POWER SOLUTIONS, INC.

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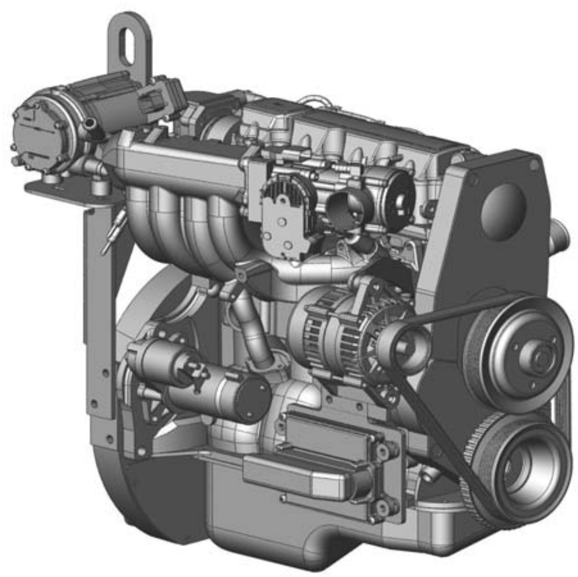
PSI 1.6L PFI TIER II CERTIFIED ENGINE SERVICE MANUAL



MANUAL SECTIONS

PSI 1.6L PFI
MAINTENANCE SECTION

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SPECTRUM by IMPCO

PSI POWER SOLUTIONS, INC.

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.

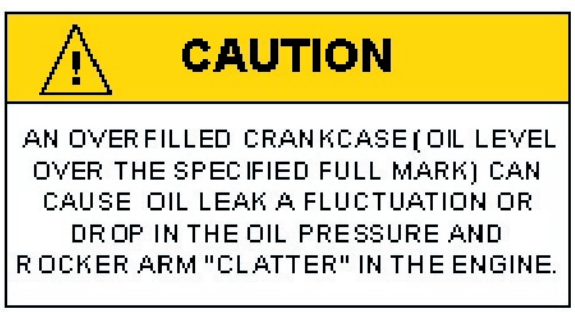
USE OF SUPPLEMENTAL ADDITIVES

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



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

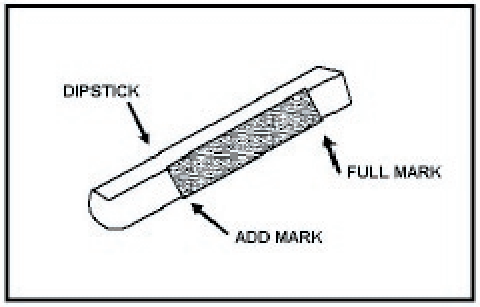


Figure 2

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. IMPCO recommends the EPR be drained at every engine oil change if contaminated or substandard fuel is suspected or known to have been used or in use with the emission compliant fuel system. This is known as special maintenance, and failure to follow this additional recommendation may not be used to deny a warranty claim.

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 operating 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 sensor in the auxiliary fuel port of the EPR.

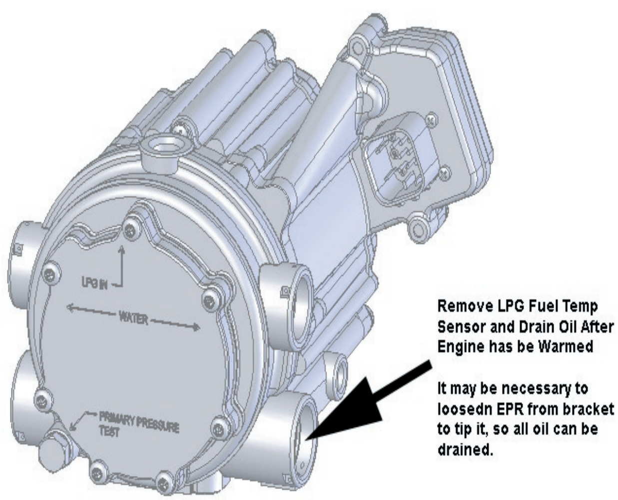
6. Remove the retainer clip for the LPG fuel temperature sensor and remove the sensor from the regulator body. It may be necessary to remove nuts from the bottom of the mounting isolators to tip EPR so that all of the oil can be drained. Note: Have a small container ready to collect oil that will drain freely from the regulator at this point.

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



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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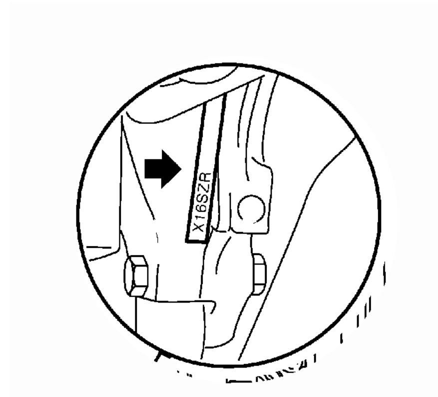
Engine Identification Code / Engine Number

The engine identification code is embossed on the flattened area (arrow) of the cylinder block on the transmission side.



Checking and Adjustment Operations

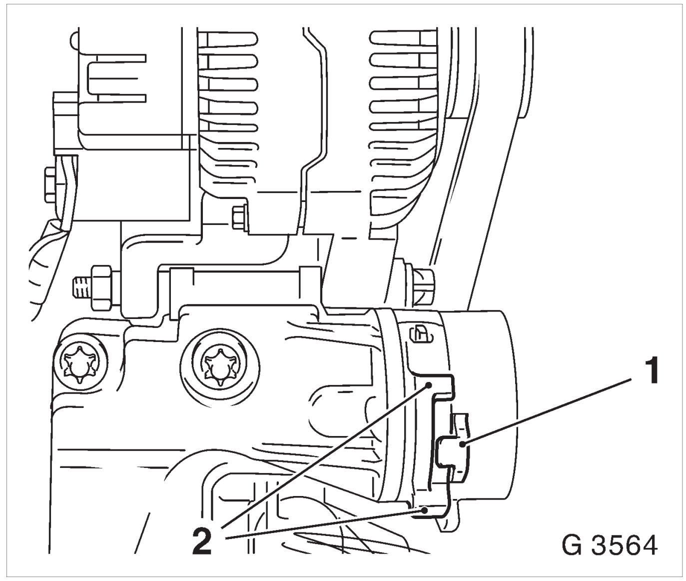
Ribbed V–belt Tension, Check

Inspect

Ribbed V–belt tension is adjusted via automatic ribbed V–belt tensioner.

Only the position of the movable ribbed V–belt tensioner tensioning arm (1) can be checked. This should lie between the stops (2).

If movable tensioner arm (1) for ribbed V–belt tensioner is located at stop (2), replace ribbed V–belt and ribbed V–belt tensioner – see operations ”Ribbed V–belt, Remove and Install” and ”Ribbed V–belt Tensioner, Remove and Install”.



Compression, Check

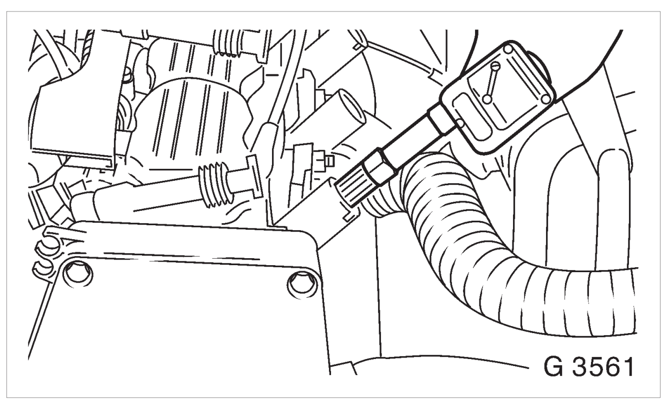
Remove, Disconnect

Engine at operating temperature (oil temperature 80 °C).

Detach spark plug connectors and remove spark plugs with KM–194–E.

Detach wiring harness plug (1) from DIS ignition module.

Open relay holder cover and pull fuel pump relay (2) out of base.



Inspect

Use compression recorder with rubber cone and a measuring range of up to 1750 kPa (250 PSI) overpressure. Actuate starter for approx. 4 seconds with throttle valve fully open – minimum engine speed 300 rpm. The pressure difference

between the individual cylinders should not exceed 100 kPa (14.5 PSI).

Install, Connect

Insert fuel pump relay in base and close relay holder cover.

Connect wiring harness plug to DIS ignition module.

Install spark plugs with KM–194–E into cylinder head – tightening torque 25 Nm / 18 lbf. ft.

Connect spark plug connectors.

Pressure Loss, Check

Engine at operating temperature (oil temperature 80 °C).

Remove, Disconnect

Detach spark plug connectors, remove spark plugs with KM–194–E.

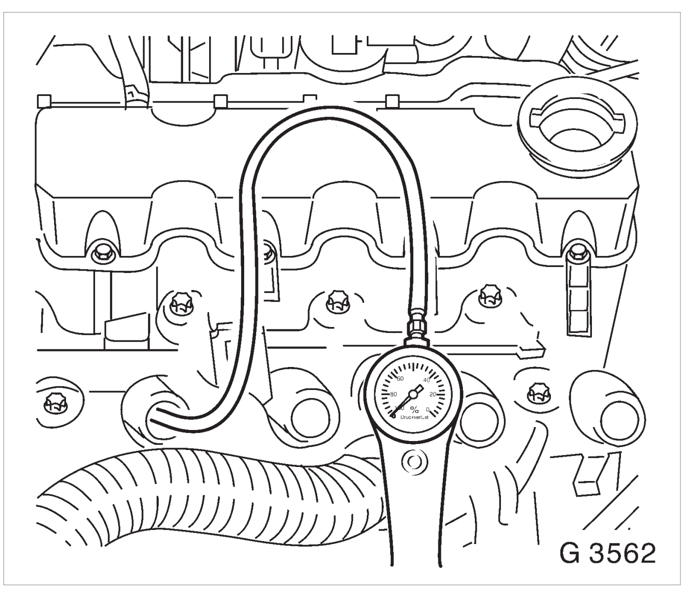
Remove fluid filler opening sealing cap, coolant compensation tank sealing cap and oil dipstick.

Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Adjust

Set piston of 1st cylinder to TDC position. To determine TDC position – see operation ”Timing, Check”.



Install, Connect

Connect pressure loss tester to compressed air system and calibrate.

Screw connector into spark plug bore of 1st cylinder and connect pressure loss tester with connector (observe manufacturer’s instructions).

Important!

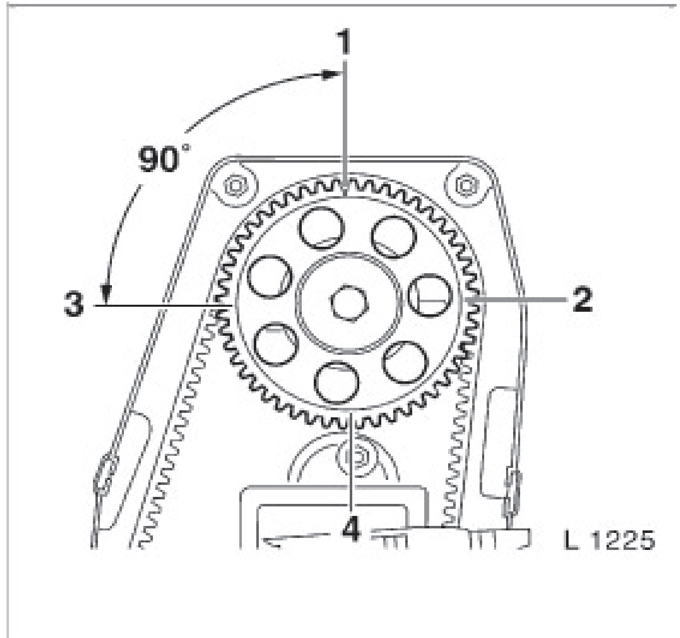
The crankshaft is not permitted to rotate during the test procedure.

Inspect

Air outlet at: inlet or exhaust side, compensation tank and crankcase housing. Max. difference in pressure between individual cylinders: 10%. The max. pres-sure loss of a cylinder should not exceed 25%.

Check pressure loss at 3rd, 4th and 2nd cylinders analogously. Bring piston of cylinder to be checked in ”ign. TDC” position, ignition sequence: 1–3–4–2. De-termine ”ign. TDC” position by placing guide marks on camshaft sprocket. Fur-ther

turn crankshaft 180° in engine rotational direction (corresponds to 90° at camshaft sprocket) up to camshaft sprocket guide mark and align toothed belt cover. Determine the ”ign. TDC” position for 4th and 2nd cylinders analogously. Turn crankshaft slowly and uniformly.



Install, Connect

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.

