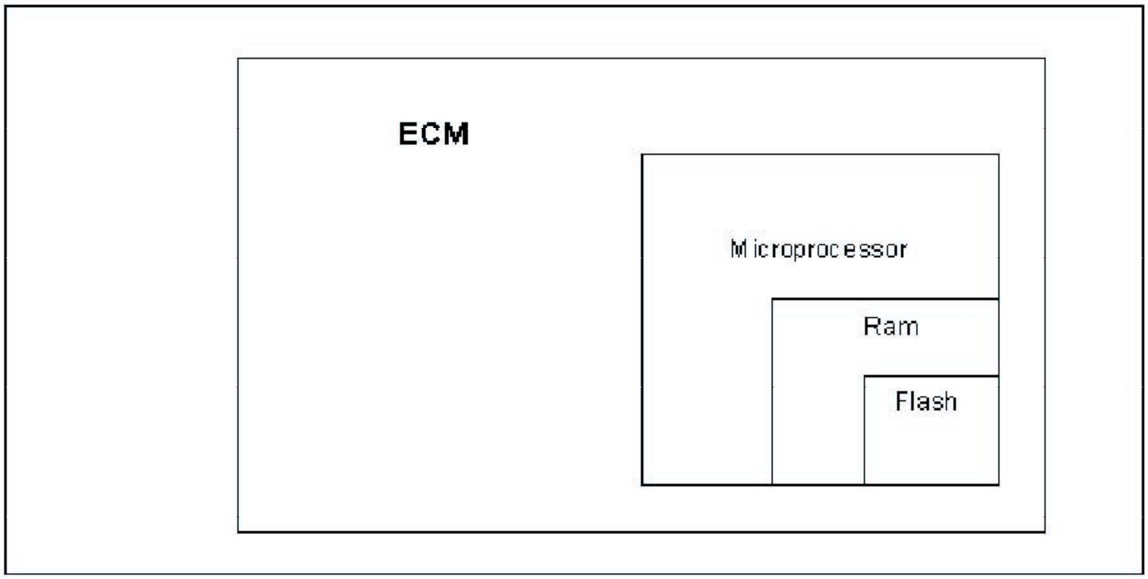
Circuit Description

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 or more anytime the engine is cranking or running. The adaptive learn function is disabled during this fault and for the remainder of the key cycle. The ECM will shut down with internal protection if the system voltage ever exceeds 26 volts.

DTC 563- System Voltage High SPN/FMI 168:15

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 greater than 18 volts?	-	Go To Step (3)	Intermittent problem Go to Engine Electrical Intermittent section
3	• Check voltage at battery terminals with DVOM with engine speed greater than 1500 rpm Is it greater than 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-563 check for any stored codes. Does the engine operate normally with no stored codes?	-	System OK	Go to OBD System Check

DTC 601-Flash Checksum Invalid SPN/FMI 628:13



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On
- Adaptive- Disabled for the remainder of the key-ON cycle
- Power Derate level 2

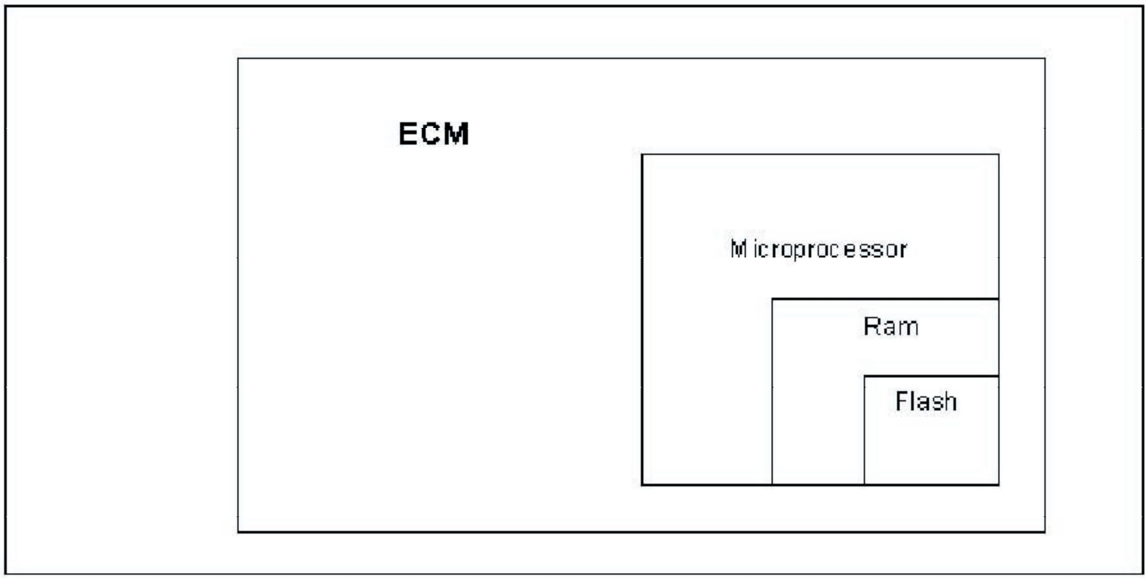
Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will attempt to reset itself in the event this fault is set. The MIL command is on and will remain on until the code is cleared using the DST. Power Derate level 2 will be enforced limiting maximum throttle position to 20%.

DTC 601- Flash Checksum Invalid SPN/FMI 628:13

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 601 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check ECM power and ground circuits 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 (5)	-
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-601 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 604-RAM Failure SPN/FMI 630:12



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On
- Adaptive- Disabled for the remainder of the key-ON cycle
- Power Derate level 2

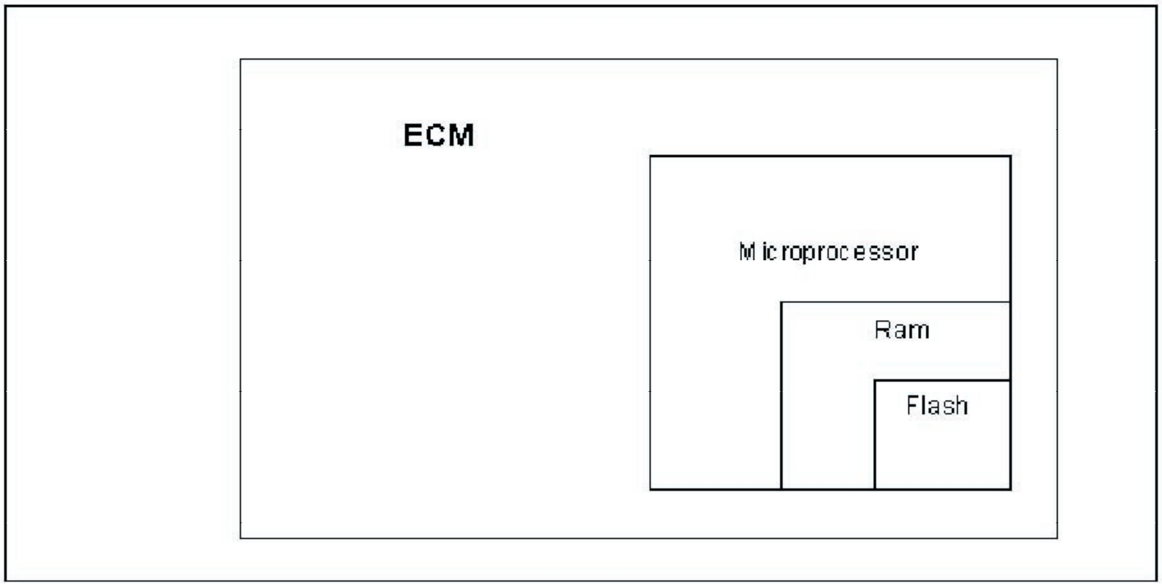
Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will attempt to reset itself in the event this fault is set. The MIL command is on and will remain on until the code is cleared using the DST. Power Derate level 2 will be enforced limiting maximum throttle position to 20%.

DTC 604- RAM Failure SPN/FMI 630:12

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 604 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check ECM power and ground circuits 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 (5)	-
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-604 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 606-COP Failure SPN/FMI 629:31



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On
- Adaptive- Disabled for the remainder of the key-ON cycle
- Power Derate level 2

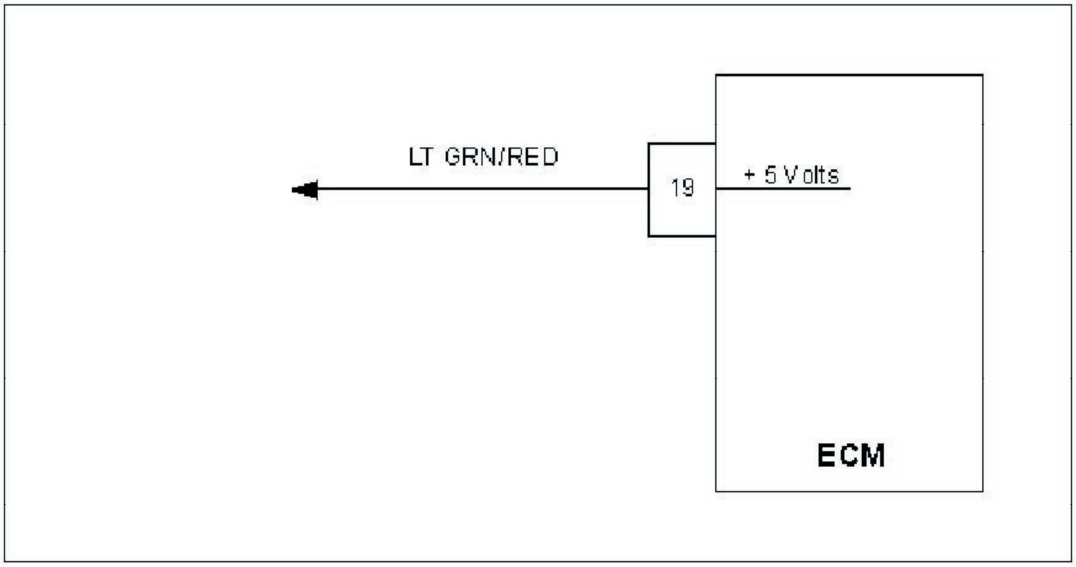
Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will attempt to reset itself in the event this fault is set. The MIL command is on and will remain on until the code is cleared using the DST. Power Derate level 2 will be enforced limiting maximum throttle position to 20%.

DTC 606- COP Failure SPN/FMI 629:31

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 606 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check ECM power and ground circuits 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 (5)	-
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-606 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 642-External 5 Volt Reference Low SPN/FMI 1079:4



Conditions for Setting the DTC

- External 5 volt reference
- Check Condition-Cranking with battery voltage greater than 8 volts and engine running
- Fault Condition-5 volt reference voltage lower than 4.6 volts for more than 1 second
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault

Circuit Description

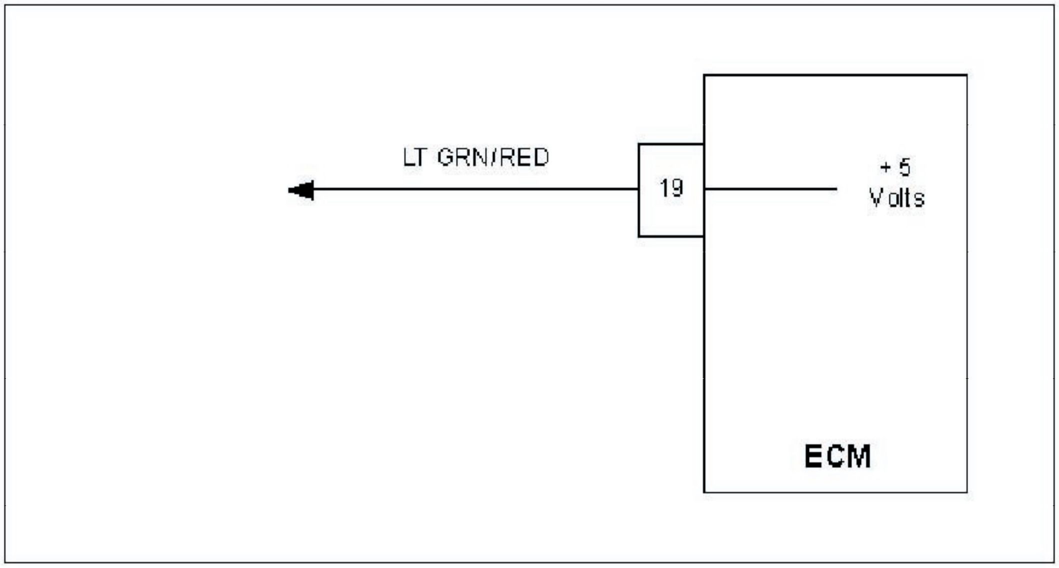
The External 5 volt supply powers many of the sensors and other components of the fuel system. The accuracy of the 5 volt supply is very important to the accuracy of the powered sensors and fuel control by the ECM. The ECM is able to determine if they are overloaded, shorted, or otherwise out of specification by monitoring the 5 volt supply. This fault will set if the 5 volt reference is below 4.6 volts for one second. Adaptive Learn will be disabled during this fault

DTC 642 External 5V Reference Low SPN/FMI 1079:4

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 642?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect ECM connector C001 • Using DVOM check for continuity between ECM 5 volt reference pin 19 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 the 5 volt reference supply wire leads for shorts before replacing the sensor. • IAT • ECT • TMAP • Electronic Throttle • Gasoline Sensor • 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)	Repair shorted wire harness
6	• Replace Sensor Is the replacement complete?		Go to step (7)	-

Step	Action	Value(s)	Yes	No
7	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-642 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 643-External 5 Volt Reference High SPN/FMI 1079:3



Conditions for Setting the DTC

- External 5 volt reference
- Check Condition-Cranking with battery voltage greater than 8 volts or engine running
- Fault Condition-5 volt reference higher than 5.4 volts for more than 1 second
- MIL-On during active fault and for 2 seconds after active fault
- Adaptive-Disabled during active fault