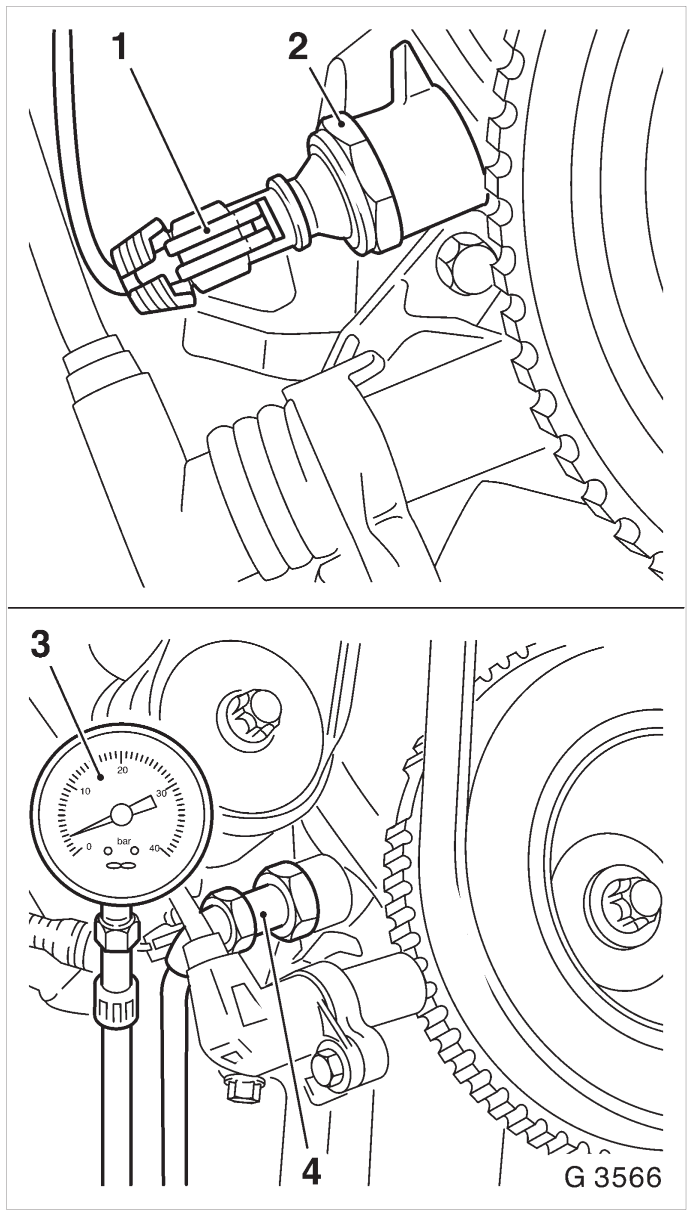
Install spark plugs in cylinder head using KM–194–E – tightening torque 25 Nm / 18.5 lbf. ft.

Attach spark plug connector, fluid filler opening sealing cap, coolant compensation tank sealing cap and oil dipstick.

Oil Pressure, Check

Remove, Disconnect

Disconnect wiring harness plug (1) from oil pressure switch, remove oil pressure switch (2) – place collecting basin underneath.



Inspect

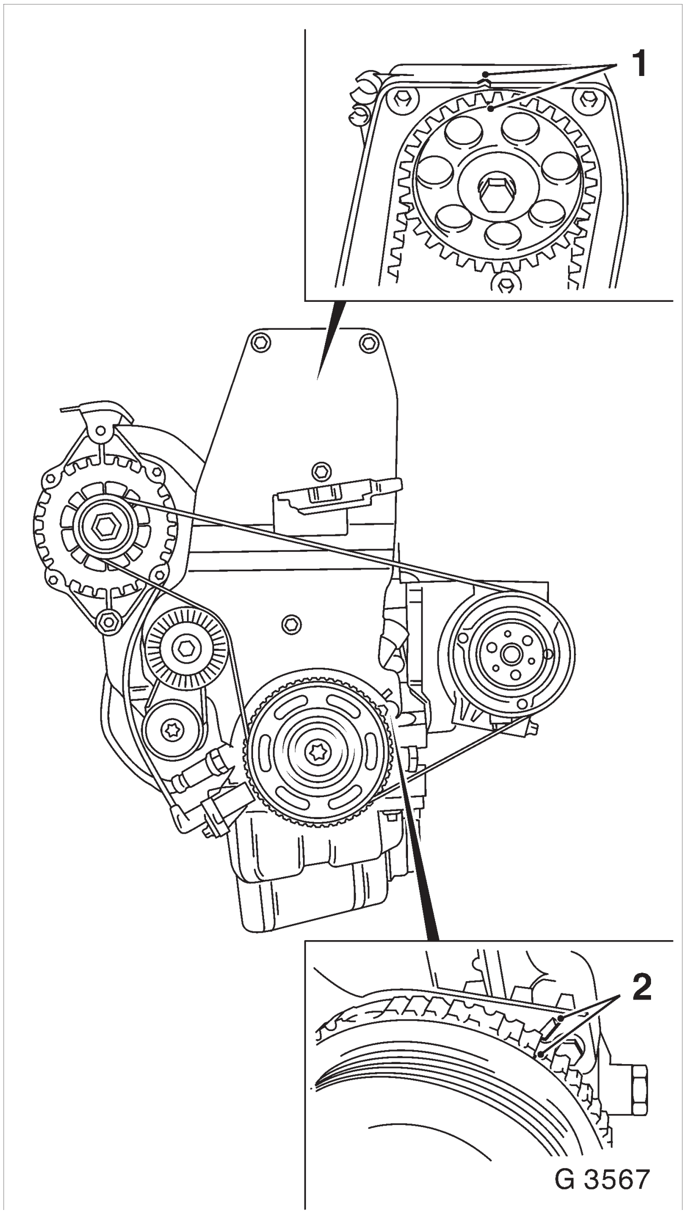
Check oil pressure with KM–498–B (3) and KM–135 (4). The oil pressure should be approx. 150 kPa (22 PSI) at idling speed with an oil temperature of.80 °C.

Install, Connect

Attach oil pressure switch to oil pump with new seal ring – tightening torque 30 Nm / 22 lbf. ft.

Connect wiring harness plug to oil pressure switch.

Check engine oil level and correct if necessary.



Timing, Check

Remove, Disconnect

Disconnect ground cable from battery.
Remove air cleaner housing with air intake cover.
Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Inspect

At fastening bolt of toothed belt drive gear, turn crankshaft in engine rotational direction to ”1st cylinder TDC” (marking 2). At the same time, notches (1) on camshaft pulley and rear toothed belt cover must align. Turn crankshaft slowly and uniformly.
If the timing marks do not align – see operation ”Timing, Adjust”.

Install, Connect

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Install air cleaner housing with air intake cover.
Connect ground cable to battery.

Timing, Adjust

Note:

Adjustment is carried out with the engine cold – at room temperature.

Remove, Disconnect

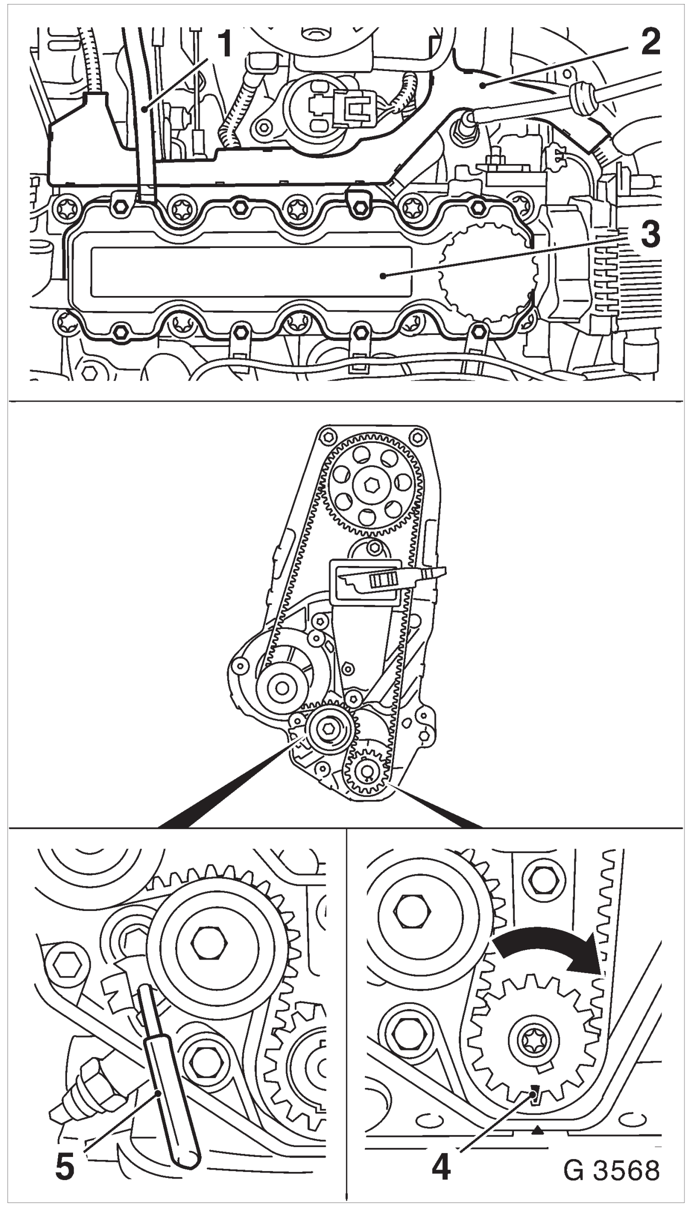
Disconnect ground cable from battery.
Remove air cleaner housing with air intake cover.
Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.
Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Remove, Disconnect

Remove engine PCV vacuum hose (1) from camshaft housing cover.

Remove wiring trough (2) from camshaft housing cover.

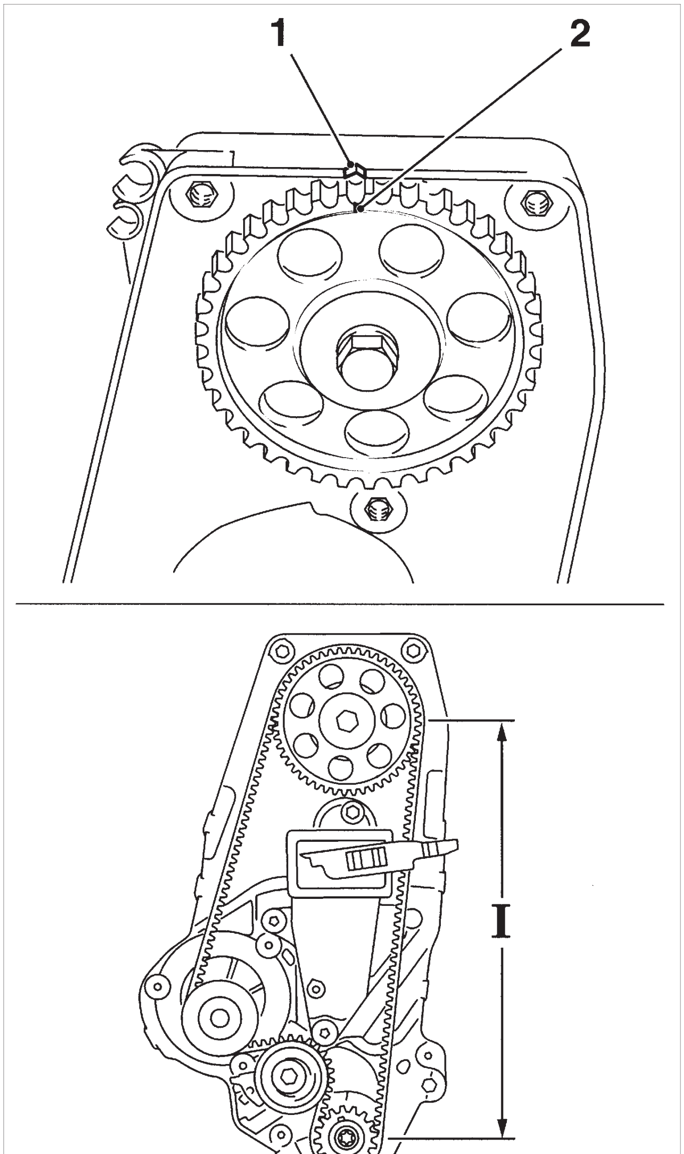
Remove camshaft housing cover (3) from camshaft housing.



Adjust

Screw fastening bolt for toothed belt drive gear into crankshaft and turn crankshaft in engine rotational direction until pointer (4) on toothed belt drive gear is flush with mark on oil pump housing.

Move toothed belt tension roller against spring force upward until bore holes align. Fix toothed belt tension roller in place with suitable drift (5). Mark running direction (front edge) of toothed belt and remove toothed belt.



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Adjust

At hex of camshaft, turn camshaft sprocket (short way) to mark. Notch (2) on camshaft sprocket must align with mark (1) on rear toothed belt cover.

Install, Connect

Attach toothed belt – ensure that tension side (I) is taut.
Note running direction of toothed belt.
Remove drift from toothed belt tension roller.
Adjust toothed belt tension – see operation ”Toothed Belt Tension, Adjust”.
Install camshaft housing cover at camshaft housing – tightening torque 8 Nm / 6 lbf. ft.
Attach wiring trough to camshaft housing – tightening torque 8 Nm / 6 lbf. ft.
Attach engine vacuum hose to camshaft housing cover.

Remove, Disconnect

Remove fastening bolt from toothed belt drive gear.

Install, Disconnect

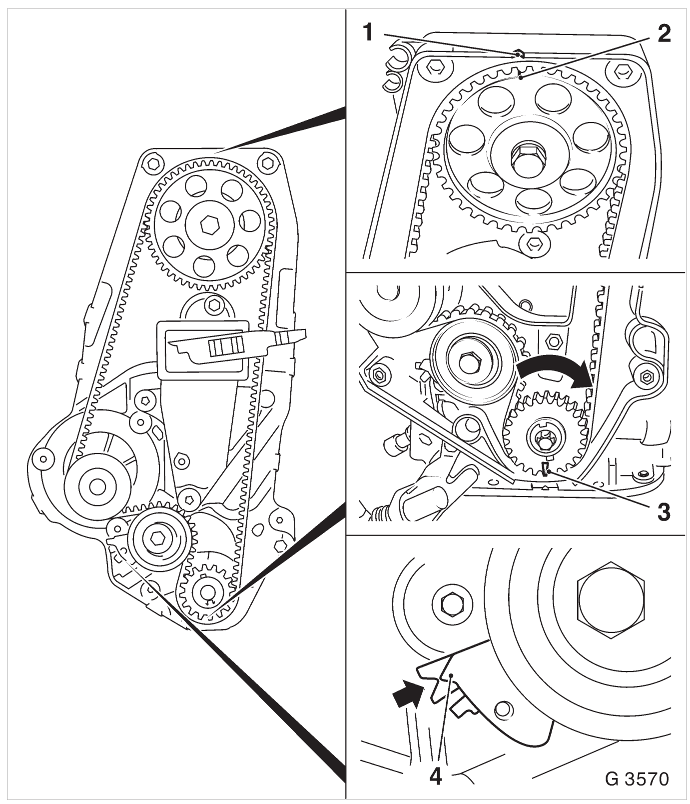
Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.
Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Install air cleaner housing with air intake cover.
Connect ground cable to battery.

Toothed Belt Tension, Check

Note:
Testing is performed with the engine cold – at room temperature.

Remove, Disconnect
Disconnect ground cable from battery.
Remove air cleaner housing with air intake cover
Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.
Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Remove, Disconnect
Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.



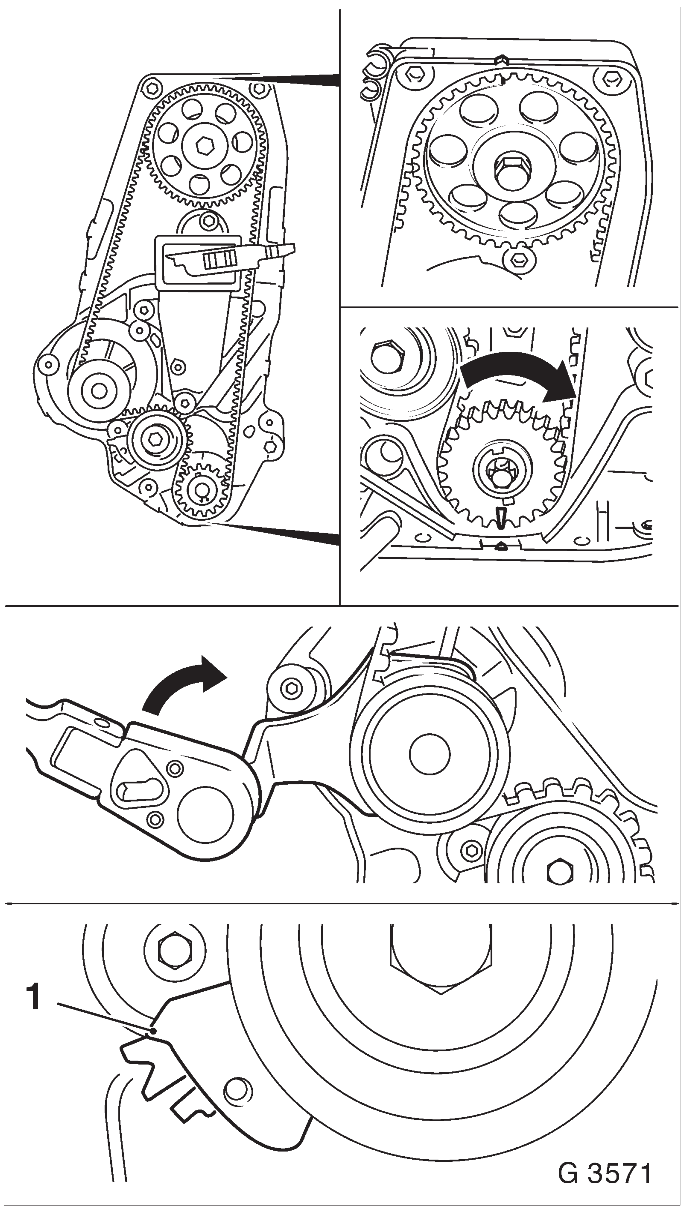
Adjust
Screw fastening bolts of toothed belt drive gear into crankshaft and turn crankshaft in engine rotational direction until pointer (3) aligns with mark on oil pump housing. At the same time, notch (2) on camshaft pulley must be aligned with mark (1) on rear toothed belt cover.

Inspect
The toothed belt tension is correctly adjusted when the pointer (4) of the movable part of the toothed belt tension roller aligns with notch (arrow).

Inspect
If the toothed belt tension is not correctly adjusted – see operation ”Toothed Belt Tension, Adjust”.

Remove, Disconnect
Remove fastening bolt from toothed belt drive gear.
Install, Disconnect

Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.
Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Install air cleaner housing with air intake cover.
Connect ground cable to battery.



Toothed Belt Tension, Adjust

Note:
Testing is performed with the engine cold – at room temperature.

Remove, Disconnect
Remove air cleaner housing with air intake cover
Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.
Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

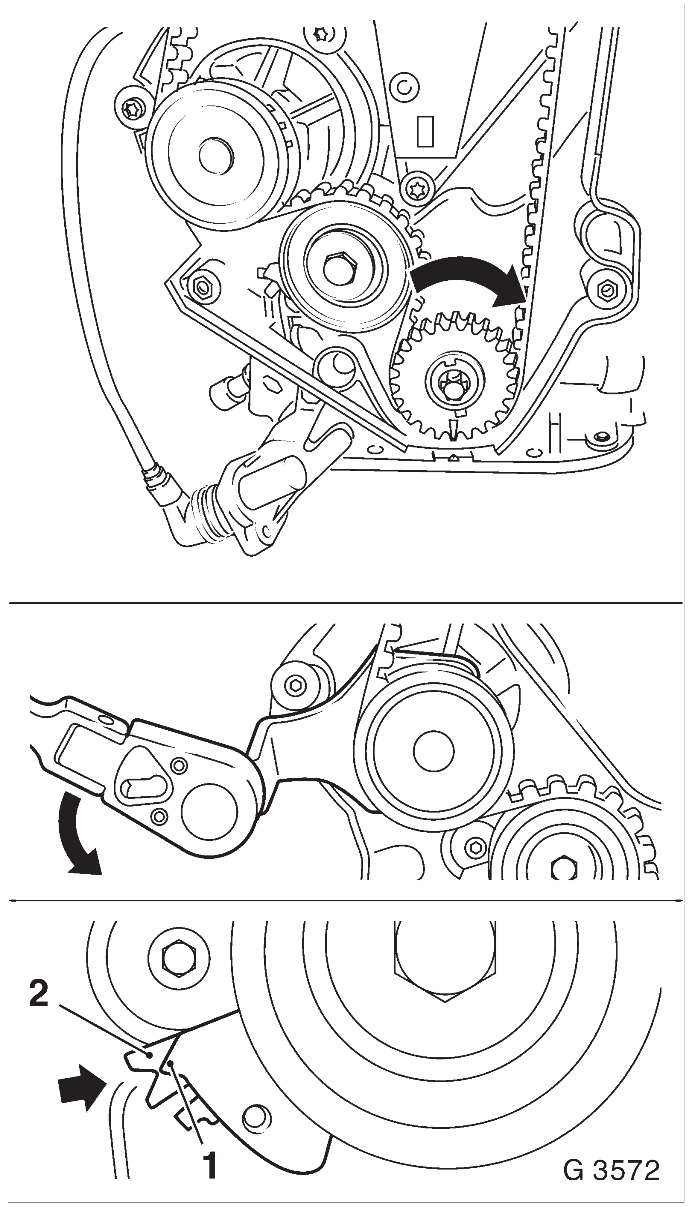
Remove, Disconnect
Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Adjust
Screw fastening bolt for toothed belt drive gear into crankshaft and turn crankshaft in engine rotational direction until pointer on toothed belt drive gear is flush with mark on oil pump housing. At the same time, notch on camshaft pulley must be flush with mark on rear toothed belt cover.
Release fastening bolts for coolant pump. Tension toothed belt by turning coolant pump in direction of arrow (clockwise) with KM–421–A until pointer (1) is at right stop.

Adjust

Turn crankshaft two revolutions (720°) in engine rotational direction, until timing marks align. Turn crankshaft slowly and uniformly and do not change position of coolant pump.

Reduce toothed belt tension by turning coolant pump in direction of arrow with KM–421–A until pointer (1) and notch (2) on toothed belt tension roller carrier plate align. Set crankshaft another two revolutions (720°) in engine rotational direction to mark ”1st cylinder ignition TDC” and check adjustment of toothed belt tension roller. If marks do not align, repeat adjustment procedure.



Tighten (Torque)

Coolant pump to cylinder block – tightening torque 8 Nm / 6 lbf. ft.

Install, Connect

Remove fastening bolt from toothed belt drive gear and install toothed belt cover, lower part – see operation ”Toothed Belt Cover, Lower Part, Remove and Install”.

Install, Connect

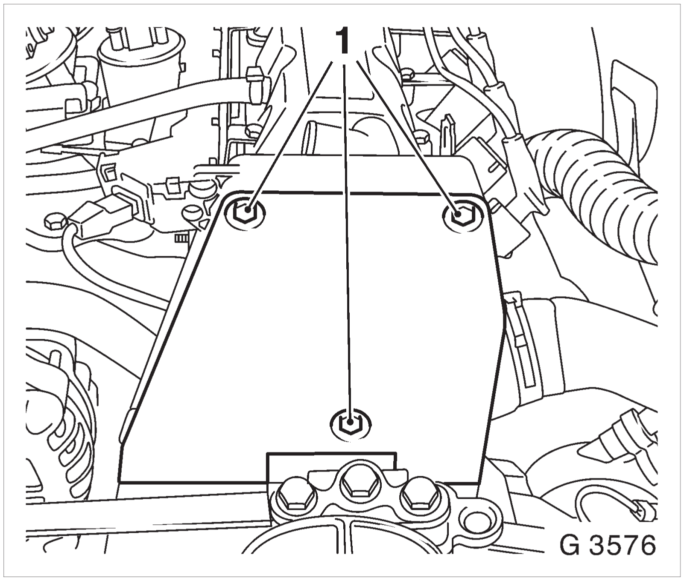
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.

Check cooling system for leaks.



Toothed Belt Cover, Upper Part, Remove and Install

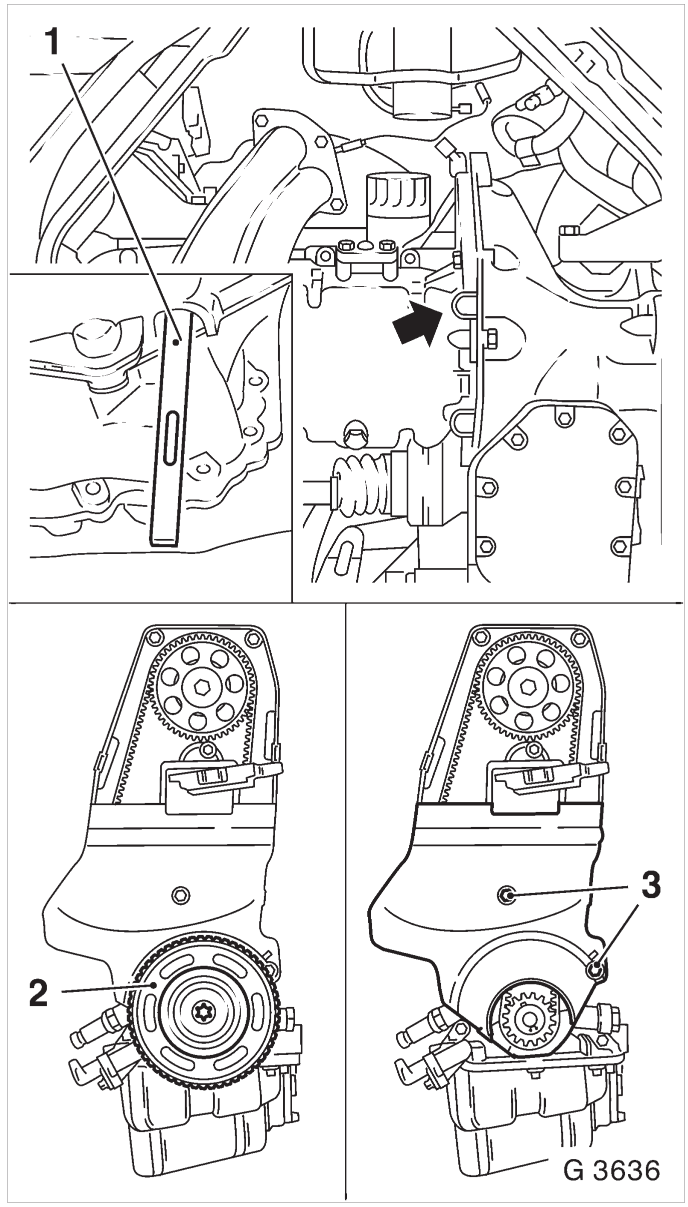
Remove, Disconnect

Remove air cleaner housing with air intake cover.
Remove fastening bolts (1) and remove upper part of toothed belt cover from rear toothed belt cover.

Install, Connect

Attach upper part of toothed belt cover to rear toothed belt cover – tightening torque 4 Nm / 3 lbf. ft.
Install air cleaner housing with air intake cover.