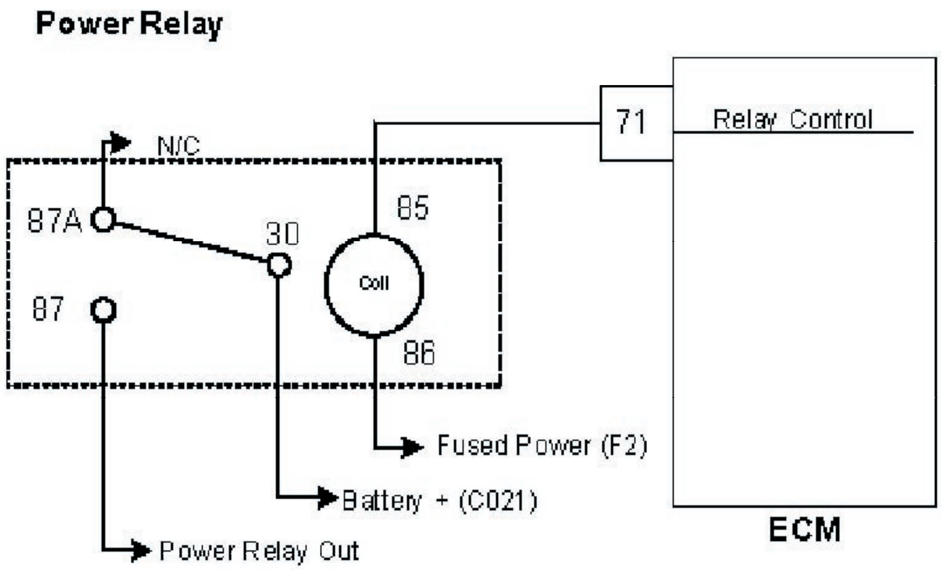
Circuit Description

The External 5 volt supply powers many of the sensors and other components in the fuel system. The accuracy of the 5 volt supply is very important to the accuracy of the powered sensors and fuel control by the ECM. The ECM is able to determine if they are overloaded, shorted, or otherwise out of specification by monitoring the 5volt supply. This fault will set if the 5 volt reference is above 5.4 volts for more than one second. Adaptive Learn will be disabled during this fault

DTC 643 External 5 Volt Reference High SPN/FMI 1079:3

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 643?		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 C001 • Key ON • Using DVOM check for Voltage between ECM harness wire pin 19 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-643 check for any stored codes. Does the vehicle engine normally with no stored codes?		System OK	Go to OBD System Check

DTC 685-Relay Coil Open SPN/FMI 1485:5



Conditions for Setting the DTC

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

Circuit Description

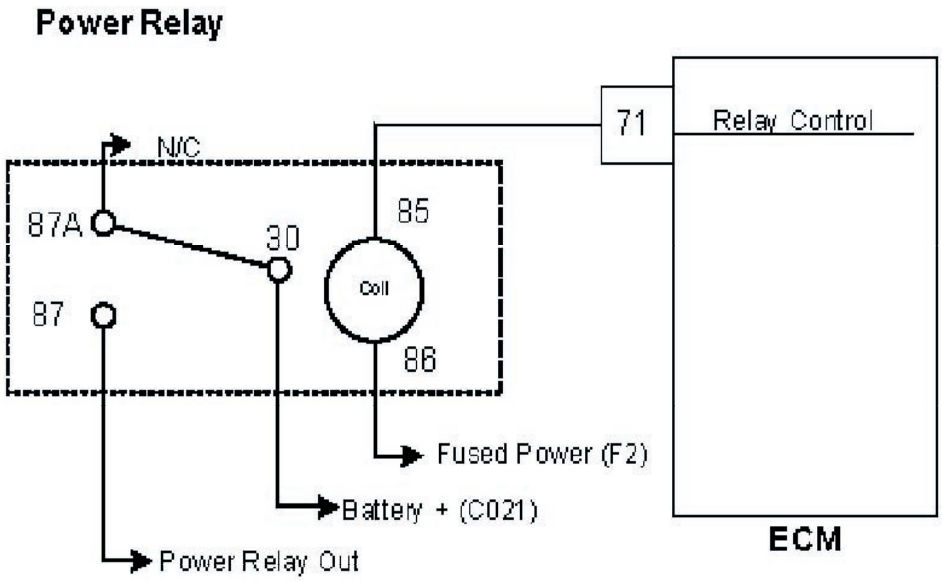
The power relay switches power out to various sensors, actuators and solenoids in the fuel system. This fault will set if the ECM detects an open circuit on the relay control output.

DTC 685- Relay Coil Open SPN/FMI 1485:5

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Key OFF • Remove the power relay from the fuse block • Using a DVOM check the resistance of the relay coil between terminals 85 and 86 Is the resistance value less than 100 ohms?		Go to step (4)	Go to step (3)
3	• Replace the power relay Is the replacement complete?		Go to step (9)	_
4	• Check fuse F2 Is the fuse open?		Replace fuse F2	Go to step (5)
5	• Disconnect ECM connector C001 • Using a DVOM check for continuity between ECM pin 71 and fuse block cavity for relay terminal 85 Do you have continuity?		Go to step (6)	Repair the open circuit as required. See wiring harness repairs
6	• Remove fuse F2 • Using a DVOM check for continuity between fuse block cavity for relay terminal 86 and the power out of the F2 fuse holder Do you have continuity?		Go to step (7)	Repair the open circuit as required. See wiring harness repairs
7	• Check all system fuses. • Check all relay placement positions in fuse block. • Run complete pin to pin checks on chassis wiring to fuel system harness. • See complete fuel system schematic for further details Did you find the problem?		Go to step (9)	Go to step (8)
8	• Replace the ECM • Is the replacement complete?		Go to step (9)	_

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-685 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 686-Relay Control Ground Short SPN/FMI 1485:4



Conditions for Setting the DTC

- Power relay ground control
- Check Condition-Key ON
- Fault Condition- Relay control shorted to ground

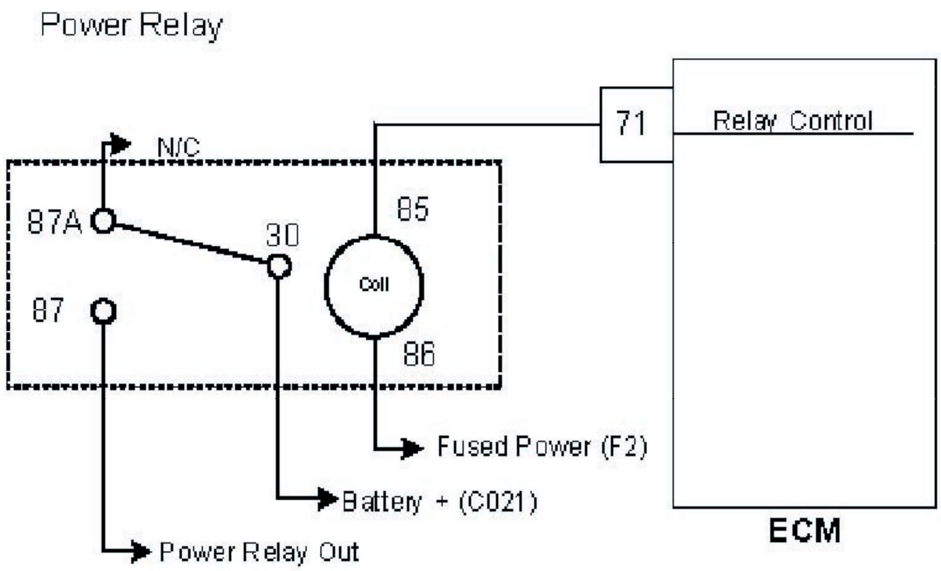
Circuit Description

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

DTC 686- Relay Control Ground Short SPN/FMI 1485:4

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
3	• Key On, DST connected in the System Data mode • Clear DTC 686 • Start the engine Does DTC 686 re-set?		Go to Step (4)	Intermittent problem Go to Intermittent section
4	• Disconnect ECM connector C001 • Using a DVOM check the resistance value between ECM pin 71 and engine ground Is the resistance less than 60 ohms?		Go to step (5)	Go to step (7)
5	• Remove the power relay from the fuse block • Using a DVOM check the resistance value again between ECM pin 71 and engine ground Is the resistance less than 60 ohms?		Repair the shorted to ground relay control circuit as necessary. See wiring harness repairs	Go to step (6)
6	• Replace the power relay Is the replacement complete?		Go to step (8)	_
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-686 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 687-Relay Coil Short to Power SPN/FMI 1485:3



Conditions for Setting the DTC

- Power relay check
- Check Condition-Key ON
- Fault Condition- Relay coil shorted to power

Circuit Description

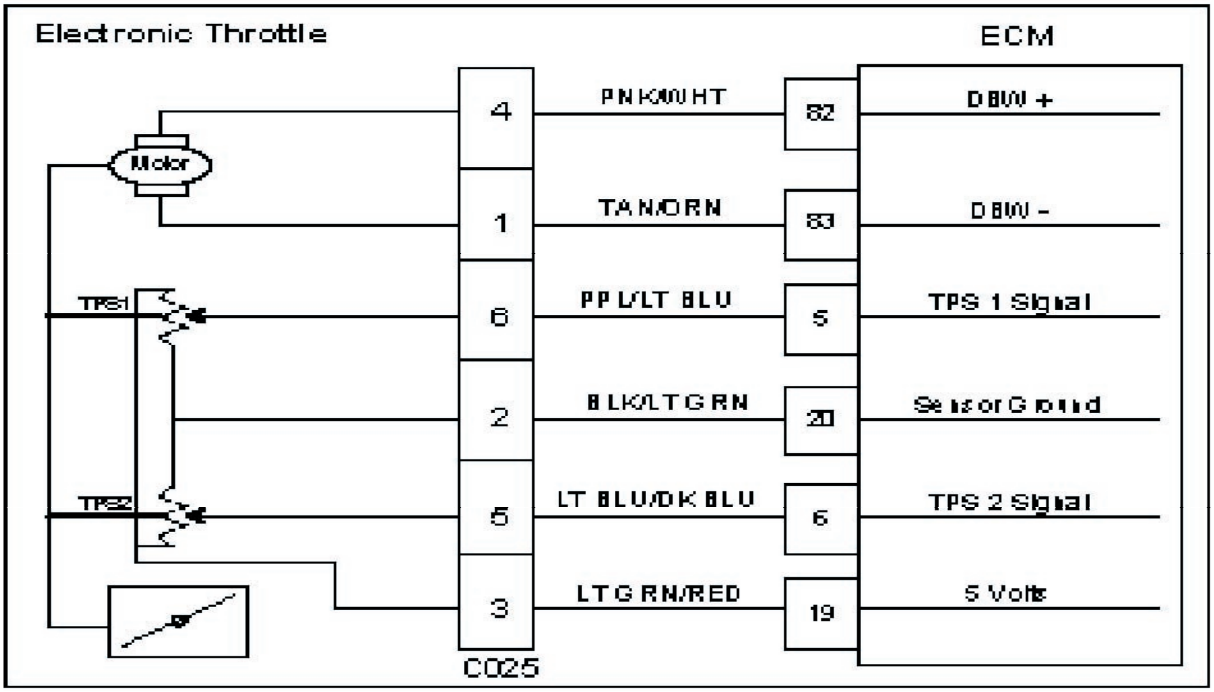
The power relay switches power out to various sensors, actuators and solenoids in the fuel system. This fault will set if the ECM detects a short circuit to power on the relay control output.

DTC 687- Relay Coil Short to Power SPN/FMI 1485:3

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Key OFF • Remove the power relay from the fuse block • Using a DVOM check the resistance of the relay coil between terminals 85 and 86 Is the resistance value less than 60 ohms?		Go to step (3)	Go to step (4)
3	• Replace the power relay Is the replacement complete?		Go to step (9)	_
4	• Using a DVOM check for continuity between relay terminals 85 and 30 Do you have continuity between them?		Go to step (3)	Go to step (5)
5	• Disconnect ECM wire harness connector C001 • Using a DVOM check for power between ECM pin 71 and engine ground with the key ON Do you have power?	System battery voltage	Repair the short to power. See wiring harness repair.	Go to step (6)
6	• Replace the power relay 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-687 check for any stored codes. Does DTC 687 still re-set?		Go to step (8)	Go to step (9)
8	• Replace the ECM • Is the replacement complete?		Go to step (9)	_

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-687 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1111-Fuel Rev Limit SPN/FMI 515:16



Conditions for Setting the DTC

- Fuel Rev Limit
- Check Condition- Engine Running
- Fault Condition- Engine RPM greater than 3400 for 2 seconds continuously
- MIL- On during active fault

Circuit Description

This fault will set anytime Engine RPM is greater than 3400 for 2 seconds continuously. When these conditions are met the ECM cuts off fueling. This is to help prevent engine or equipment damage. The MIL will be on during this active fault.

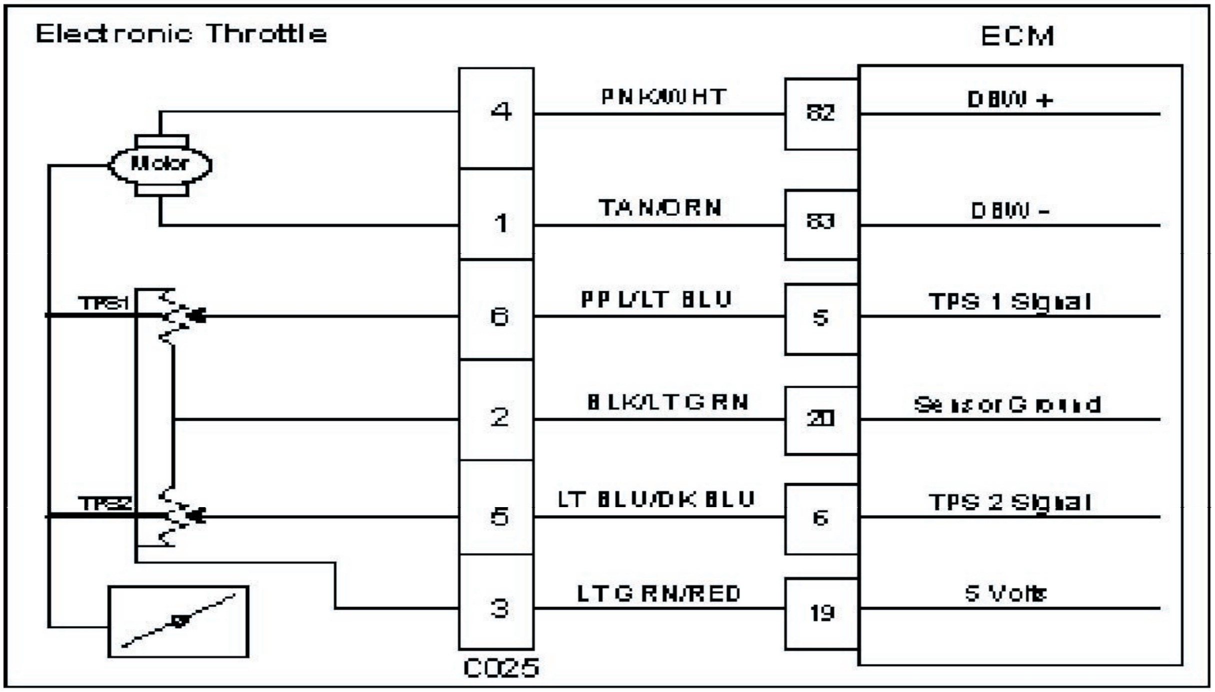
Diagnostic Aid

Always check for other stored DTC codes before using the following DTC chart for this code set. Repair any existing codes starting with the lowest numerical code first.

DTC 1111-Fuel Rev Limit SPN/FMI 515:16

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 1111?		Go to Step (3)	Go to Step (4)
3	• Diagnose and repair 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 the 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 section 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 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-1111 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1112-Spark Rev Limit SPN/FMI 515:0



Conditions for Setting the DTC

- Spark Rev Limit
- Check Condition- Engine running
- Fault Condition- Engine RPM greater than 3600
- MIL- On during active fault
- Engine Shut Down

Circuit description

This fault will set anytime the engine RPM exceeds 3600. During this condition the ECM will shut off spark to the engine. This is to help prevent engine or equipment damage. The MIL command is ON during this active fault and the engine will shut down.

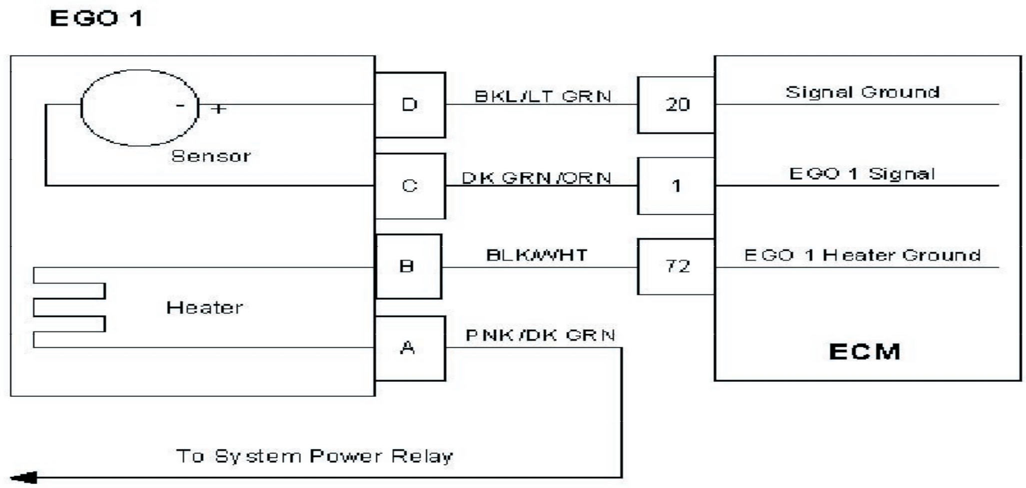
Diagnostic Aid

Always check for other stored DTC codes before using the following DTC chart for this code set. Repair any existing codes starting with the lowest numerical code first.

DTC 1112- Spark Rev Limit SPN/FMI 515:0

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 connected Are any other DTC codes present with DTC 1112?		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 section 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 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-1112 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1151- Closed Loop Multiplier High LPG SPN/FMI 520206:0



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine running
- Fault Condition- Closed Loop multiplier out of range (greater than 35%)
- MIL- ON

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

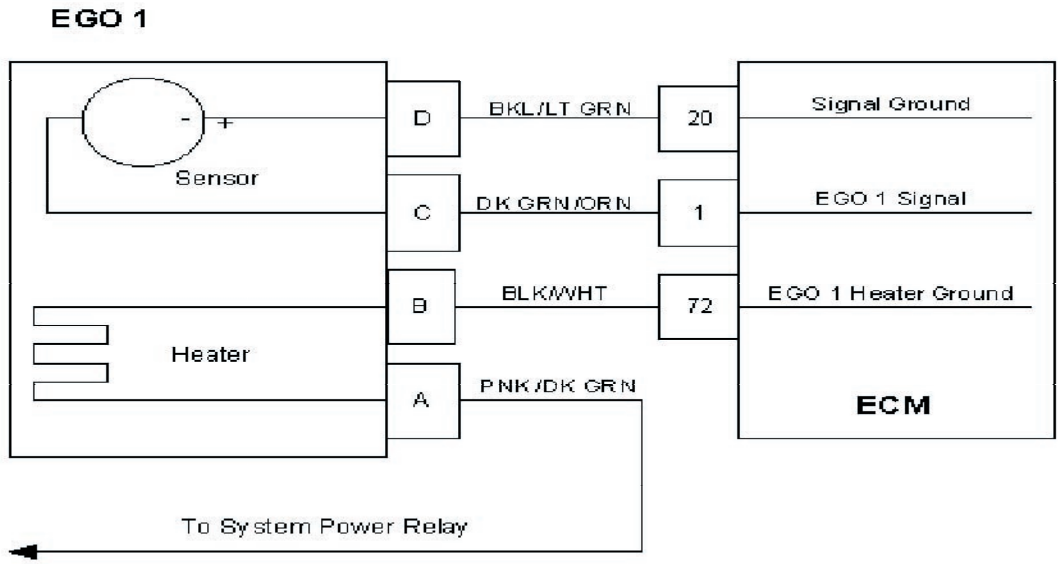
Diagnostic Aid

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.
Fuel Mixer System can be lean due to faulty EPR (Electronic Pressure Regulator) or faulty fuel mixer.
Fuel Pressure Low fuel pressure, faulty fuel regulator or contaminated fuel filter can cause fuel the system to run lean
Exhaust Leaks If there is an exhaust leak, outside air can be pulled into the exhaust and past the 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 clean, tight and in the proper location.

DTC 1151- Closed Loop Multiplier High LPG SPN/FMI 520206:0

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 EGO 1 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 C001 • Disconnect EGO 1 wire harness connector C006 • Using a high impedance DVOM check for continuity between EGO 1 connector 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 (4)
4	• Using a high impedance DVOM check for continuity between EGO 1 connector signal pin C and EGO 1 connector signal ground pin D • 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 1151 Did you check the diagnostic Aids for DTC 1151?		Go to Step (6)	
6	• Replace EGO 1 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-1151 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1152- Closed Loop Multiplier Low LPG SPN/FMI 520206:1



Conditions for Setting the DTC

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

Circuit Description

The EGO 1 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 Aid

Fuel System High secondary fuel pressure may cause the system to run rich. A worn fuel mixer, faulty EPR (Electronic Pressure Regulator) may also cause the system to run rich.

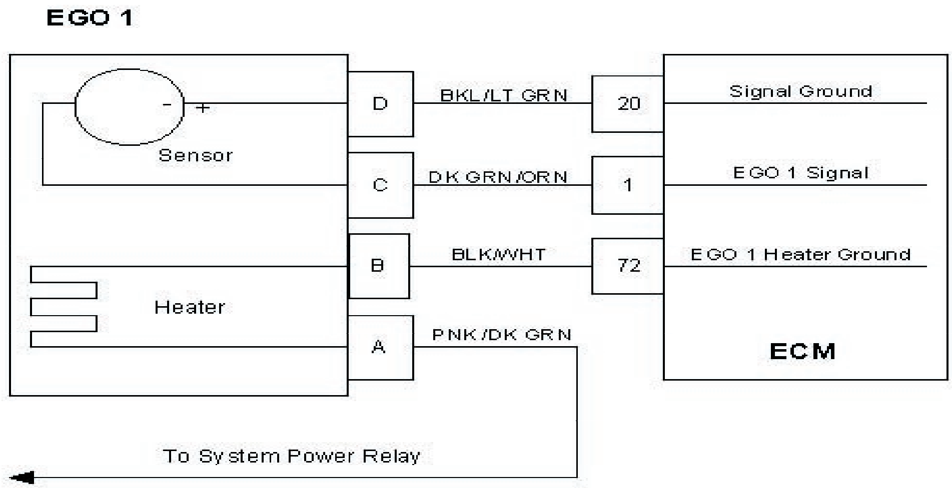
Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the fuel system to run rich. Be sure that the specified HD-5 or HD-10 motor fuel grade propane is used

Air Filter A plugged, damaged or modified air filter may cause the system to run rich.

DTC 1152- Closed Loop Multiplier Low LPG SPN/FMI 520206:1

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, 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 C 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 1152

DTC 1155 -Closed Loop Multiplier High Gasoline SPN/FMI 520204:0



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

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 the Closed Loop multiplier exceeds 35%. The MIL command is ON

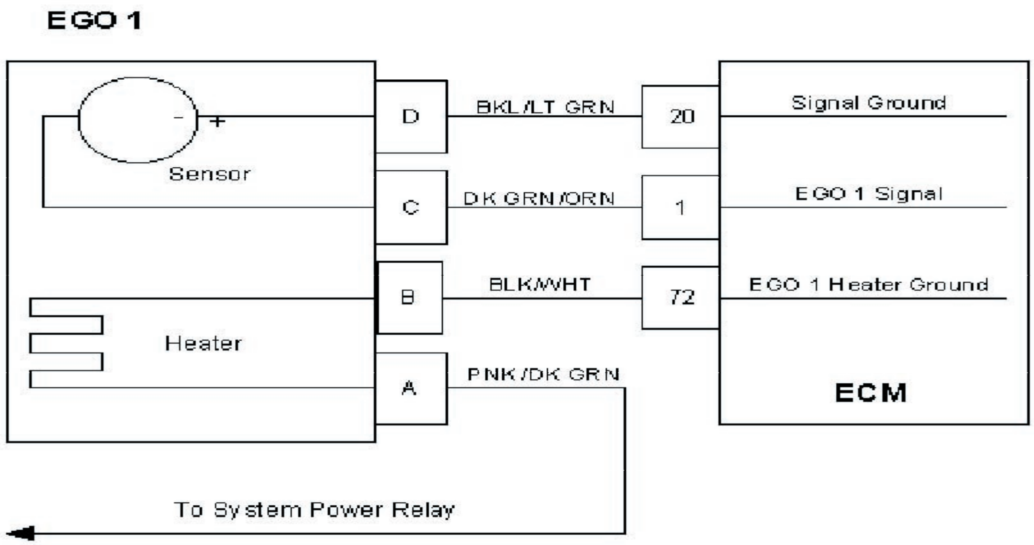
Diagnostic Aid

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.
Fuel Mixer System can be lean due to faulty EPR (Electronic Pressure Regulator) or faulty fuel mixer.
Fuel Pressure Low fuel pressure, faulty fuel regulator or contaminated fuel filter can cause fuel the system to run lean
Exhaust Leaks If there is an exhaust leak, outside air can be pulled into the exhaust and past the 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 clean, tight and in the proper location.

DTC 1155- Closed Loop Multiplier High Gasoline SPN/FMI 520204:0

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 EGO 1 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 EGO 1 sensor connector C006 • Disconnect ECM connector C001 • Using a high impedance DVOM Check for continuity between EGO 1 connector signal pin C 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 EGO 1 connector signal pin C and EGO 1 sensor ground pin D 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 1155 Did you check the diagnostic Aids for DTC 1155?		Go to Step (6)	-
6	• Replace EGO 1 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-1155 check for any stored codes. Does the engine operate normally with no stored codes?			

DTC 1156- Closed Loop Multiplier Low Gasoline SPN/FMI 520204:1



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

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 will set if the Closed Loop multiplier is less than -35%. The MIL command is ON.

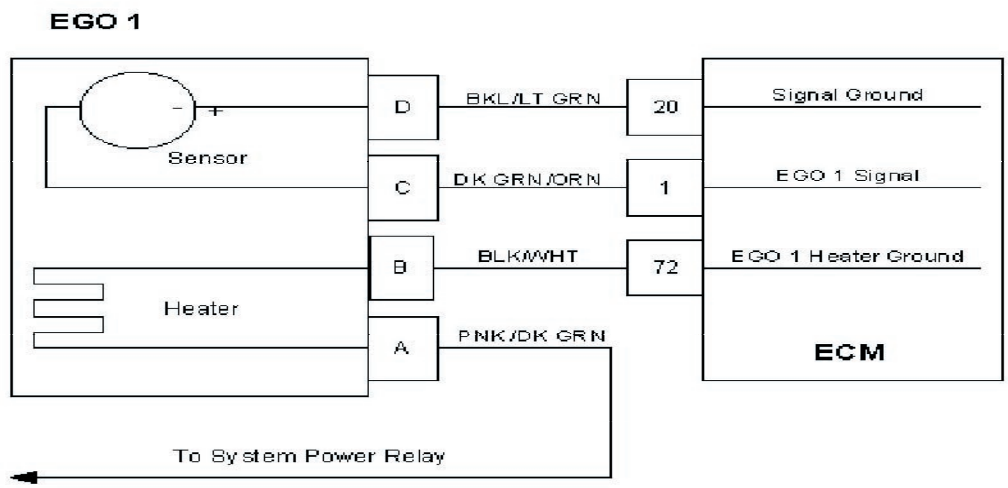
Diagnostic Aid

Check for other DTC codes Correct those starting with the lowest code set number before proceeding with the diagnostic chart.
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 1156- Closed Loop Multiplier Low Gasoline SPN/FMI: 520204:1

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, 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 EGO 1 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 EGO 1 wire connector C006 • Disconnect ECM wiring harness connector C001 • Key ON • Using a high impedance DVOM check for voltage between EGO 1 connector signal pin C and engine ground Do you have voltage?		Repair the circuit as required Refer to Wiring Repairs in Engine Electrical.	Refer to Diagnostic Aid for DTC 1156

DTC 1161-Adaptive Learn High LPG SPN/FMI 520202:0



Conditions for Setting the DTC

- Heated Oxygen Sensor
- Check Condition- Engine Running
- Fault Condition- Adaptive multiplier out of range (greater than +30%)
- MIL- On

Circuit Description

The EGO 1 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 Aid

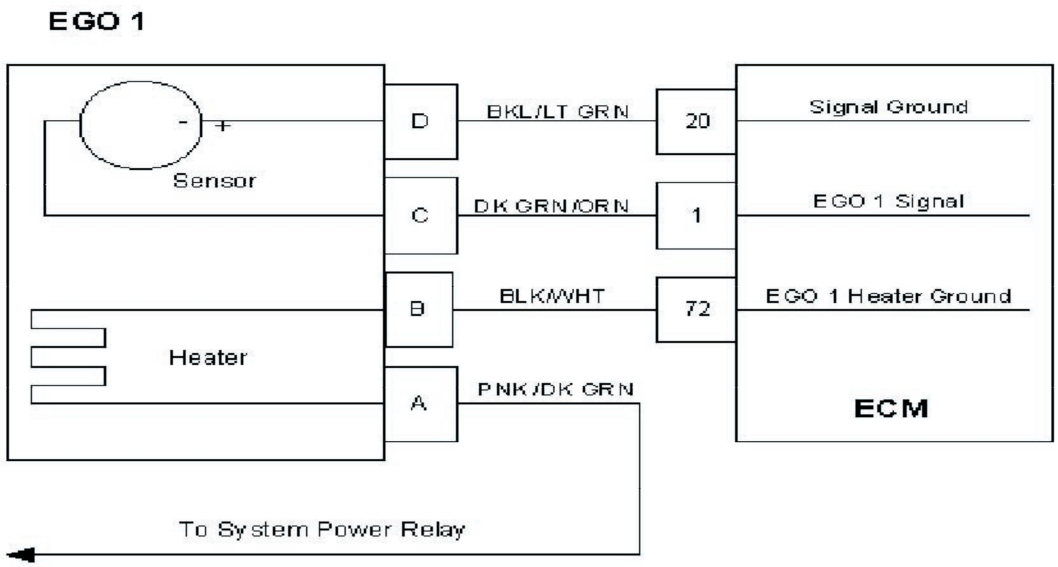
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at especially at light load.
Fuel Mixer System can be lean due to faulty EPR (Electronic Pressure Regulator) or faulty fuel mixer.
Fuel Pressure Low fuel pressure, faulty fuel regulator or contaminated fuel filter can cause fuel the system to run lean
Exhaust Leaks If there is an exhaust leak, outside air can be pulled into the exhaust and past the 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 clean, tight and in the proper location.