Toothed Belt Cover, Lower Part, Remove and Install

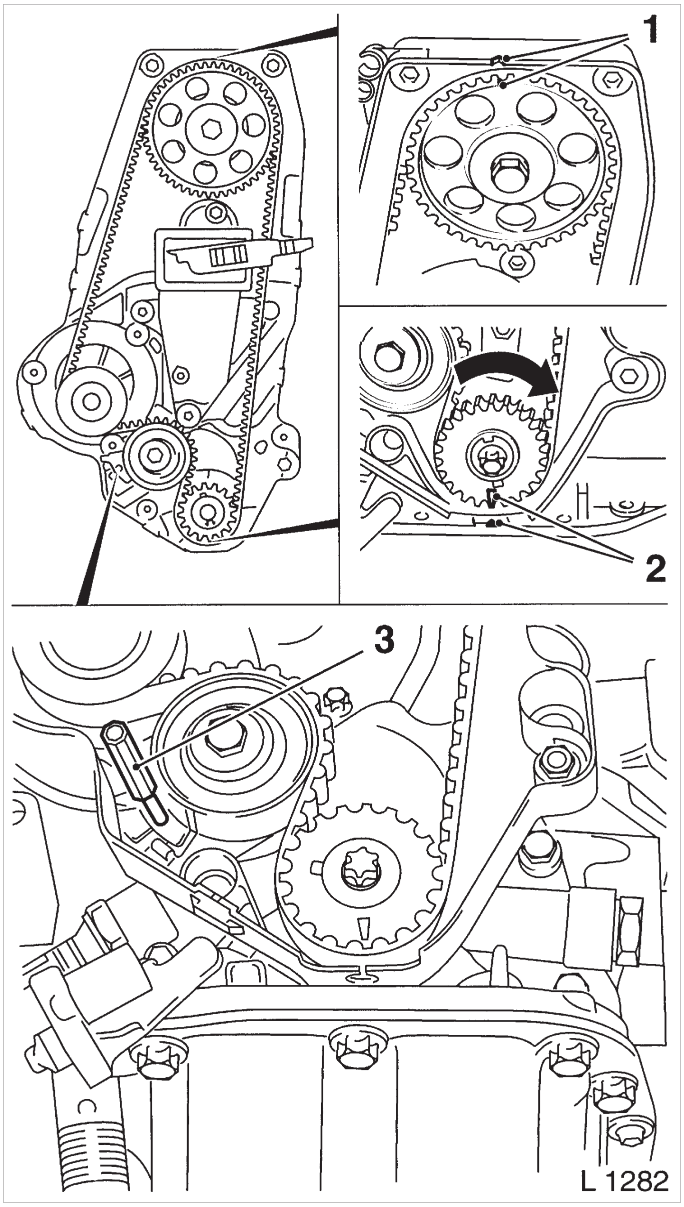


Remove, Disconnect

Remove air cleaner housing with air intake cover.
Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.
Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Lock drive disk or flywheel with KM–911 (1).
Detach crankshaft pulley/reluctor wheel (2) from crankshaft.
Remove fastening bolts (3) and remove lower part of toothed belt cover from rear toothed belt cover.

Install, Connect

Attach lower part of toothed belt cover to rear toothed belt cover – tightening torque 4 Nm / 3 lbf. ft.
Attach crankshaft pulley/reluctor wheel with new fastening bolt to crankshaft – tightening torque 95 Nm / 70 lbf. ft. + 30° + 15°.
Remove Locking Tool KM–911.
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.
Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Install air cleaner housing with air intake cover.



Toothed Belt, Remove and Install

Remove, Disconnect

Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Adjust

Screw fastening bolt for toothed belt drive gear into crankshaft and turn crankshaft in engine rotational direction until marks (2) on toothed belt drive gear and oil pump housing are flush.

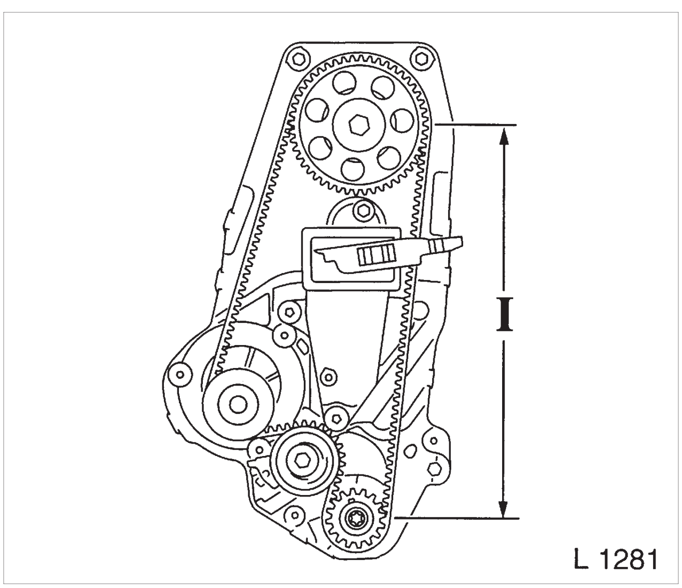
At the same time, notches (1) on camshaft pulley and rear toothed belt cover must be flush.

Turn crankshaft slowly and smoothly.

Remove, Disconnect

Move toothed belt tension roller upward against spring force until bore holes align. Fix toothed belt tension roller in place with suitable drift (3).

Mark running direction (front edge) of the toothed belt for identification and remove toothed belt.



Install, Connect

Check toothed belt for wear – replace if necessary.

Install toothed belt – ensure that tensioned side (I) is taut.

Observe timing marks. Adjust toothed belt tension – see operation ”Toothed Belt Tension, Adjust”.

Install, Connect

Remove fastening bolt from toothed belt drive gear and install toothed belt cover, lower part – see operation ”Toothed Belt Cover, Lower Part, Remove and Install”.

Install, Connect

Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.

Toothed Belt Tension Roller, Remove and Install

Remove, Disconnect

Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

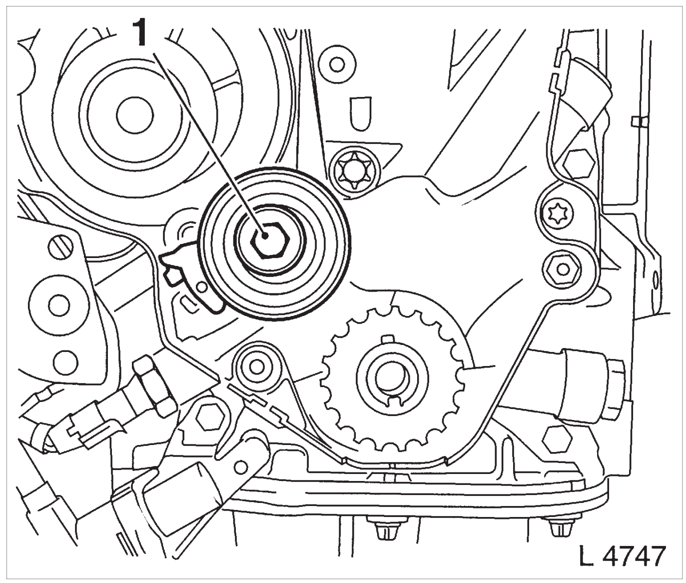
Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

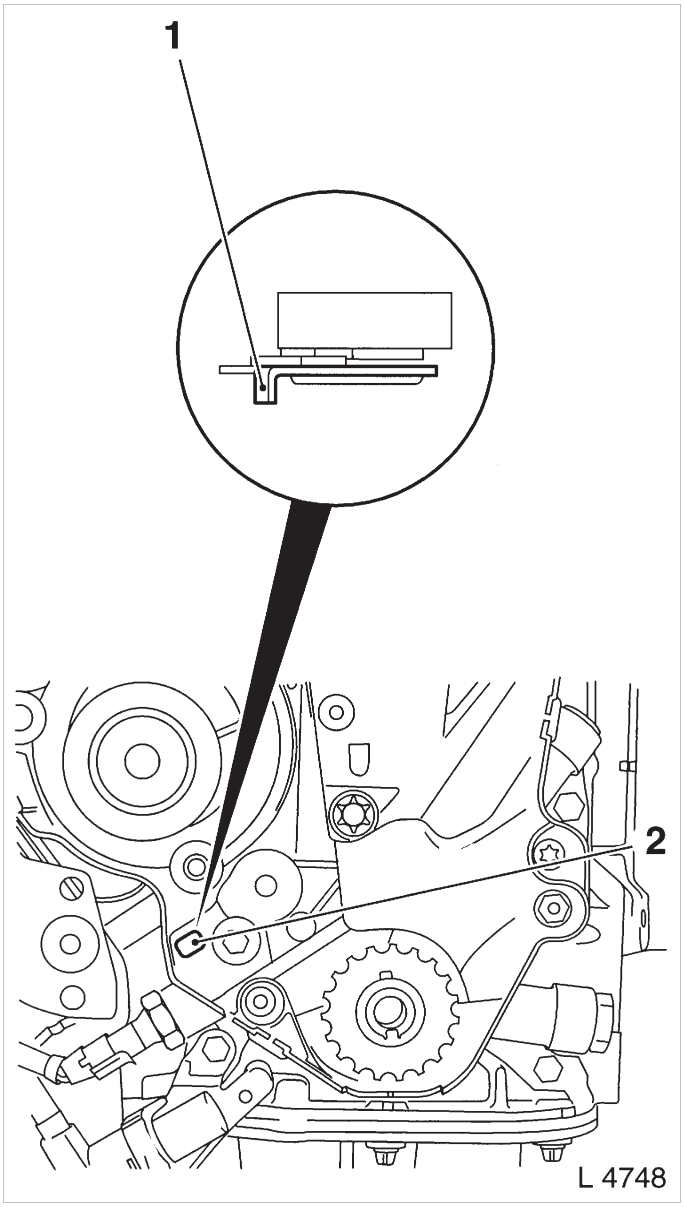
Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Remove toothed belt – see operation ”Toothed Belt, Remove and Install”.

Remove toothed belt tension roller (1) from oil pump.





Install, Connect

Install toothed belt tension roller – make sure that lug (1) of toothed belt tension roller base plate engages in groove (2) of oil pump.

Attach toothed belt tension roller to oil pump – tightening torque 20 Nm / 15 lbf. ft.

Install toothed belt – see operation ”Toothed Belt, Remove and Install”.

Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Install, Connect

Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.

Seal Ring in Front Camshaft Housing, Replace

Remove, Disconnect

Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Remove toothed belt – see operation ”Toothed Belt, Remove and Install”.

Remove, Disconnect

Remove engine vent hose from camshaft housing cover.

Detach wiring trough from camshaft housing cover.

Remove camshaft housing cover from camshaft housing.

Remove camshaft sprocket (1) from camshaft – (hold with open–ended wrench on hex of camshaft).

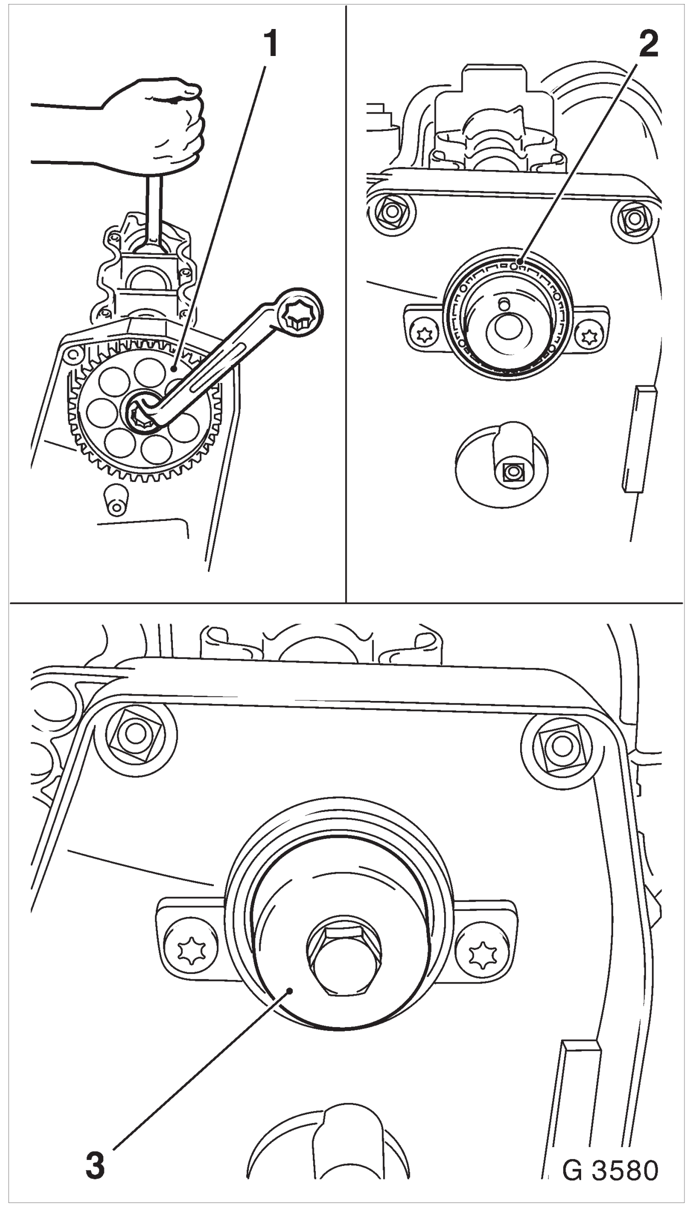
Edge out seal ring (2) with suitable tool.

Important!

Do not damage sealing surfaces.

Install, Connect

Lightly coat sealing lip of seal ring with silicon grease (white). Press seal ring with KM–422 (3) in camshaft housing – use bolt and washer of camshaft pulley.