DTC 1161 Adaptive Learn High LPG SPN/FMI 520202:0

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 EGO 1 sensor installed securely and the wire leads not contacting the exhaust manifold or ignition wires • ECM grounds must be clean and tight. Refer to Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to 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. Always repair existing codes starting with the lowest numerical code set first. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (8)	Go to step (4)
4	• Disconnect EGO1 connector C006 • Using a DVOM check for voltage between EGO 1 connector pins A and B • Key ON (**CHECK MUST BE MADE WITHIN 30 SECONDS OR BEFORE POWER RELAY SHUTS DOWN)** Do you have voltage?	System voltage	Go to Step (5)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Key OFF • Disconnect EGO 1 sensor wire harness connector C006 • Disconnect ECM wire harness connector C001 • Key ON • Using a high impedance DVOM check for continuity between EGO 1 connector signal pin C and engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Using a high impedance DVOM check for continuity between EGO 1 connector signal ground pin D and EGO 1 signal pin C • Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace EGO 1 sensor Is the replacement complete?		Go to Step (8)	-

Step	Action	Value(s)	Yes	No
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-1161 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1162-Adaptive Learn Low (LPG) SPN/FMI 520202:1



Conditions for Setting the DTC

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

Circuit Description

The EGO1 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 Aid

Fuel System High secondary fuel pressure will cause the system to run rich. A worn fuel mixer, faulty EPR (Electronic Pressure Regulator) may also cause the system to run rich.

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

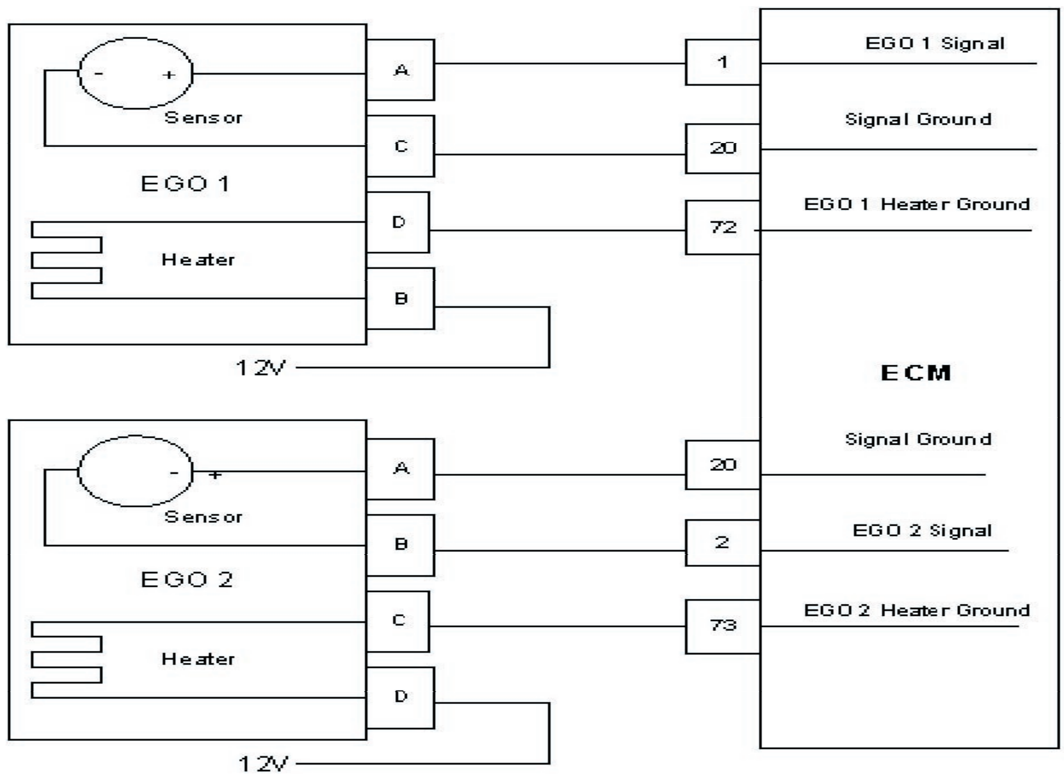
Air Filter A plugged, damaged or modified air filter may cause the system to run rich.

DTC 1162-Adaptive Learn Low LPG SPN/FMI 520202:1

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 EGO 1 sensor installed securely and the wire leads not contacting the exhaust manifold or ignition wires • ECM grounds must be clean and tight. Refer to Engine Electrical Power and Ground Distribution • Fuel System Diagnostics. Refer to 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. Always repair existing codes starting with the lowest numerical code set first. Have any other DTC codes been detected, diagnosed and repaired?		Go to Step (8)	Go to step (4)
4	• Disconnect EGO1 connector C006 • Using a DVOM check for voltage between EGO 1 connector pins A and B • Key ON **(CHECK MUST BE MADE WITHIN 30 SECONDS OR BEFORE POWER RELAY SHUTS DOWN)** Do you have voltage?	System voltage	Go to Step (5)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Key OFF • Disconnect EGO 1 sensor wire harness connector C006 • Disconnect ECM wire harness connector C001 • Key ON • Using a high impedance DVOM check for continuity between EGO 1 connector signal pin C and engine ground Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (6)
6	• Using a high impedance DVOM check for continuity between EGO 1 connector signal ground pin D and EGO 1 signal pin C • Do you have continuity?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to Step (7)
7	• Replace EGO 1 sensor Is the replacement complete?		Go to Step (8)	-

Step	Action	Value(s)	Yes	No
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-1162 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1165 LPG Catalyst Monitor SPN/FMI 520213:10



Conditions for Setting the DTC

- Catalyst Function
- Check condition- Engine running
- Fault condition- EGO 1 signal = EGO 2 signal for 100 updates
- MIL- On during active fault and for 1 second after active fault
- Adaptive- Disabled during active fault

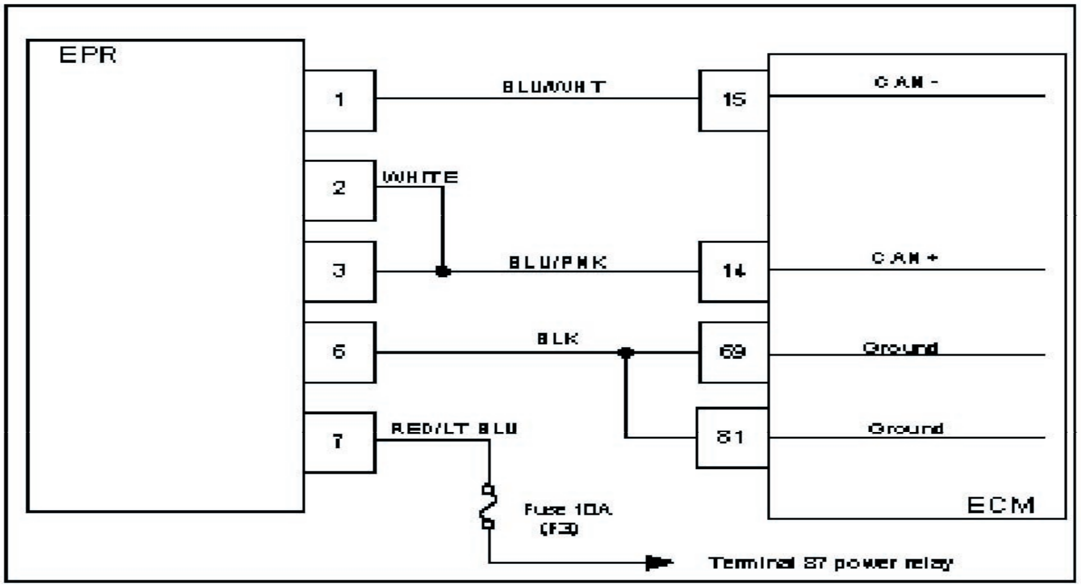
Circuit Description

The ECM uses EGO 1 and EGO 2 sensor signals to diagnose problems with the catalyst muffler. When the signals for EGO 1 & EGO 2 are similar it may indicate a problem with the catalyst.

Diagnostic Aids

Always diagnose any other troubles, stored along with DTC 420 first. Check for and eliminate any exhaust leaks prior to replacing catalyst muffler. Look for exhaust leaks at the catalyst muffler inlet and tail pipes. Clear this trouble code after repairing exhaust leaks, and recheck for code.

DTC1171- EPR Pressure Higher Than Expected SPN/FMI 520260:0



Conditions for Setting the DTC

- EPR delivery pressure
- Check condition-Engine running or cranking
- MIL-On during active fault
- Fault condition-EPR actual pressure greater than 4.0 inches above commanded pressure
- Adaptive disabled
- Power derate level 1

Circuit Description

The EPR (Electronic Pressure Regulator) unit measures and controls the amount of fuel that is able to pass to the fuel mixer. Pressure readings are sent over the CAN to the ECM and in return the ECM sends back a control signal to the EPR to increase or decrease pressure for precise mixture control. This code will set in the event the actual pressure is 4.0 inches water pressure higher than the actual commanded pressure. The MIL command is on. Adaptive and closed loop are disabled with power derate level 1 enforced limiting throttle position to 70% maximum.

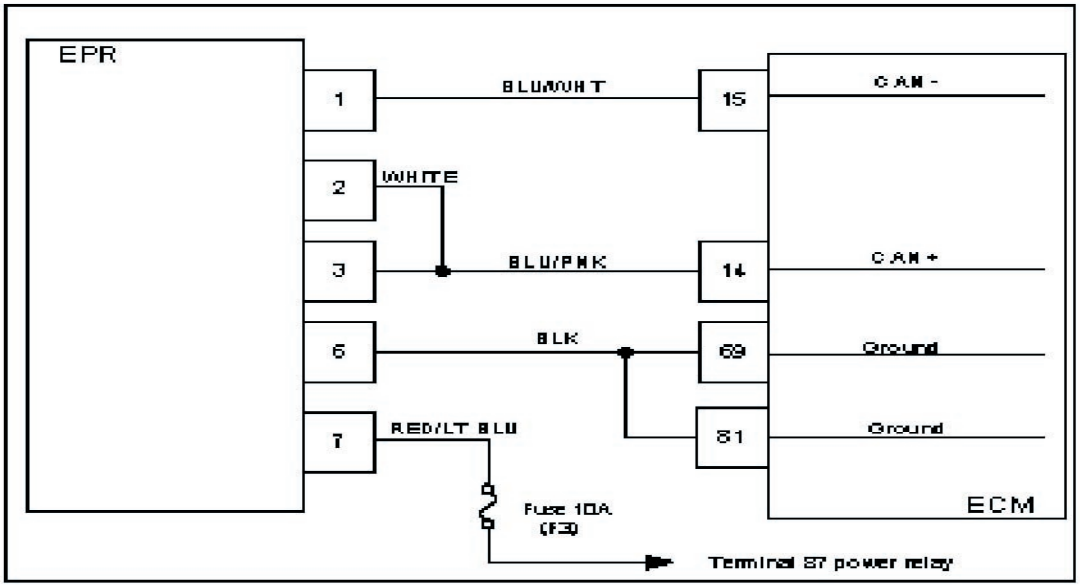
Diagnostic Aid

Always run the fuel system diagnostic pressure check before proceeding with the following diagnostic chart. High secondary fuel pressure due to a worn or damaged primary or secondary seat may cause this fault to set

DTC 1171-EPR Pressure Higher Than Expected SPN/FMI 520260:0

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	• Did you run the fuel pressure diagnostic test in the fuel system diagnostic section with no problems found?		Go to step (4)	Go to step 3
3	• Run the EPR pressure test in the fuel system diagnostic section Did the EPR pass the fuel pressure test specifications?		Go to step (4)	Follow the EPR service recommendations from the fuel pressure test chart.
4	Inspect the EPR electrical connector C026 for damage, corrosion or contamination. Did you find a problem?		Repair the circuit as necessary. Refer to wire harness repair section.	Go to step (5)
5	• Replace the EPR 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 DTC1171 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC1172- EPR Pressure Lower Than Expected SPN/FMI 520260:1



Conditions for Setting the DTC

- EPR delivery pressure
- Check condition-Engine running or cranking
- MIL-On during active fault
- Fault condition-EPR actual pressure less than 4.0 inches below commanded pressure
- Adaptive disabled
- Power derate level 1

Circuit Description

The EPR (Electronic Pressure Regulator) unit measures and controls the amount of fuel that is able to pass to the fuel mixer. Pressure readings are sent over the CAN to the ECM and in return the ECM sends back a control signal to the EPR to increase or decrease pressure for precise mixture control. This code will set in the event the actual pressure is 4.0 inches water pressure lower than the actual commanded pressure. The MIL command is on. Adaptive and closed loop are disabled with power derate level 1 enforced limiting throttle position to 70% maximum.

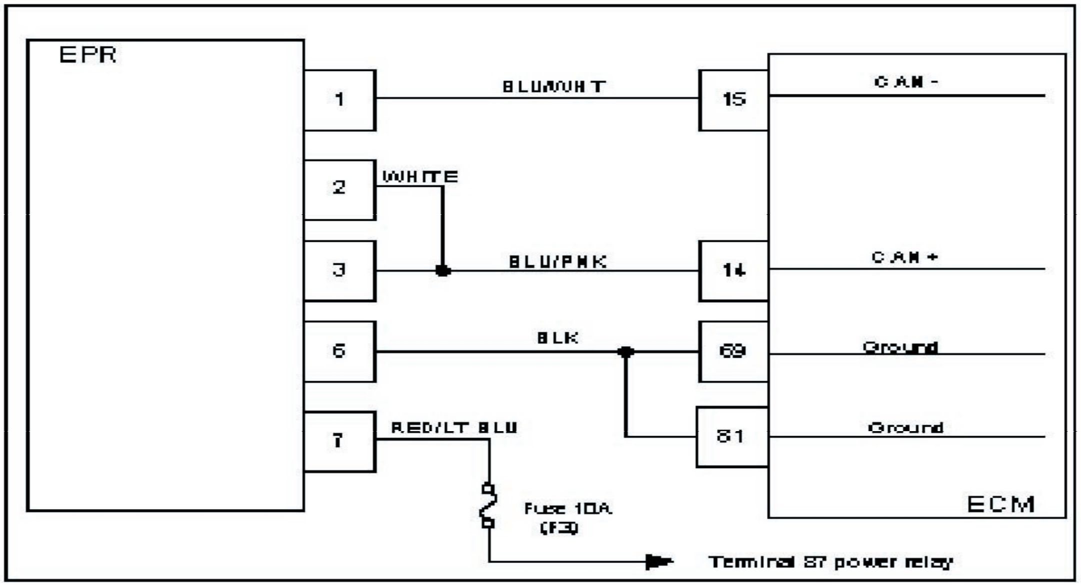
Diagnostic Aid

Always run the fuel system diagnostic pressure check before proceeding with the following diagnostic chart. Low secondary fuel pressure due to a fuel restriction or faulty regulator may cause this fault.

DTC 1172-EPR Pressure Lower Than Expected SPN/FMI 520260:1

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	• Did you run the fuel pressure diagnostic test in the fuel system diagnostic section with no problems found?		Go to step (4)	Go to step 3
3	• Run the EPR pressure test in the fuel system diagnostic section Did the EPR pass the fuel pressure test specifications?		Go to step (4)	Follow the EPR service recommendations from the fuel pressure test chart.
4	Inspect the EPR electrical connector C026 for damage, corrosion or contamination. Did you find a problem?		Repair the circuit as necessary. Refer to wire harness repair section.	Go to step (5)
5	• Replace the EPR 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 DTC1172 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC1173- EPR Communication Lost SPN/FMI 520260:31



Conditions for Setting the DTC

- EPR CAN communication
- Check condition-Engine running or cranking
- MIL-On during active fault
- Fault condition-No packets received within 500 ms
- Adaptive disabled

Circuit Description

The EPR (Electronic Pressure Regulator) unit measures and controls the amount of fuel that is able to pass to the fuel mixer. Pressure readings are sent over the CAN to the ECM and in return the ECM sends back a control signal to the EPR to increase or decrease pressure for precise mixture control. This code will set in the event communication with the ECM is lost. The MIL command is on.

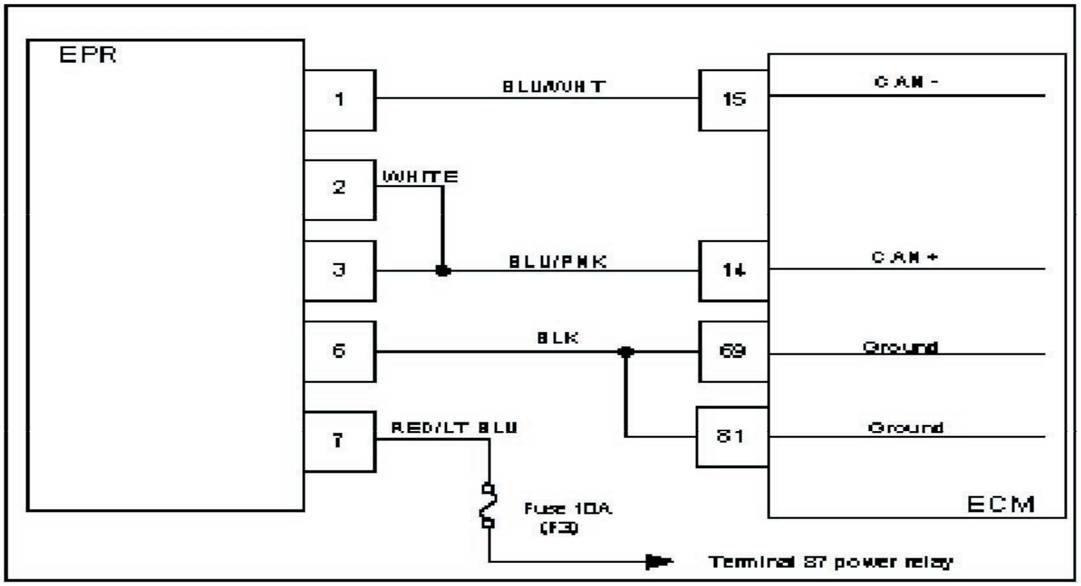
DTC 1173-EPR Communication Lost SPN/FMI 520260:31

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 the system data mode • Clear DTC1173 • Key OFF • Key ON, and attempt to start the engine Does DTC1173 re-set		Go to step (3)	Intermittent problem. Go to Intermittent Problem section in the electrical section of this manual.
3	• Key OFF • Disconnect EPR electrical connector C026 • Key ON • Using a DVOM check for system power between EPR connector pin 7 and engine ground (Be sure to activate relay control ON using the DST function or check before ECM relay control times out) Do you have power?	System battery voltage	Go to step (7)	Go to step (4)
4	• Check the 10A (F3) fuse Is the fuse open?		Go to step (5)	Go to step (6)
5	• Replace F3 fuse Is the replacement complete?		Go to step (17)	_
6	• Using a DVOM check for system power at power relay terminal 87 (Be sure to activate relay control ON using the DST function or check before ECM relay control times out) Do you have power?	System battery voltage	Repair the open circuit between power relay pin 87 and EPR pin 7 Go to step (17)	Repair the power relay circuit as required Go to step (17)
7	• Using a DVOM check for continuity between EPR connector pin 6 and engine ground Do you have continuity?		Go to step (8)	Repair the open ground circuit as necessary. Refer to wiring repairs in engine electrical
8	• Key OFF • Disconnect the EPR connector C026 • Disconnect the ECM connector C001 • Using a DVOM check for continuity between EPR pin 1 and ECM pin 15 Do you have continuity?		Go to step (9)	Repair the open circuit as necessary. Refer to wiring repairs in engine electrical

Step	Action	Value(s)	Yes	No
9	• Using a DVOM check for continuity between EPR pin 2 and ECM pin 14 Do you have continuity?		Go to step (10)	Repair the open circuit as necessary. Refer to wiring repairs in engine electrical
10	• Using a DVOM check for continuity between EPR pin 3 and ECM pin 14 Do you have continuity?		Go to step (11)	Repair the open circuit as necessary. Refer to wiring repairs in engine electrical
11	• Using a DVOM check for continuity between EPR pin 6 and ECM pin 69 Do you have continuity?		Go to step (12)	Repair the open circuit as necessary. Refer to wiring repairs in engine electrical
12	• Using a DVOM check for continuity between EPR pin 6 and ECM pin 81 Do you have continuity?		Go to step (13)	Repair the open circuit as necessary. Refer to wiring repairs in engine electrical
13	• Disconnect vehicle interface connector C011 • Disconnect DST from the DLC connector C016 • Using a DVOM check for continuity between engine ground and EPR pins 1 and 3 Do you have continuity?		Repair the shorted to ground CAN circuit as necessary. Refer to wiring repairs in engine electrical	Go to step (14)
14	• Replace the EPR Is the replacement complete?		Go to step (15)	_
15	• Remove all test equipment and reconnect 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 DTC1173 check for any stored codes. Does DTC1173 still re-set?		Go to step (16)	System OK

Step	Action	Value(s)	Yes	No
16	• Replace the ECM Is the replacement complete?		Go to step (17)	_
17	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC1173 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC1174- EPR Supply Voltage High SPN/FMI 520260:3



Conditions for Setting the DTC

- EPR supply voltage
- Check condition-Engine running or cranking
- MIL-On during active fault
- Fault condition- internal EPR supply voltage too high
- Adaptive disabled
- Closed loop disabled

Circuit Description

The EPR (Electronic Pressure Regulator) unit measures and controls the amount of fuel that is able to pass to the fuel mixer. Pressure readings are sent over the CAN to the ECM and in return the ECM sends back a control signal to the EPR to increase or decrease pressure for precise mixture control. This code will set if the EPR internal supply voltage is too high.

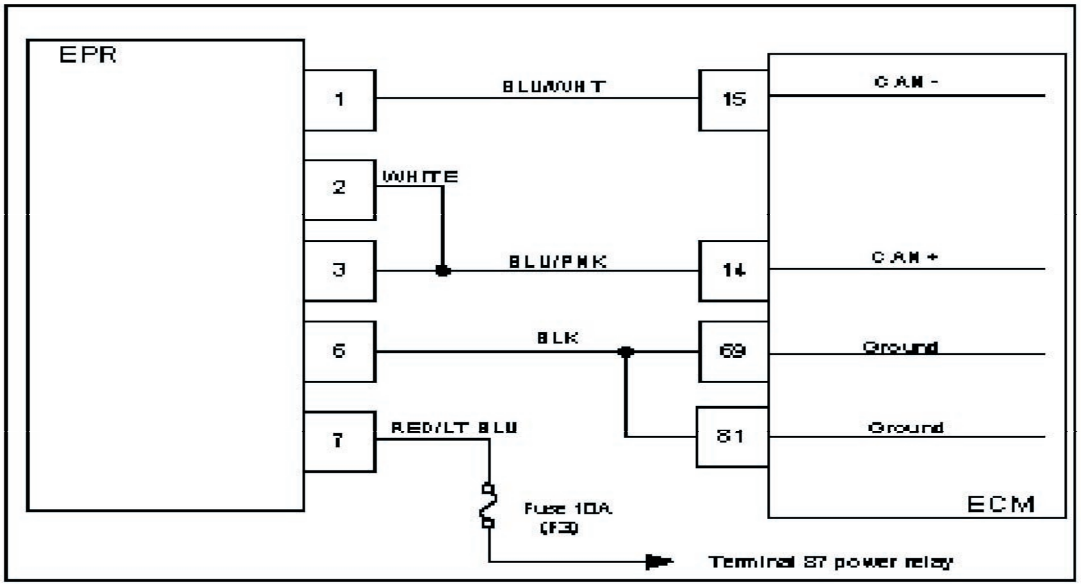
Diagnostic Aid

This DTC indicates abnormal EPR internal voltages that are not measurable externally. Check the system charging voltage to be sure this DTC and other over voltage DTC's are not present. Repair the charging system if it is found to be out of specification for high charge voltage. In the event of multiple code sets, always start the diagnostic repair with the lowest numerical value DTC first.

DTC 1174-EPR Voltage Supply High SPN/FMI 520260:3

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Engine running • Check the system battery voltage. Is the charging voltage within specifications?		Go to step (3)	Repair the charging system
3	Using a DVOM compare the system battery voltage to the DST display. Is the voltage reading within 1 volt between the two of them?	1 volt	Go to step (4)	Go to step (5)
4	• Replace the EPR Is the replacement complete?		Go to step (6)	_
5	• Replace the 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 DTC1174 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC1175- EPR Supply Voltage Low SPN/FMI 520260:4



Conditions for Setting the DTC

- EPR supply voltage
- Check condition-Engine running or cranking
- MIL-On during active fault
- Fault condition-EPR internal supply voltage low
- Adaptive disabled
- Closed loop disabled

Circuit Description

The EPR (Electronic Pressure Regulator) unit measures and controls the amount of fuel that is able to pass to the fuel mixer. Pressure readings are sent over the CAN to the ECM and in return the ECM sends back a control signal to the EPR to increase or decrease pressure for precise mixture control. This code will set if the internal EPR supply voltage is low.

Diagnostic Aid

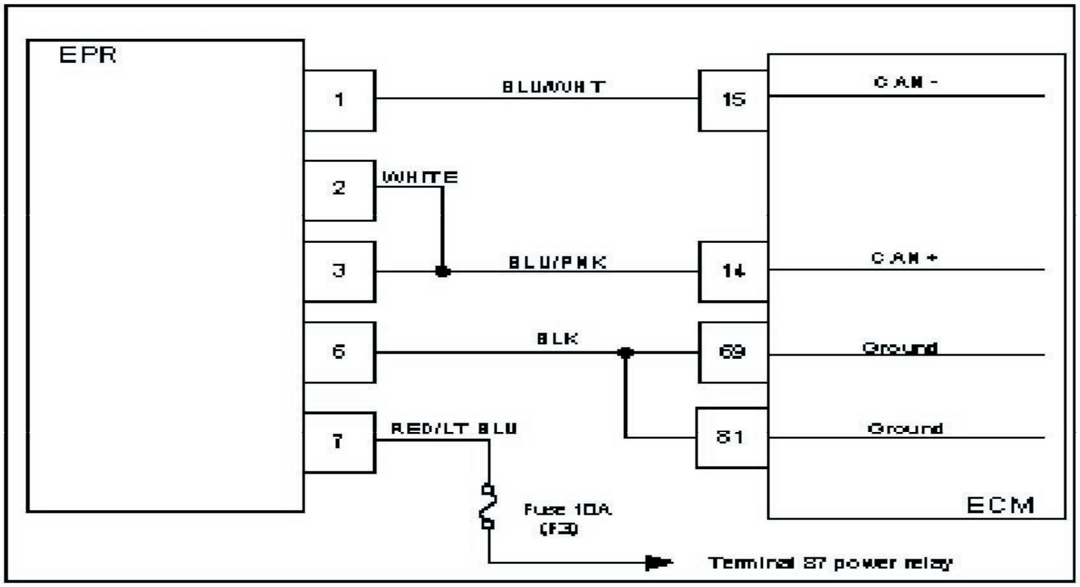
This DTC indicates abnormal EPR internal voltages that are not measurable externally. Check the system charging voltage to be sure this DTC and other low voltage DTC's are not present. Repair the charging system if it is found to be out of specification for low charge voltage. In the event of multiple code sets, always start the diagnostic repair with the lowest numerical value DTC first.