Install, Connect

Attach camshaft sprocket to camshaft – hold with open–ended wrench on hex of camshaft – tightening torque 45 Nm / 33 lbf. ft.

Install camshaft housing cover at camshaft housing – tightening torque 8 Nm / 6 lbf. ft.

Attach engine vacuum hose to camshaft housing cover.

Install toothed belt – see operation ”Toothed Belt, Remove and Install”.

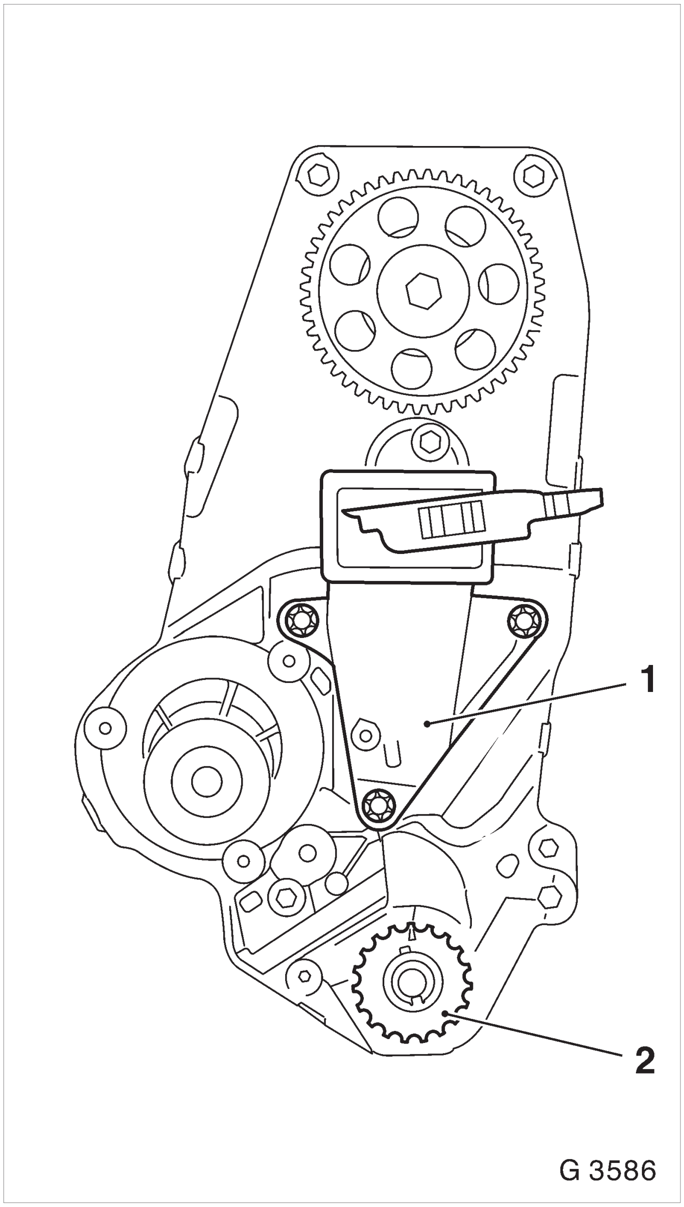
Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.



Rear Toothed Belt Cover, Remove and Install

Remove, Disconnect

Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

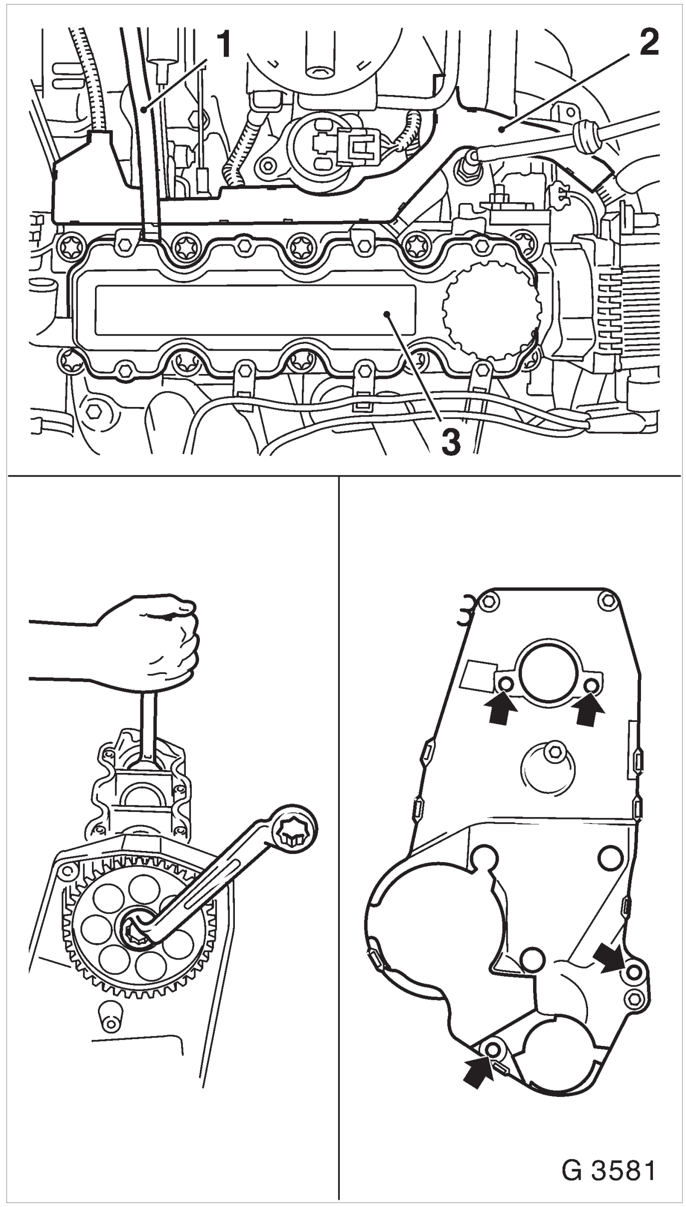
Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Remove toothed belt – see operation ”Toothed Belt, Remove and Install”.

Remove toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.

Remove toothed belt drive gear (2) from crankshaft.

Detach engine damping block support (1) from cylinder block.



Remove, Disconnect

- Remove engine vacuum hose (1) from camshaft housing cover.
- Remove camshaft housing cover (3) from camshaft housing.
- Remove camshaft sprocket – hold with open–ended wrench on hex of camshaft.
- Unclip cable for crankshaft position sensor from rear toothed belt cover.
- Remove rear toothed belt cover (arrows) from oil pump and camshaft housing.

Install, Connect

- Attach rear toothed belt cover to oil pump and camshaft housing – tightening torque 6 Nm / 4 lbf. ft.

Install, Connect

Clip cable for crankshaft position sensor to rear toothed belt cover – note cable routing.

Attach camshaft sprocket to camshaft – hold with open–ended wrench on hex of camshaft – tightening torque 45 Nm / 33 lbf. ft.

Install camshaft housing cover at camshaft housing – tightening torque 8 Nm / 6 lbf. ft.

Attach engine vacuum hose to camshaft housing cover.

Attach engine damping block support to cylinder block – tightening torque 50 Nm / 37 lbf. ft.

Slide toothed belt drive gear onto crankshaft journal – note installation position.

Install toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.

Install toothed belt – see operation ”Toothed Belt, Remove and Install”.

Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

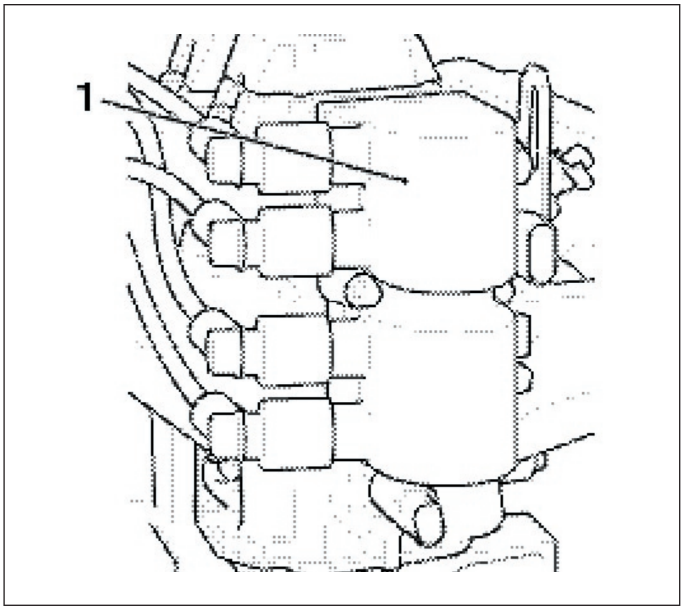
Install, Connect

Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.



Seal Ring in Rear Camshaft Housing, Replace

Remove, Disconnect

Remove DIS ignition module (1). Remove carrier plate (2) from camshaft housing.

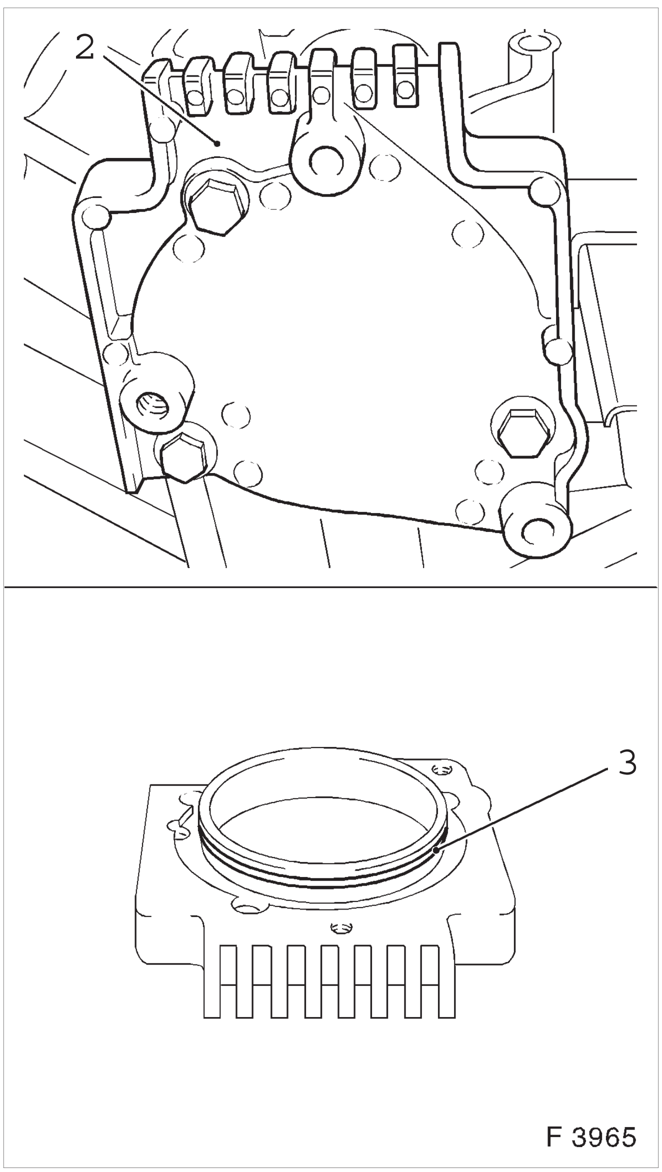
Clean

Clean sealing surfaces and remove gasket remnants.

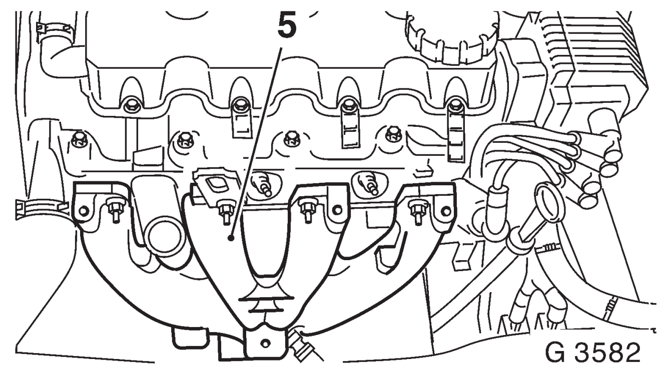
Install, Connect

Coat seal ring (3) of carrier plate with silicone grease (white) and attach carrier plate to camshaft housing – tightening torque 12 Nm / 9 lbf. ft.

Install DIS ignition module – tightening torque 12 Nm / 9 lbf. ft.



Exhaust Manifold, Remove and Install



Remove, Disconnect

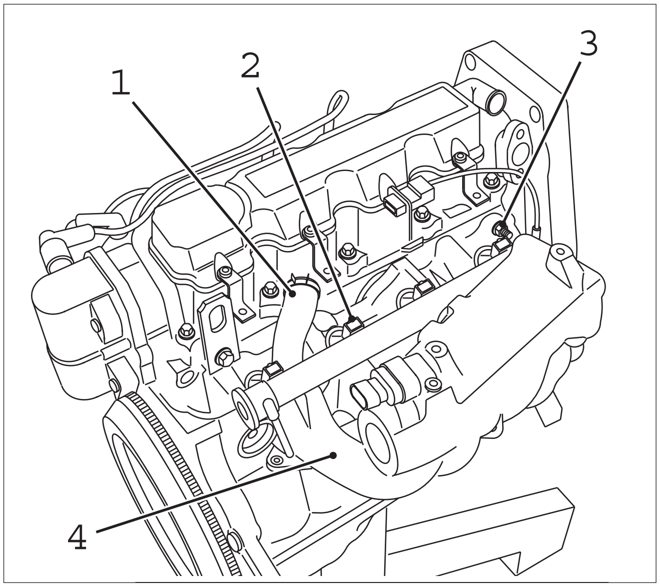
Disconnect spark plug wires from all spark plugs.
Remove exhaust manifold (5) and gasket from cylinder head.