DTC 1175-EPR Voltage Supply Low SPN/FMI 520260:4

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Engine running • Check the system battery voltage. Is the charging voltage within specifications?		Go to step (3)	Repair the charging system
3	• Key OFF • Disconnect the EPR electrical connector C026 • Using a DVOM check for power between the EPR connector pin 7 and engine ground. • Key ON • Record the voltage reading. (Be sure to activate relay control ON using the DST function or check before ECM relay control times out) • Using a DVOM check the system battery power at the battery terminals and record the voltage reading. Are the recorded voltage readings within 1 volt of each other?		Go to step (6)	Go to step (4)
4	• Inspect the EPR connector and F3 fuse holder terminals for damage corrosion or contamination Did you find a problem?		Correct the problem as necessary. See wiring harness repair in the electrical section of this manual	Go to step (5)
5	• Check the power relay circuit. Check the power relay connections for damage corrosion or contamination Did you find a problem?		Correct the problem as necessary. See wiring harness schematic in the electrical section of this manual	_

Step	Action	Value(s)	Yes	No
6	• Key OFF • Disconnect the ECM connector C001 • Using a DVOM check the resistance reading between EPR connector pin 6 and ECM connector pin 69 and 81. (Do not forget to subtract any resistance value that may be present in you test cables) Is the resistance reading less than .5 ohms?	Less than .5 Ohms	Go to step (7)	Repair the poor EPR power ground circuit. See wiring harness repair in the electrical section of this manual
7	• Replace the EPR 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 DTC1175 check for any stored codes. Does DTC 1175 still re-set?		Go to step (9)	System OK
9	• Replace the ECM Is the replacement complete?		Go to step (10)	_
10	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC1175 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC1176- EPR Internal Actuator Fault SPN/FMI 520260:12



Conditions for Setting the DTC

- EPR internal actuator test
- Check condition-Engine running or cranking
- MIL-On during active fault
- Fault condition- Failed acuator
- Adaptive disabled
- Closed loop disabled

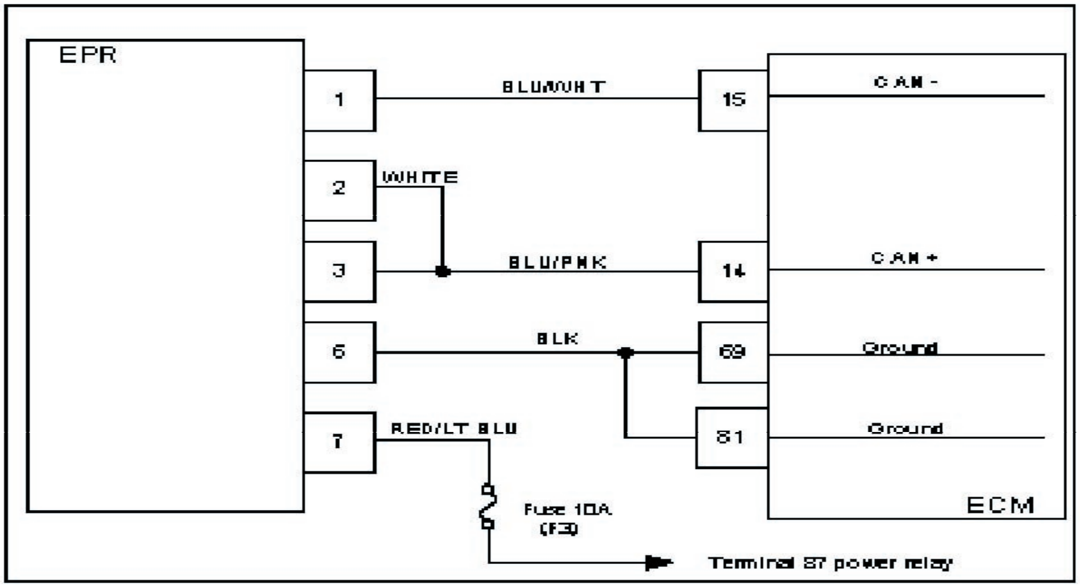
Circuit Description

The EPR (Electronic Pressure Regulator) unit measures and controls the amount of fuel that is able to pass to the fuel mixer. Pressure readings are sent over the CAN to the ECM and in return the ECM sends back a control signal to the EPR to increase or decrease pressure for precise mixture control. This code will set if the ECM detects an internal actuator fault with the EPR. In the event of multiple code sets, always start the diagnostic repair with the lowest numerical value DTC first. In most instances the EPR will need to be replaced in the event of this code set.

DTC 1176-EPR Internal Actuator Fault SPN/FMI 520260:12

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Check for any other current or active DTCs Does the DST show any other codes set?		Go to step (3)	Go to step (6)
3	• Repair any other DTC's set starting with the lowest DTC number first Have the other DTC's set been corrected?		Go to step (4)	_
4	• 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 DTC1176 check for any stored codes. Does DTC 1176 still re-set?		Go to step (5)	System OK
5	• Replace the EPR 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 DTC1176 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC1177- EPR internal Circuitry Fault SPN/FMI 620260:12



Conditions for Setting the DTC

- EPR internal circuitry test
- Check condition-Engine running or cranking
- MIL-On during active fault
- Fault condition-
- Adaptive disabled
- Closed loop disabled

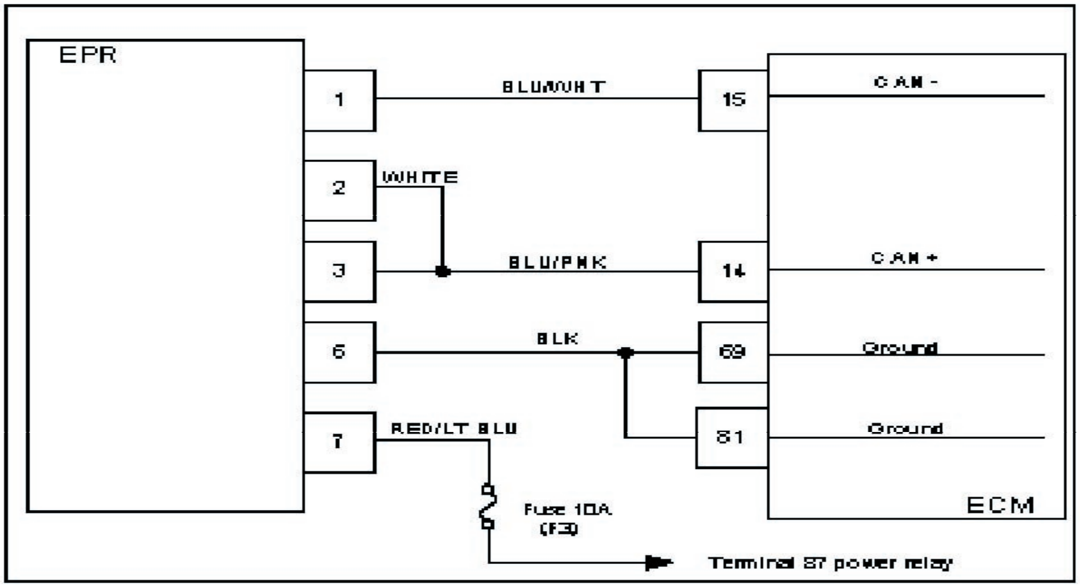
Circuit Description

The EPR (Electronic Pressure Regulator) unit measures and controls the amount of fuel that is able to pass to the fuel mixer. Pressure readings are sent over the CAN to the ECM and in return the ECM sends back a control signal to the EPR to increase or decrease pressure for precise mixture control. This code will set if the ECM detects an internal circuitry fault in the EPR. In the event of multiple code sets, always start the diagnostic repair with the lowest numerical value DTC first. In most instances the EPR will need to be replaced in the event of this code set.

DTC 1177-EPR Internal Circuitry Failure SPN/FMI 520260:12

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Check for any other current or active DTCs Does the DST show any other codes set?		Go to step (3)	Go to step (6)
3	• Repair any other DTC's set starting with the lowest DTC number first Have the other DTC's set been corrected?		Go to step (4)	_
4	• 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 DTC1177 check for any stored codes. Does DTC 1177 still re-set?		Go to step (5)	System OK
5	• Replace the EPR 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 DTC1177 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC1178- EPR Internal Communication Error SPN/FMI 520260:12



Conditions for Setting the DTC

- EPR internal communication test
- Check condition-Engine running or cranking
- MIL-On during active fault
- Fault condition-
- Adaptive disabled
- Closed loop disabled

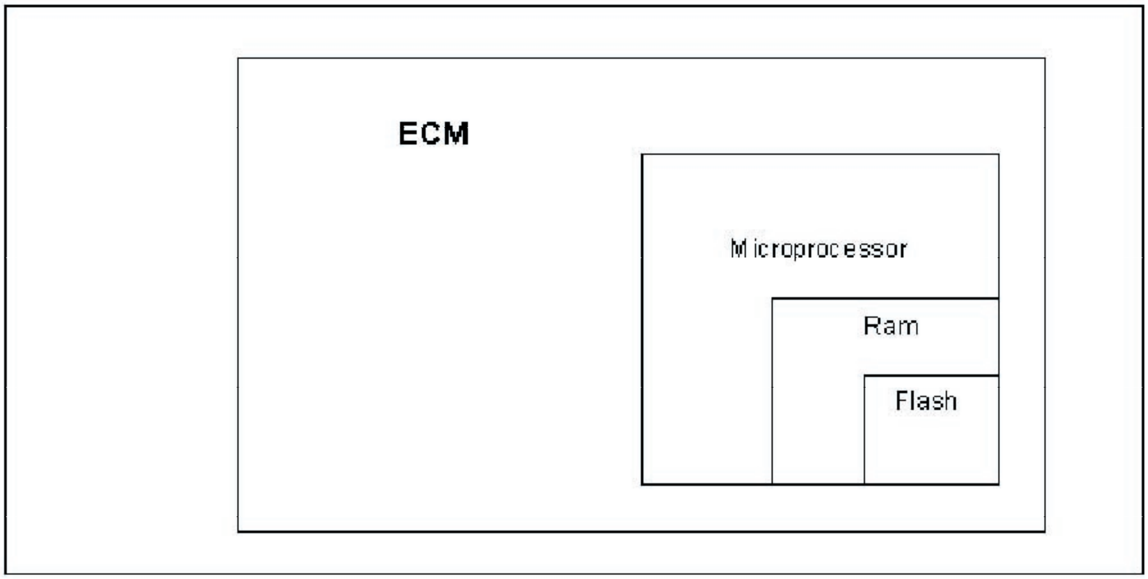
Circuit Description

The EPR (Electronic Pressure Regulator) unit measures and controls the amount of fuel that is able to pass to the fuel mixer. Pressure readings are sent over the CAN to the ECM and in return the ECM sends back a control signal to the EPR to increase or decrease pressure for precise mixture control. This code will set if the ECM detects an internal communication error in the EPR. In the event of multiple code sets, always start the diagnostic repair with the lowest numerical value DTC first. In most instances the EPR will need to be replaced in the event of this code set.

DTC 1178-EPR Internal Comm Fault SPN/FMI 520260:12

Step	Action	Value(s)	Yes	No
1	Did you perform the On-Board (OBD) System Check?	-	Go to Step (2)	Go to OBD System Check Section
2	• DST connected and in the system data mode • Check for any other current or active DTCs Does the DST show any other codes set?		Go to step (3)	Go to step (6)
3	• Repair any other DTC's set starting with the lowest DTC number first Have the other DTC's set been corrected?		Go to step (4)	_
4	• 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 DTC1178 check for any stored codes. Does DTC 1178 still re-set?		Go to step (5)	System OK
5	• Replace the EPR 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 DTC1178 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1612-RTI 1 Loss SPN/FMI 629:31



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On
- Adaptive- Disabled for the remainder of the key-ON cycle
- Power Derate level 2

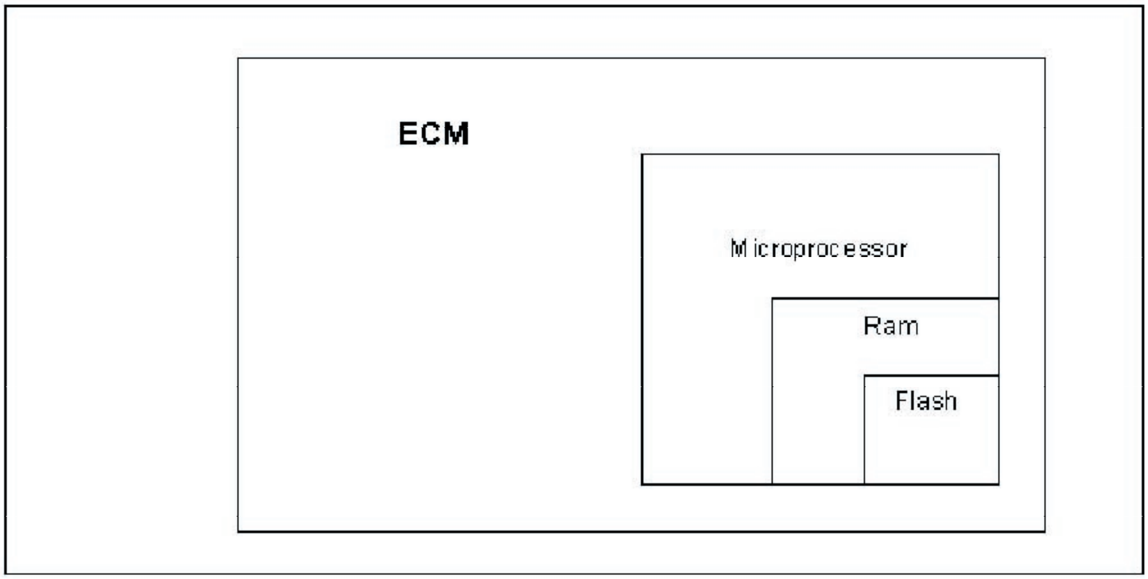
Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will attempt to reset itself in the event this fault is set. The MIL command is on and will remain on until the code is cleared using the DST. Power Derate level 2 will be enforced limiting maximum throttle position to 20%.

DTC 1612- RT 1 Loss SPN/FMI 629:31

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 1612 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check ECM power and ground circuits 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 (5)	-
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-1612 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1613-RTI 2 Loss SPN/FMI 629:31



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On
- Adaptive- Disabled for the remainder of the key-ON cycle
- Power Derate level 2

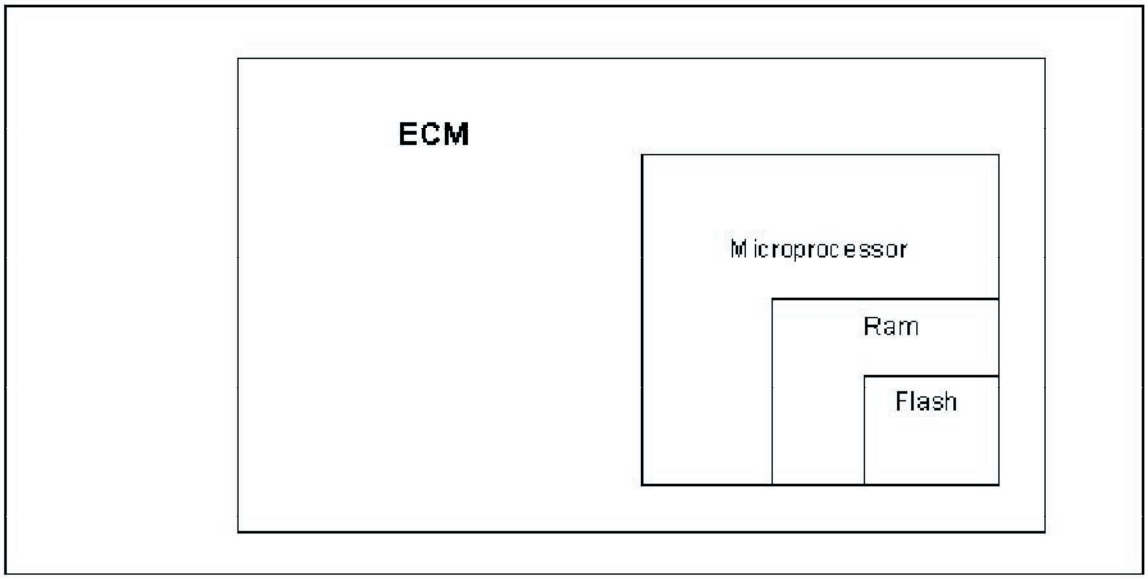
Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will attempt to reset itself in the event this fault is set. The MIL command is on and will remain on until the code is cleared using the DST. Power Derate level 2 will be enforced limiting maximum throttle position to 20%.