Clean

Clean sealing surfaces and remove gasket remnants.

Install, Connect

Attach exhaust manifold with new gasket and new nuts to cylinder head – tightening torque 22 Nm / 16 lbf. ft.
Connect spark plug wires.



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Intake Manifold, Remove and Install

Important!

Fuel leak – observe safety regulations and national legislation. Reduce fuel pressure with Pressure Tester KM–J–34730–91 via testing port – collect escaping fuel in suitable container.

Remove, Disconnect

Disconnect ground cable from battery.
Open coolant drain bolt – collect escaping coolant. Drain cooling system.
Remove engine vent hoses and from camshaft housing cover. Remove coolant hose from intake (1).
Remove air cleaner housing and air intake hose. Remove fuel lines and harness from fuel injectors (2).
Remove intake manifold nuts (3).
Remove intake manifold and gasket (4).

Clean

Clean sealing surfaces and remove gasket remnants.

Install, Connect

Attach inlet manifold with new gasket to cylinder head – tightening torque 22 Nm / 16 lbf. ft.
Attach fuel lines.
Attach coolant hose to intake manifold.
Connect wiring harness plug to injectors.

Install, Connect

Install air cleaner housing with air intake hose.

Attach engine vent hoses to camshaft housing cover.

Close coolant drain bolt. Connect ground cable to battery.

Refill cooling system and purge air from system.

Camshaft and Cam Follower, Remove and Install (Cylinder Head Installed)

Remove, Disconnect

Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

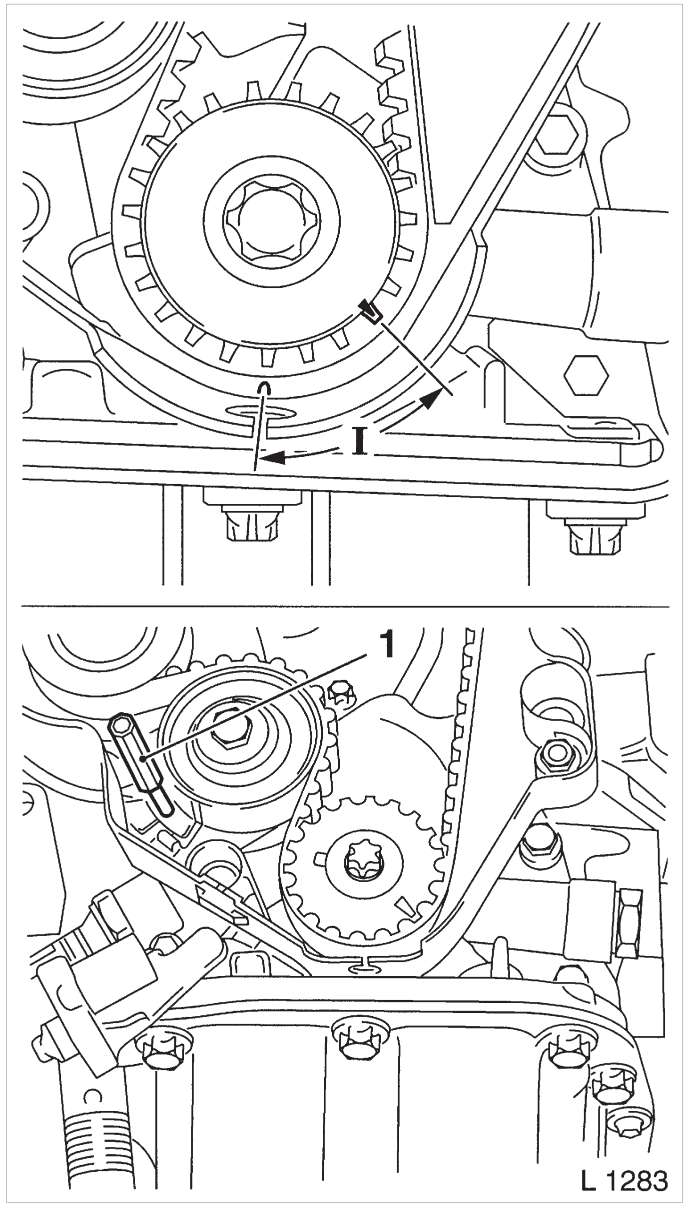
Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Important!

Before dismantling the toothed belt – screw fastening bolt for toothed belt drive gear into crankshaft and move crankshaft in engine rotational direction by 60° (dimension I) to before TDC mark.

Remove, Disconnect

Move toothed belt tension roller upward against spring force until bore holes align. Fix toothed belt tension roller in place with suitable drift (1).



Remove, Disconnect

Remove toothed belt from camshaft sprocket.

Remove camshaft sprocket – see operation ”Seal Ring in Front Camshaft Housing, Replace”.

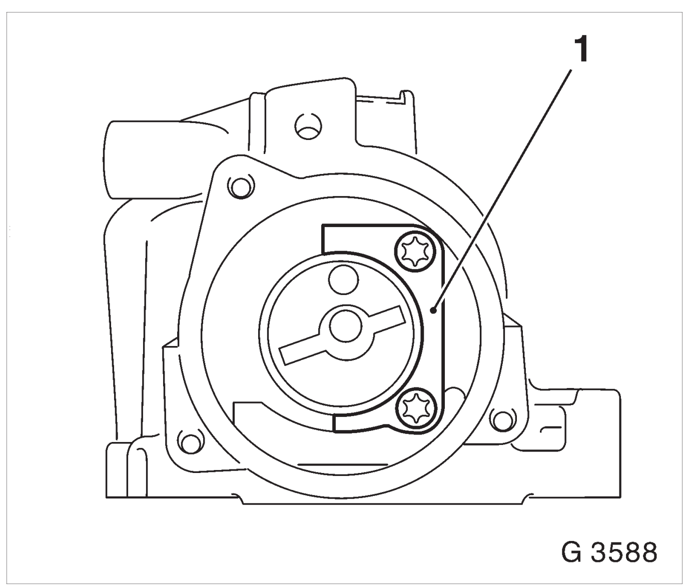
Remove DIS ignition module – see operation ”DIS Ignition Module, Remove and Install”.

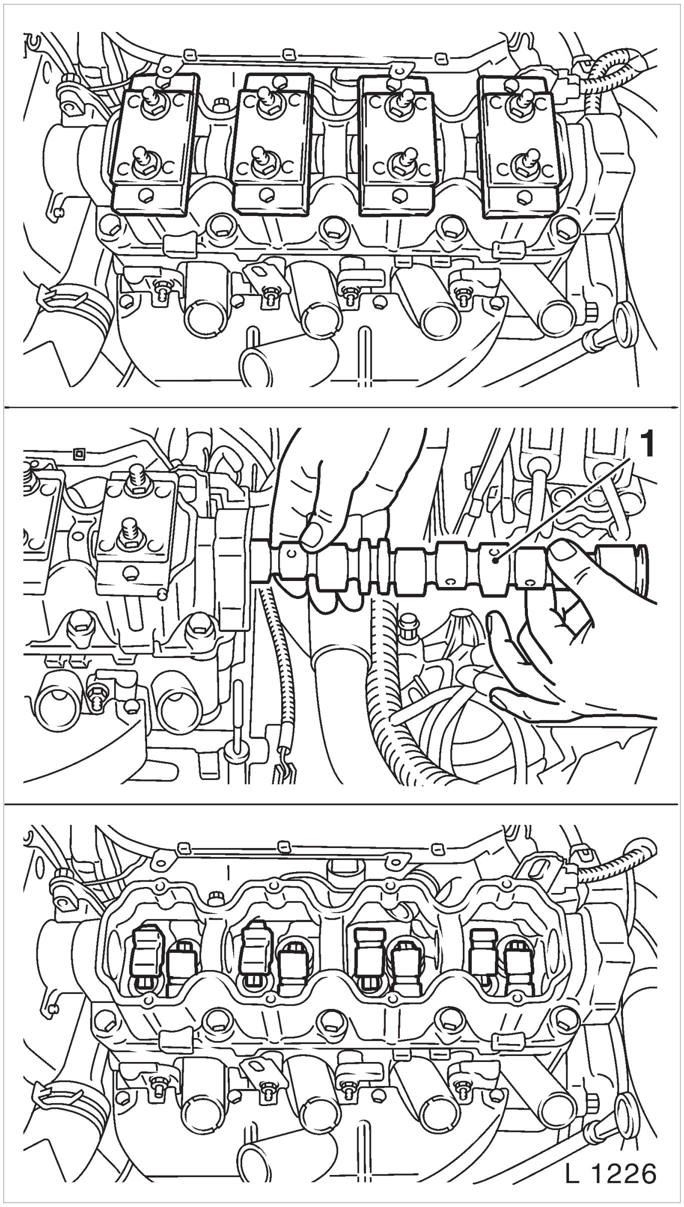
Remove carrier plate from camshaft housing – see operation ”Seal Ring in Rear Camshaft Housing, Replace”.

Remove pressure plate (1) from camshaft housing.

Important!

Cover oil return bore holes in cylinder head during assembly so thrust pieces cannot fall in.





Remove, Disconnect

Attach Valve Lifter Depressor MKM–891 to camshaft housing.

Uniformly compress all cam followers. Pull camshaft (1) out of camshaft housing. Release valve lifter depressor and remove from camshaft housing. Remove cam followers and thrust pieces – lay aside in installation position and note layout.

Inspect

Check all parts for damage and wear and replace if necessary. When replacing camshaft all cam followers must be replaced. Prior to installation ensure that crankshaft is 60° before TDC mark.

Install, Connect

Insert thrust pieces and cam followers – note installation position and allocation.

Attach valve lifter depressor onto camshaft housing and press down all cam followers uniformly. Coat sliding surfaces with MoS2 lubricating paste (grey). Insert camshaft in camshaft housing.

Install, Connect

Install pressure plate on camshaft housing – 8 Nm / 6 lbf. ft.

Remove, Disconnect

Release tension in valve lifter depressor and remove from camshaft housing.

Install, Connect

Attach carrier plate to camshaft housing – see operation ”Seal Ring in Rear Camshaft Housing, Replace”.

Attach DIS ignition module – see operation ”DIS Ignition Module, Remove and Install”.

Install camshaft sprocket – see operation ”Seal Ring in Front Camshaft Housing, Replace”.

Important!

Prior to installation of toothed belt, marks on toothed belt drive gear and oil pump housing, as well as notches on camshaft sprocket and rear toothed belt cover, must align – see operation ”Timing, Adjust”.

Install, Connect

Install toothed belt – see operation ”Toothed Belt, Remove and Install”.

Remove fastening bolt from toothed belt drive gear and install toothed belt cover, lower part – see operation ”Toothed Belt Cover, Lower Part, Remove and Install”.

Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.

Hydraulic Valve Lifter, Replace (Cylinder Head Installed)

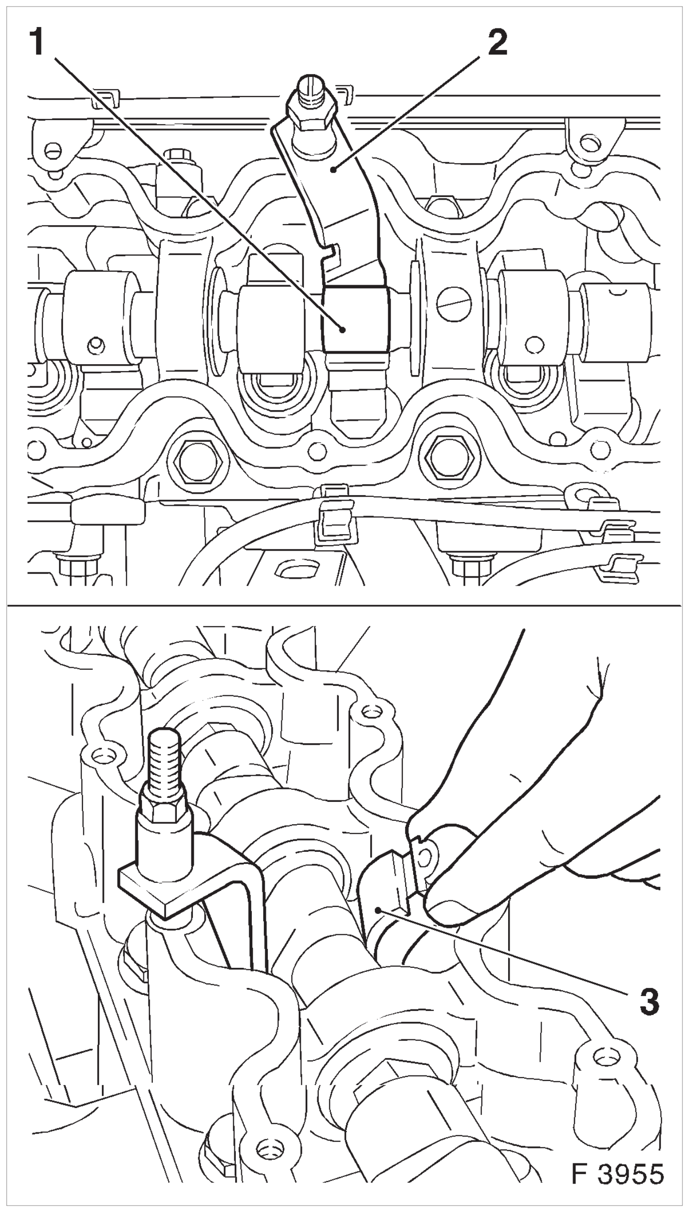
Remove, Disconnect

Remove air intake cover.

Detach engine vent hose from camshaft housing cover.

Detach wiring trough from camshaft housing cover.

Remove camshaft housing cover from camshaft housing.

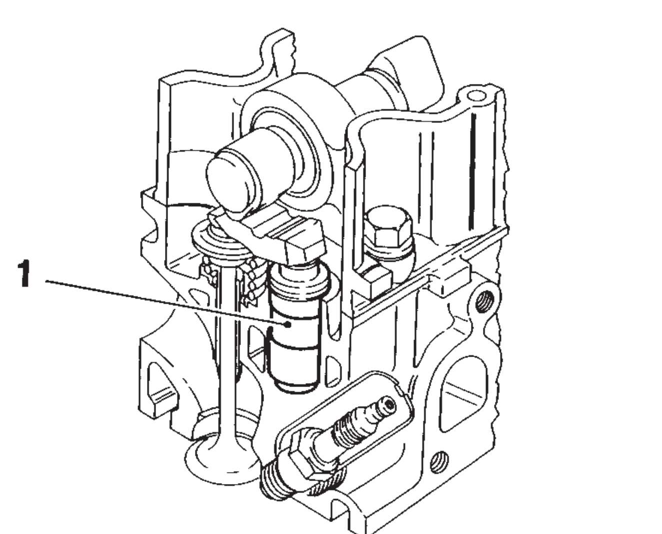


Adjust

At fastening bolt of toothed belt drive gear, turn crankshaft in engine rotational direction until cam (1) of hydraulic valve lifter to be replaced assumes a vertical position.

Remove, Disconnect

Place KM–565–A (2) on camshaft housing and valve head and tension valve spring. Remove cam follower (3) from camshaft housing – note thrust piece. Remove hydraulic valve lifter from camshaft housing.



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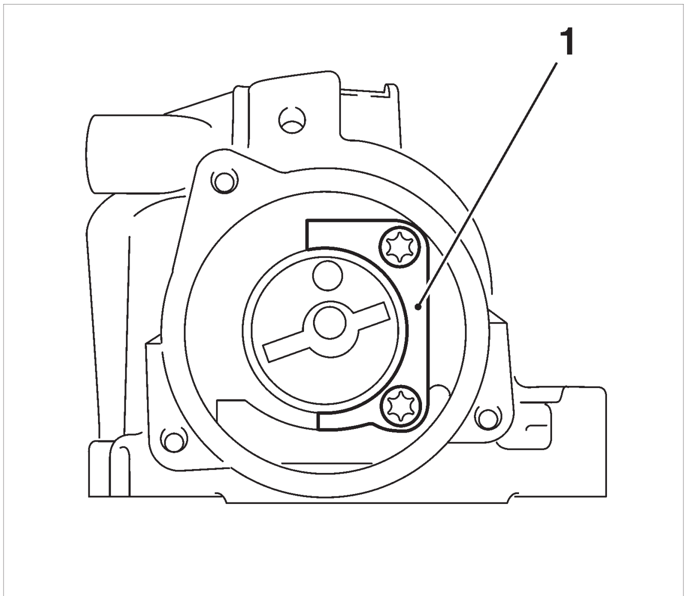

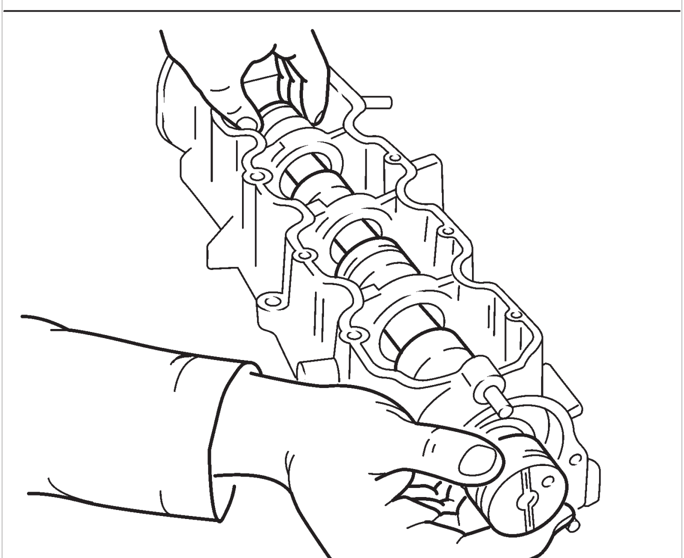

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Install, Connect

Insert hydraulic valve lifter (1) in camshaft housing. Coat sliding surfaces of the rocker arm with MoS2 lubricating paste (grey) and insert in camshaft housing – note thrust piece.

Adjust

Adjustment of the hydraulic valve lifter is no longer required, as pre–tensioning has been taken into account in design.

Install, Connect

Release valve spring and remove KM–565–A.
Install camshaft housing cover at camshaft housing – tightening torque 8 Nm / 6 lbf. ft.
Attach wiring trough to camshaft housing cover – tightening torque 8 Nm / 6 lbf. ft.
Attach engine bleeding hose to camshaft housing cover.

Camshaft, Remove and Install (Cylinder Head Removed)

Remove, Disconnect

Remove DIS ignition module – see operation ”DIS Ignition Module, Remove and Install”.
Remove carrier plate from camshaft housing – see operation ”Seal Ring in Rear Camshaft Housing, Replace”.
Remove pressure plate (1) from camshaft housing.
Remove camshaft from camshaft housing.
Edge front seal ring out of camshaft housing.

Clean

Clean sealing surfaces and remove gasket remnants.

Inspect

Check camshaft housing for damage and wear – see operation ”Camshaft Housing for Plane Surface, Check”. When replacing camshaft, always replace all cam followers.

Install, Connect

Coat sliding surfaces of the camshaft with MoS2 lubricating paste (grey), insert camshaft in camshaft housing.

Install pressure plate on camshaft housing – 8 Nm / 6 lbf. ft.

Lightly coat sealing lip of front seal ring with silicon grease (white). Install new front seal ring with KM–422 in camshaft housing – use bolt and washer of camshaft pulley.

Attach carrier plate to camshaft housing – see operation ”Seal Ring in Rear Camshaft Housing, Replace”.

Attach DIS ignition module – see operation ”DIS Ignition Module, Remove and Install”.

Camshaft Housing, Replace

Remove, Disconnect

Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

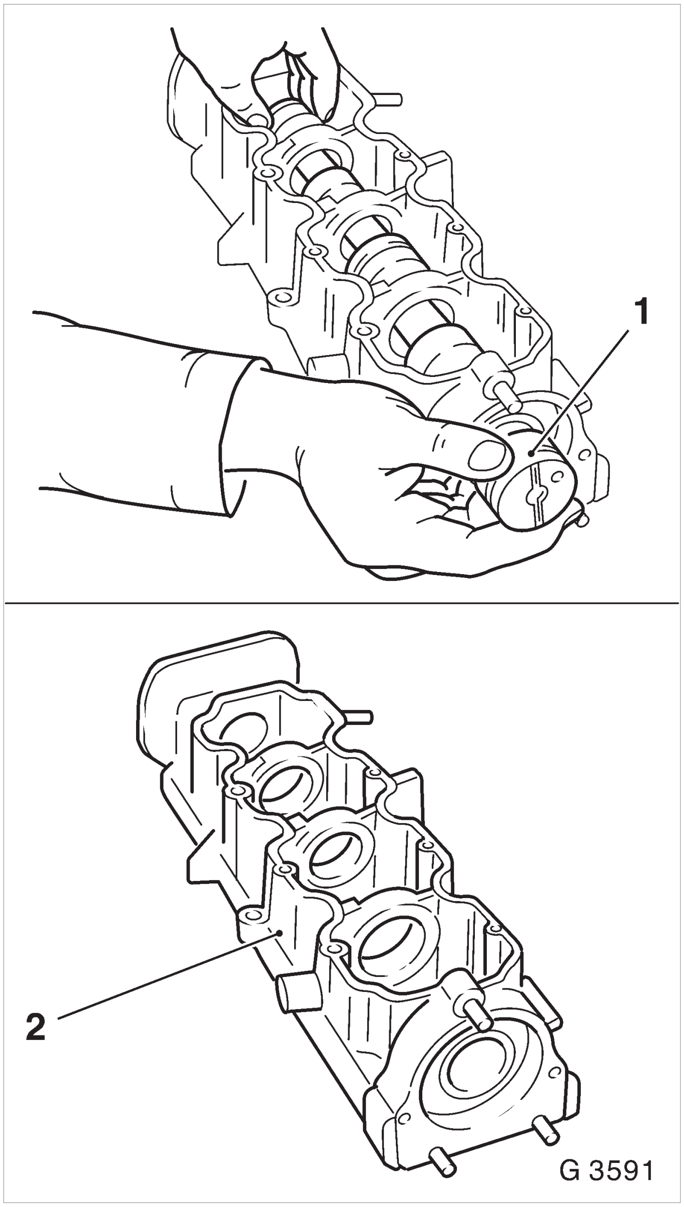
Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Remove toothed belt – see operation ”Toothed Belt, Remove and Install”.

Remove toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.

Rear toothed belt cover – see operation ”Toothed Belt Cover – Rear, Remove and Install”.

Detach or disconnect all wiring harness plugs, ground connections and hose connections from intake manifold ”Intake Manifold, Remove and Install”.



Remove, Disconnect

Remove cylinder head – see operation ”Cylinder Head, Remove and Install”.

Remove DIS ignition module – see operation ”DIS Ignition Module, Remove and Install”.

Remove carrier plate – see operation ”Seal Ring in Rear Camshaft Housing, Replace”.

Remove camshaft (1) – see operation ”Camshaft, Remove and Install (Cylinder Head Removed)”.

Clean

Clean sealing surfaces and bore holes and remove sealant residues.

Inspect

Check camshaft housing (2) for plane surface – see operation ”Camshaft Housing for Plane Surface, Check”.

Install, Connect

Install camshaft – see operation ”Camshaft, Remove and Install (Cylinder Head Removed)”.

Install carrier plate – see operation ”Seal Ring in Rear Camshaft Housing, Replace”.

Install DIS ignition module – see operation ”DIS Ignition Module, Remove and Install”.

Install cylinder head – see operation ”Cylinder Head, Remove and Install”.

Attach or connect all wiring harness plugs, ground connections and hose connections to intake manifold – see operation ”Intake Manifold, Remove and Install”.

Install rear toothed belt cover – see operation ”Toothed Belt Cover – Rear, Remove and Install”.

Install toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.

Install toothed belt – see operation ”Toothed Belt, Remove and Install”.

Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

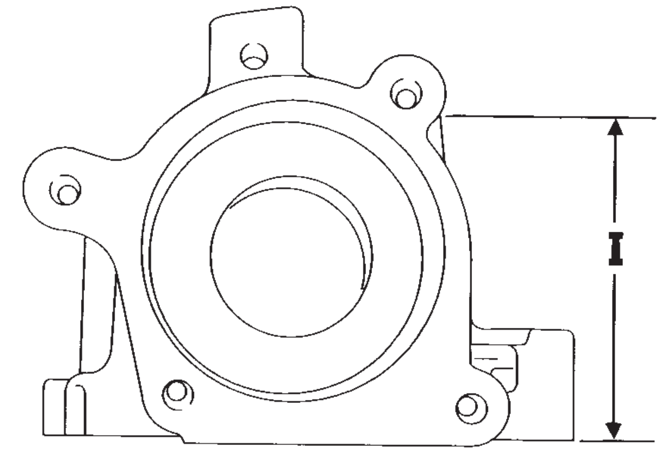
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Install, Connect

Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.



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Camshaft Housing, Check for Plane Surface

Clean

Clean sealing surfaces and remove gasket remnants.

Inspect

Check sealing surfaces in length and width for deformation and check for warping along the diagonals – use straight edge. If deformed or warped, replace camshaft housing.

Measure

Height of camshaft housing (sealing surface to sealing surface).

Dimension I: 66.5 mm

Cylinder Head, Remove and Install

Important!

Remove cylinder head only with cold engine (room temperature).

Remove, Disconnect

Detach battery ground cable.

Open coolant drain bolt – collect escaping coolant.