DTC 1613- RTI 2 Loss SPN/FMI 629:31

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 1613 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check ECM power and ground circuits 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 (5)	-
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-1613 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1614-RTI 3 Loss SPN/FMI 629:31



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On
- Adaptive- Disabled for the remainder of the key-ON cycle
- Power Derate level 2

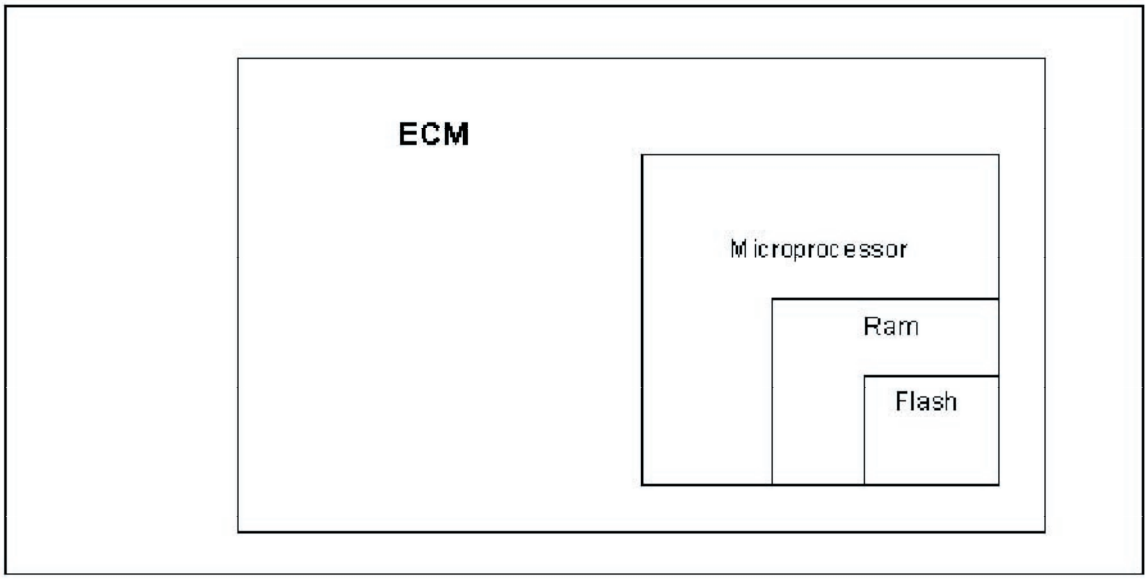
Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will attempt to reset itself in the event this fault is set. The MIL command is on and will remain on until the code is cleared using the DST. Power Derate level 2 will be enforced limiting maximum throttle position to 20%.

DTC 1614- RTI 3 Loss SPN/FMI 629:31

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 1614 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check ECM power and ground circuits 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 (5)	-
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-1614 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1615-A/D Loss SPN/FMI 629:31



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On
- Adaptive- Disabled for the remainder of the key-ON cycle
- Power Derate level 2

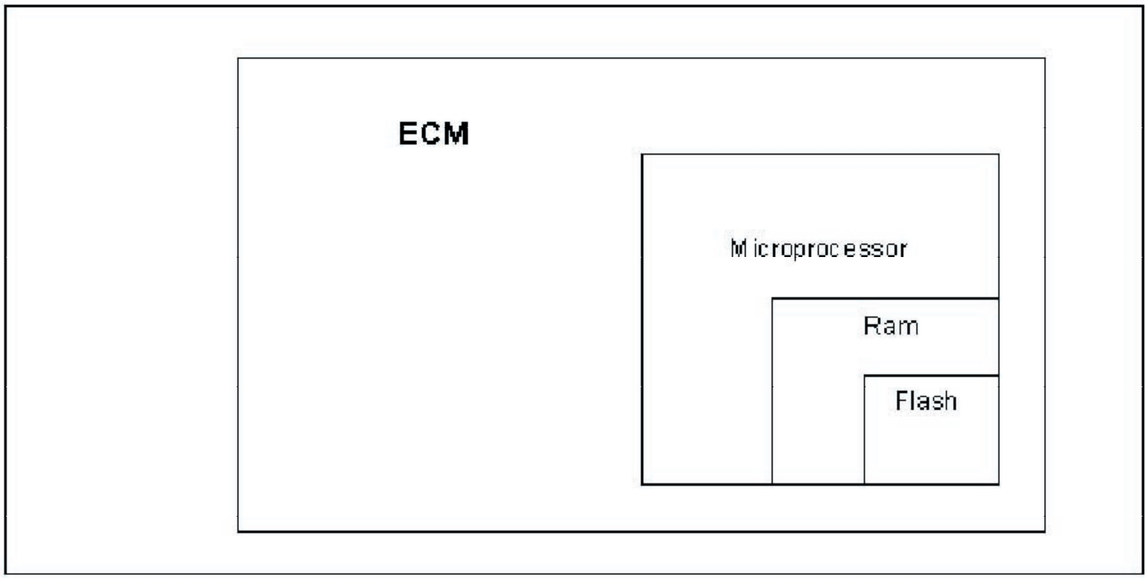
Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will attempt to reset itself in the event this fault is set. The MIL command is on and will remain on until the code is cleared using the DST. Power Derate level 2 will be enforced limiting maximum throttle position to 20%.

DTC 1615- A/D Loss SPN/FMI 629:31

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 1615 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check ECM power and ground circuits 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 (5)	-
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-1615 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1616-Invalid Interrupt SPN/FMI 629:31



Conditions for Setting the DTC

- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On
- Adaptive- Disabled for the remainder of the key-ON cycle
- Power Derate level 2

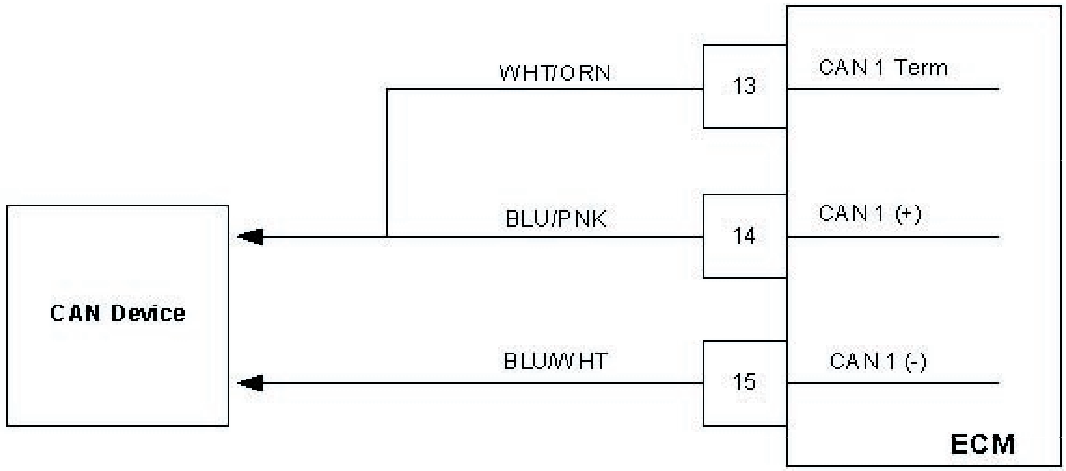
Circuit Description

The ECM has several internal checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will attempt to reset itself in the event this fault is set. The MIL command is on and will remain on until the code is cleared using the DST. Power Derate level 2 will be enforced limiting maximum throttle position to 20%.

DTC 1616- Invalid Interrupt SPN/FMI 629:31

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 1616 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check ECM power and ground circuits 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 (5)	-
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-1616 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1626-CAN Tx Failure SPN/FMI 639:12



Conditions for Setting the DTC

- CAN Tx
- Check Condition- Engine running
- Fault Condition- CAN Tx error 100 packets lost within 1 second
- MIL- ON

Circuit description

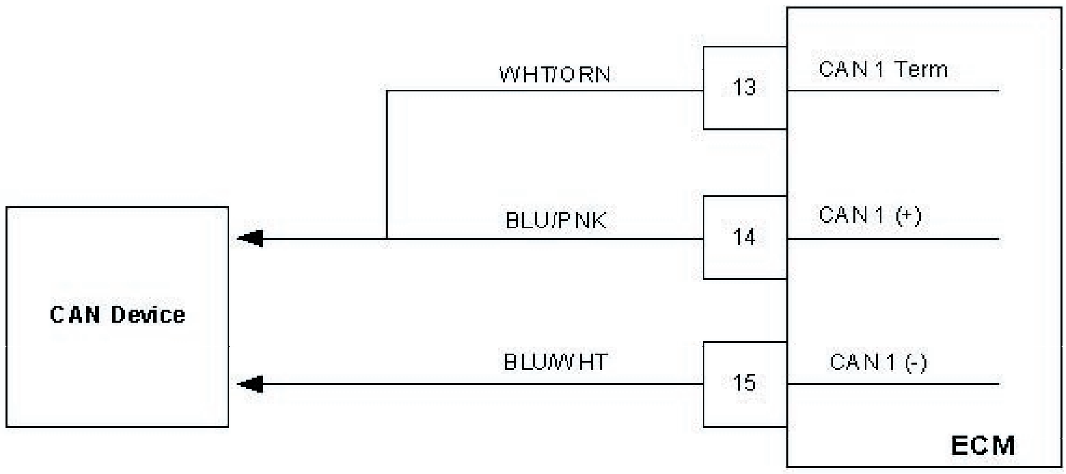
The CAN bus (controller area network) is used by the ECM to communicate with other digital devices used throughout the fuel system. Information is sent over the CAN bus in digital information “packets” that contain information for various control functions. This fault will set if the ECM detects 100 packets lost within a one second time period. The MIL command is ON.

DTC 1626- CAN Tx Failure SPN/FMI 639:12

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 DTC1626 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check that the ECM power connections C020, C021 and C024 are clean and tight. • Check that the ECM ground connections C014 and C023 are clean and tight. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Key OFF • Disconnect ECM harness connector C001 • Using a DVOM check for continuity between ECM connector pin 13 and 14 Do you have continuity?		Go to step (5)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between ECM pins 14 and 15 Do you have continuity between them?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (6)
6	• Using a DVOM check for continuity to engine ground on pins 14 and 16 Do have continuity to engine ground?		Repair the shorted to ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (7)
7	• Using a DVOM check for continuity to battery positive on pins 14 and 16 Do have continuity them?		Repair the shorted to ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (8)
8	• Replace the ECM Is the replacement complete?		Go to step (9)	_

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-1626 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1627-CAN Rx Failure SPN/FMI 639:12



Conditions for Setting the DTC

- CAN Rx
- Check Condition- Engine running
- Fault Condition- CAN Rx error 100 packets lost within 1 second
- MIL- ON

Circuit description

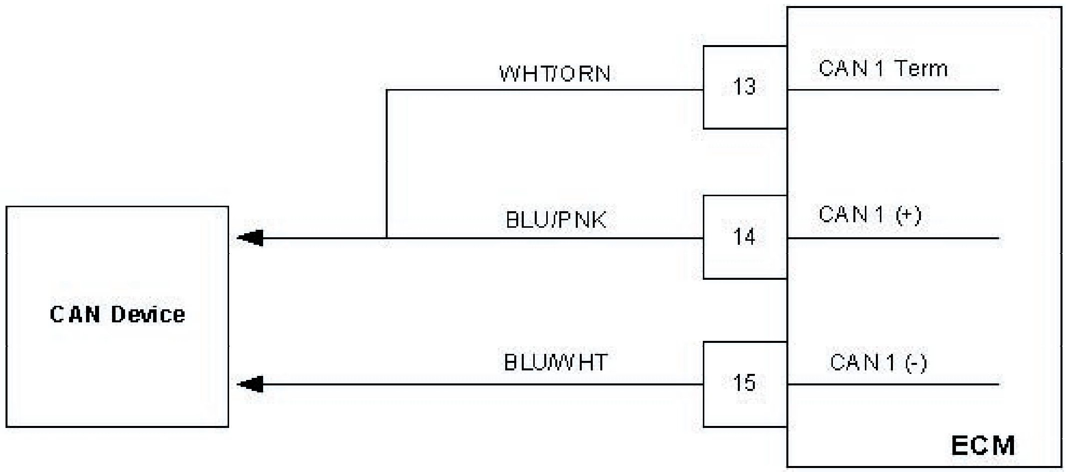
The CAN bus (controller area network) is used by the ECM to communicate with other digital devices used throughout the fuel system. Information is sent over the CAN bus in digital information “packets” that contain information for various control functions. This fault will set if the ECM detects 100 packets lost within a one second time period. The MIL command is ON.

DTC 1627- CAN Rx Failure SPN/FMI 639:12

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 DTC1627 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Check that the ECM power connections C020, C021 and C024 are clean and tight. • Check that the ECM ground connections C014 and C023 are clean and tight. Are the power and ground circuits Ok?		Go to Step (4)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
4	• Key OFF • Disconnect ECM harness connector C001 • Using a DVOM check for continuity between ECM connector pin 13 and 14 Do you have continuity?		Go to step (5)	Repair the open circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
5	• Using a DVOM check for continuity between ECM pins 14 and 15 Do you have continuity between them?		Repair the shorted circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (6)
6	• Using a DVOM check for continuity to engine ground on pins 14 and 16 Do have continuity to engine ground?		Repair the shorted to ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (7)
7	• Using a DVOM check for continuity to battery positive on pins 14 and 16 Do have continuity them?		Repair the shorted to ground circuit as necessary. Refer to Wiring Repairs in Engine Electrical.	Go to step (8)
8	• Replace the ECM Is the replacement complete?		Go to step (9)	_

Step	Action	Value(s)	Yes	No
9	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-1627 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1628-CAN Address Conflict SPN/FMI 639:13



Conditions for Setting the DTC

- CAN Rx
- Check Condition- Engine running
- Fault Condition- 5 or more address conflict errors
- MIL- ON

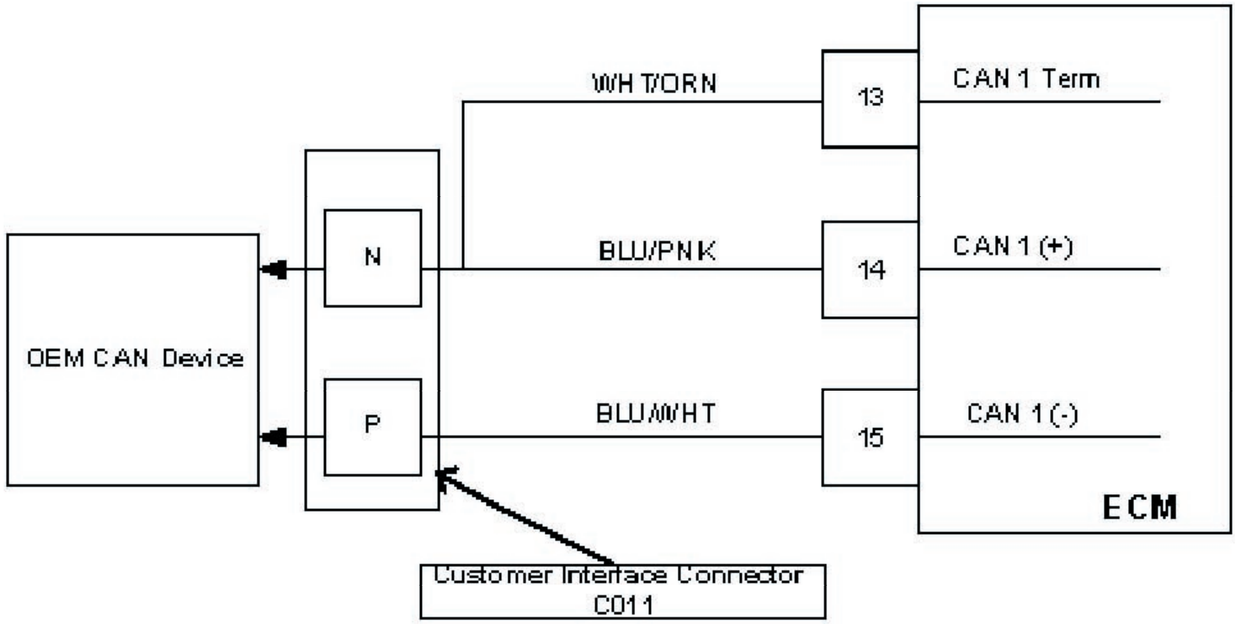
Circuit description

The CAN bus (controller area network) is used by the ECM to communicate with other digital devices used throughout the fuel system. Information is sent over the CAN bus in digital information “packets” that contain information for various control functions. Individual devices are assigned network addresses. This fault will set if the ECM detects an address conflict, such as two devices with the same address. This is usually not due to an in field failure and may be the results of “add on” CAN devices

DTC 1628- CAN Address Conflict SPN/FMI 639:13

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 DTC1628 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Key OFF • Disconnect one CAN device • Clear DTC 1628 • Key ON (start engine if possible if not continue cranking for at least 3 seconds) • Wait 5 seconds • Does DTC 1628 re-set		Repeat step 3 until all CAN devices have been disconnected one at a time	Contact the CAN device manufacturer for additional CAN address information Go to Step (4)
4	Has the CAN device been replaced or address conflict resolved		Go to step (5)	_
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-1628 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 1629-Loss of TSC 1 SPN/FMI 639:31



Conditions for Setting the DTC

- CAN TSC 1 Input Lost
- Check Condition- Engine running
- Loss of TSC 1 command from OEM CAN device for more than 1 s
- MIL- ON
- Force 1800 rpm engine speed

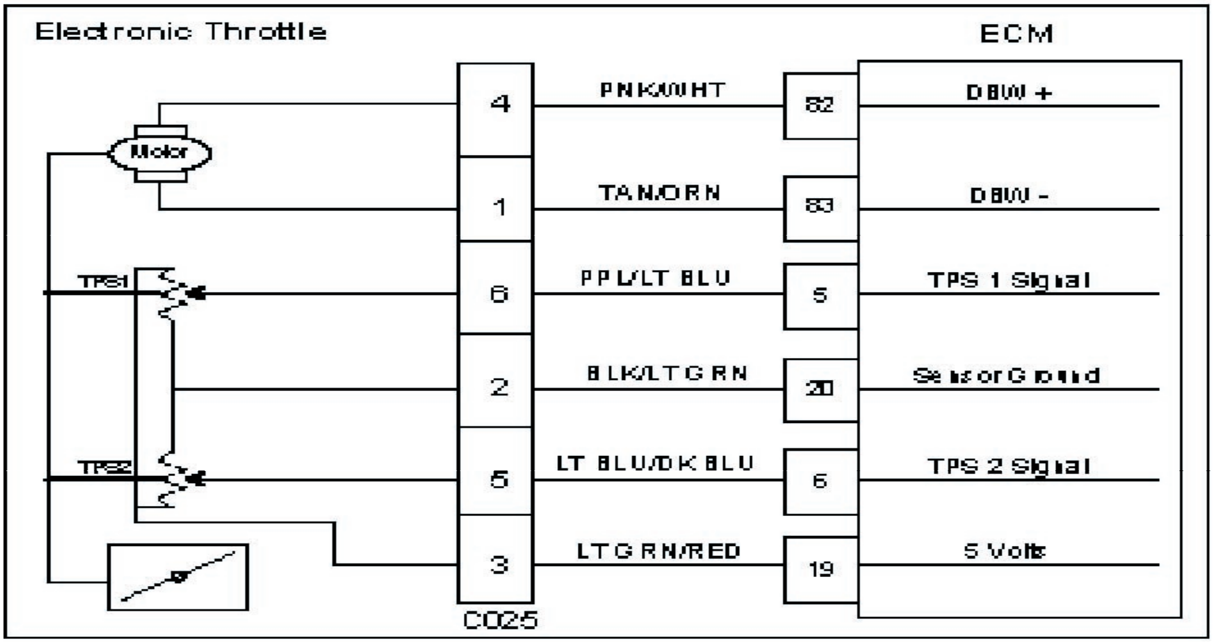
Circuit description

The CAN bus (controller area network) is used by the ECM to communicate with other digital devices used throughout the engine control system. Information is sent over the CAN bus in digital information “packets” that contain information for various control functions. Individual devices are assigned network addresses. This fault will set if the ECM does not detect the TSC 1 (torque speed command) command from the OEM CAN module.

DTC 1629- Loss of TSC 1 SPN/FMI 639:31

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 DTC1629 reset with the engine idling?		Go to Step (3)	Intermittent problem Go to Intermittent section
3	• Are other CAN related DTC's set?		Diagnose others first and return here if 1629 persists	Go to Step 4
4	• Key OFF • Disconnect ECM connector C001 • Disconnect customer interface connector 1 C011 • Using a DVOM check resistance between terminal N at CO11 and 14 at the ECM and check between terminal P at C011 and 15 at the ECM. • Is resistance less than 2 ohms?		Contact the equipment manufacture for help in diagnosing their CAN system. The problem is in their transmission	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
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-1629 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 2111- Unable To Reach Lower TPS SPN/FMI 51:7



Conditions for Setting the DTC

- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition- Actual throttle position is 20% greater than the throttle command
- MIL-On during active fault
- Engine Shut Down

Circuit Description

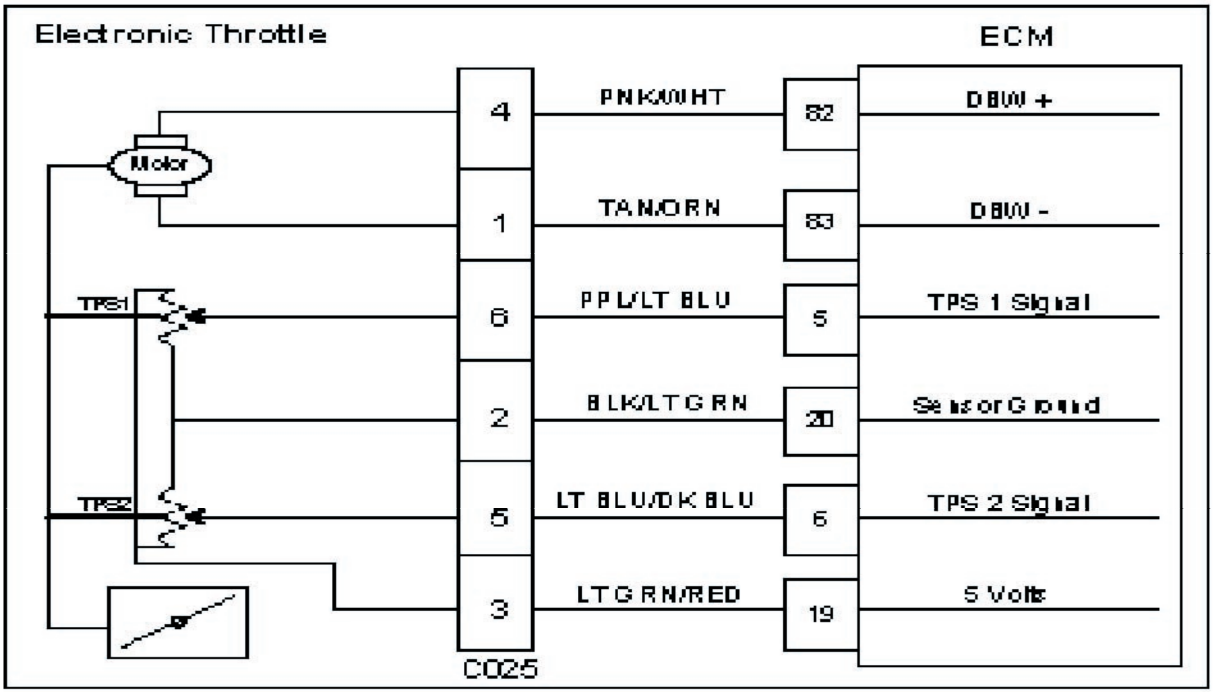
There are two Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS 1 will read low voltage when closed and TPS 2 will read high voltage when closed. The TPS 1 and TPS 2 percentages are calculated from these 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 actual throttle position is 20% greater than the throttle command. During this active fault the MIL command is ON and the engine will shut down.

DTC 2111 Unable To Reach Lower TPS SPN/FMI 51:7

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 electronic throttle connector C025 • Probe TPS 1 signal pin 6 with a 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 C001 • Key ON • Using a DVOM check for voltage between throttle connector TPS 1signal pin 6 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	• Probe sensor ground circuit at ECM connector C001 with a 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 C001 • Using a DVOM check for continuity between throttle connector signal ground pin 2 and ECM signal ground circuit pin 20 Do you have continuity between them?		Go to Step (8)	Repair the circuit as necessary. Refer to Wiring Repairs in Engine Electrical.
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)	-

Step	Action	Value(s)	Yes	No
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and 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-2111 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 2112-Unable To Reach Higher TPS SPN/FMI 51:7



Conditions for Setting the DTC

- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition- Actual throttle position is 20% less than the throttle command
- MIL-On during active fault
- Engine Shut Down

Circuit Description

There are two Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS 1 will read low voltage when closed and TPS 2 will read high voltage when closed. The TPS 1 and TPS 2 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.

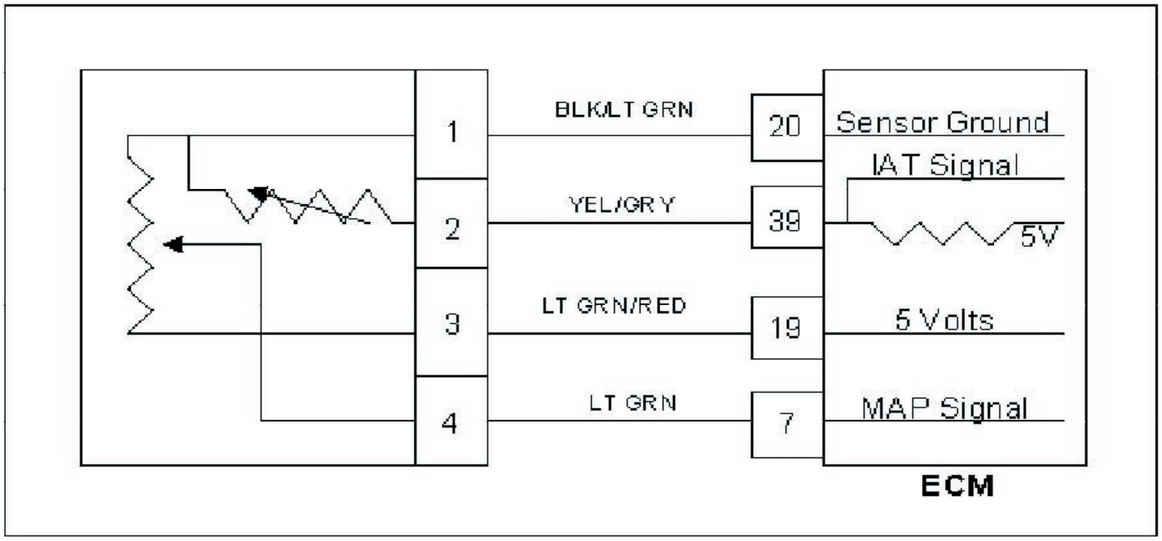
This fault will set if the actual throttle position is 20% less than the throttle command. During this active fault the MIL command is ON and the engine will shut down.

DTC 2112- Throttle Unable to Open SPN/FMI 51:7

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 electronic throttle connector C025 • Probe TPS 1 signal circuit pin 6 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 electronic 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 C001 • Using a DVOM check for continuity between throttle connector TPS 1 signal pin 6 and ECM TPS 1 signal pin 5 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 pin 6 and engine ground Do you have continuity between them?		Repair the shorted to ground 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)	-

Step	Action	Value(s)	Yes	No
11	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe the MIL • Observe engine performance and driveability • After operating the engine within the test parameters of DTC-2112 check for any stored codes. Does the engine operate normally with no stored codes?		System OK	Go to OBD System Check

DTC 2229-BP High Pressure SPN/FMI 108:0



Conditions for Setting the DTC

- Barometric pressure check
- Check condition-engine off and key on
- Fault Condition-BP greater than 16 PSIA
- MIL-On for active fault and for 2 seconds after active fault
- Adaptive-disabled for the remainder of key cycle

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 operating range.

DTC 2229- BP High Pressure SPN/FMI 108:0

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?		Go to Step (4)	-
4	• 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-2229 check for any stored codes. Does the engine operate normally with no stored codes?		System Ok	*Go to OBD System Check*