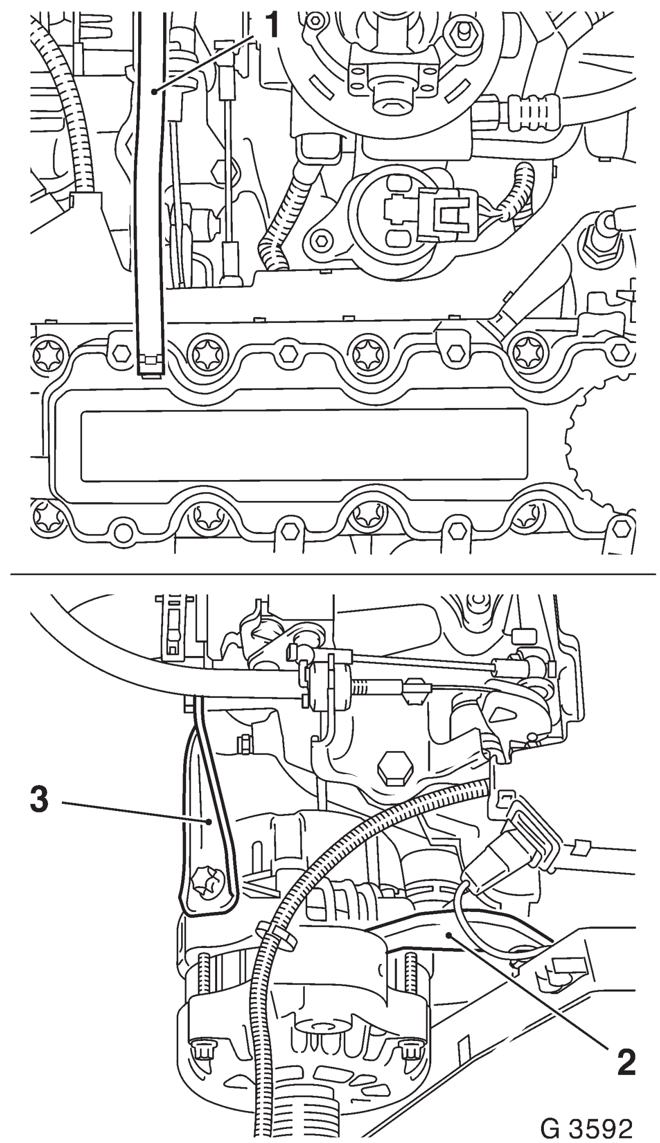
Remove air cleaner housing with air intake cover.

Remove engine vacuum hose (1) from camshaft housing cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

Detach alternator support (3) from alternator and intake manifold. Release alternator from alternator shackle (2) and swing alternator rearwards.



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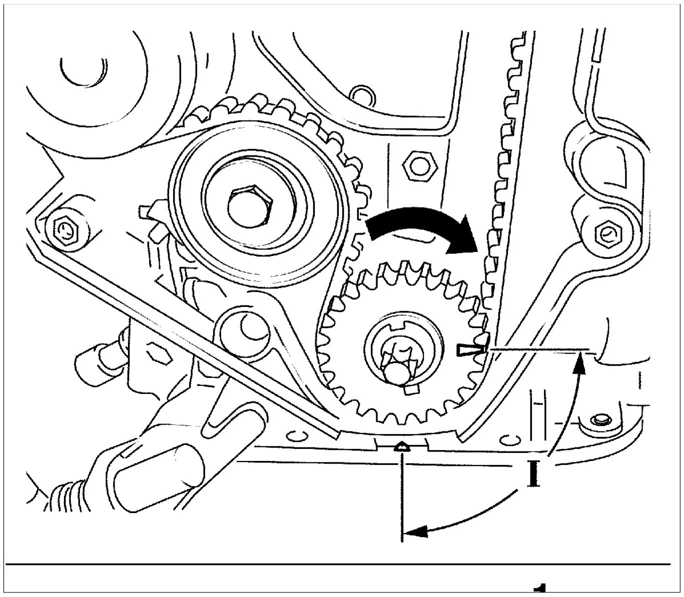
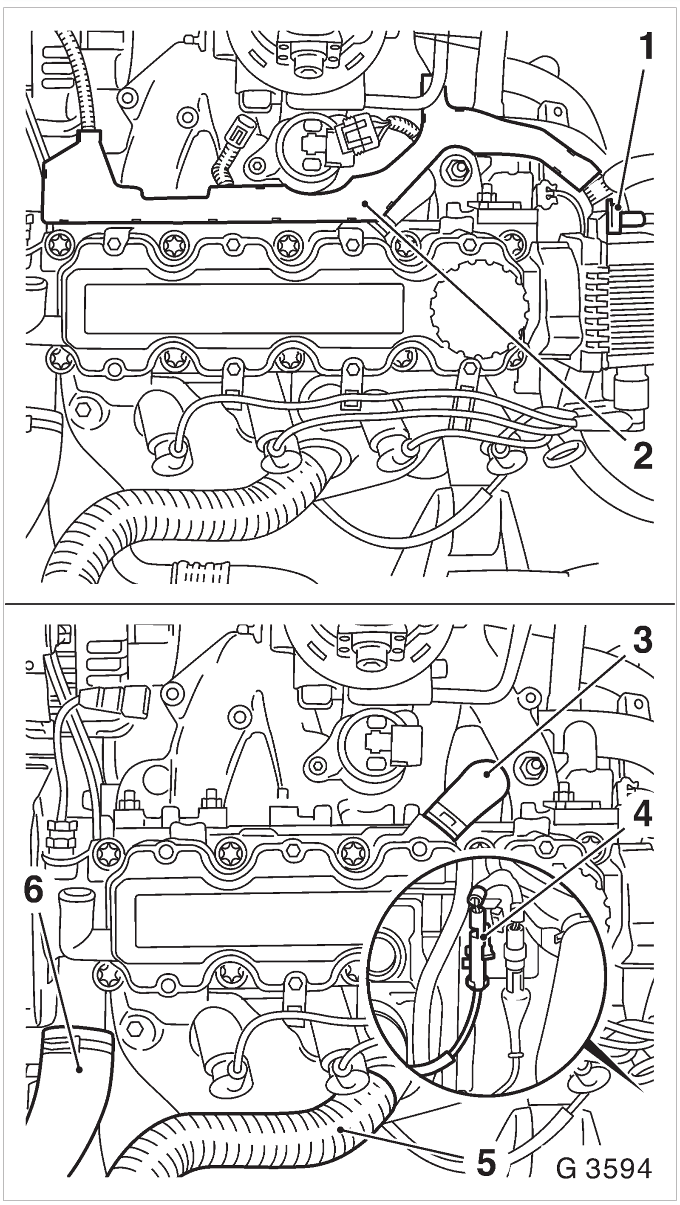


Remove, Disconnect

Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Screw fastening bolt for toothed belt drive gear into crankshaft and move crankshaft in engine rotational direction by 90° (dimension I) to before TDC mark.



Remove, Disconnect

Detach or disconnect all wiring harness plugs, ground connections and hose connections from intake manifold – see operation ”Intake Manifold, Remove and Install”.

Detach wiring harness plug (1) from DIS ignition module and expose wiring harness.

Detach wiring trough (2) from camshaft housing cover and lay aside.

Detach engine vent hose (3) from camshaft housing and engine vent flange and remove.

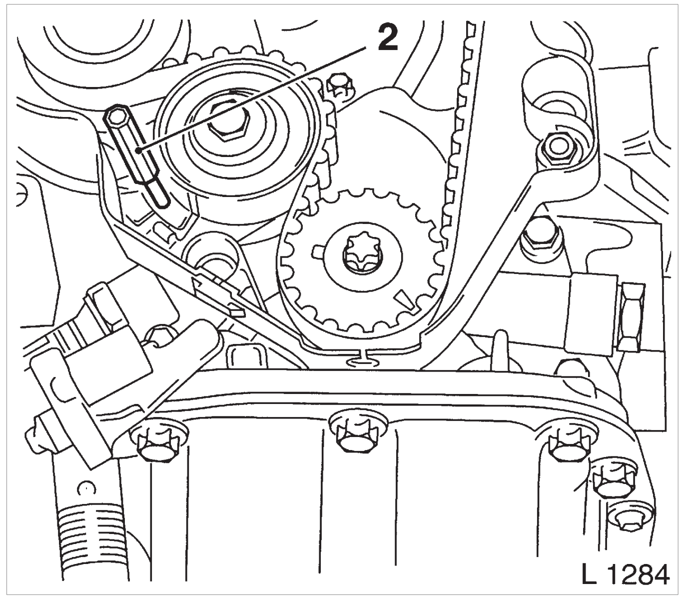
Remove coolant hose (6) from thermostat housing.

Disconnect spark plug connectors.

Remove, Disconnect

Move toothed belt tension roller upwards against spring force until bore holes align. Fix toothed belt tension roller in place with suitable drift (2).

Mark running direction (front edge) of the toothed belt for identification and remove toothed belt.



Remove, Disconnect

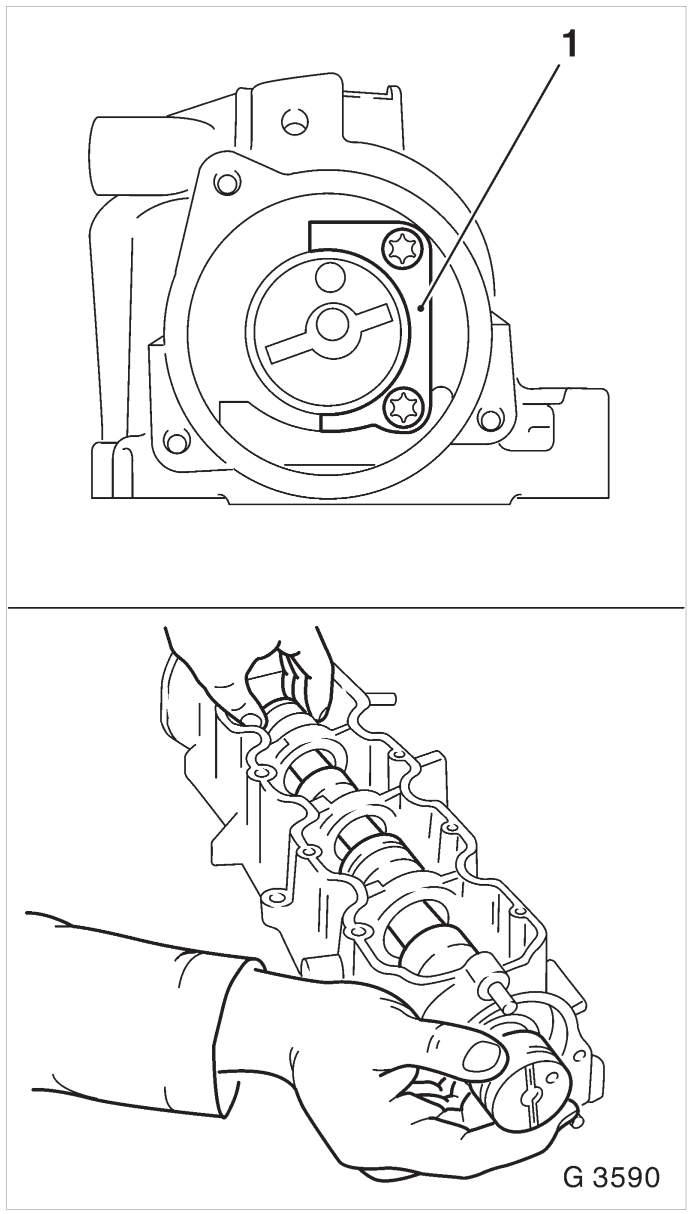
Remove toothed belt tension roller (4) from oil pump.

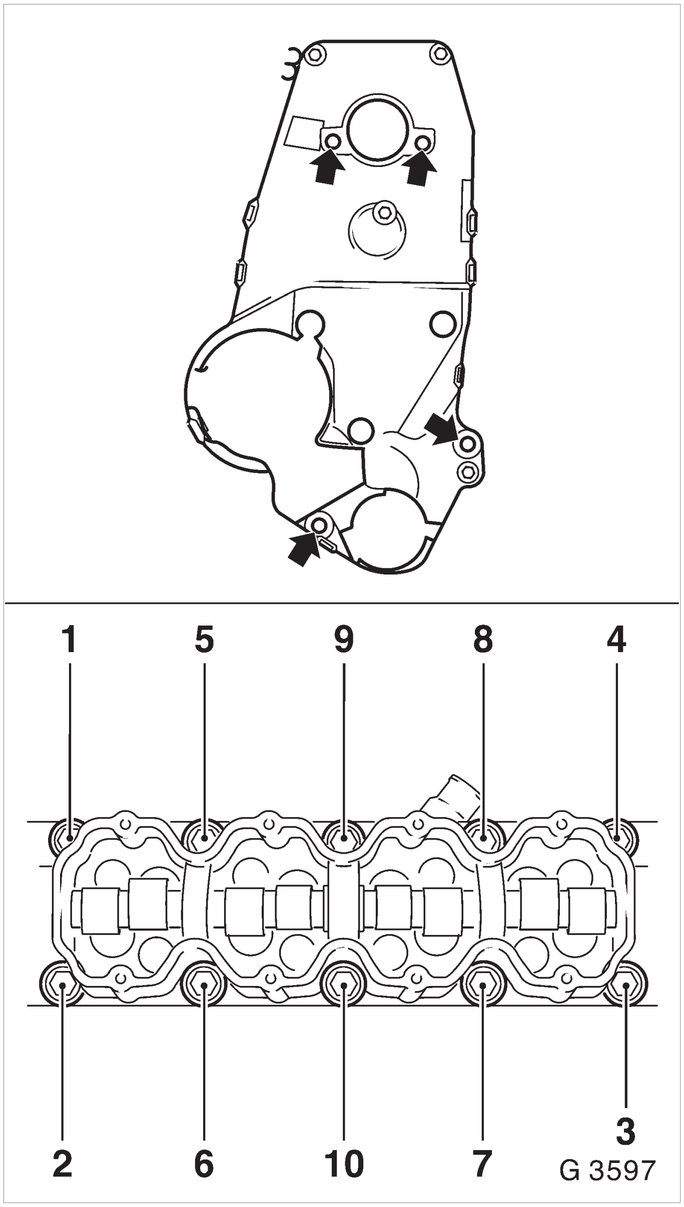
Remove toothed belt drive gear (3) from crankshaft.

Remove engine damping block main bracket (2) from cylinder block.

Remove camshaft housing cover from camshaft housing.

Remove camshaft sprocket (1) – hold with open–ended wrench on hex of camshaft.





Remove, Disconnect

Remove rear part of toothed belt cover (arrow) from oil pump and camshaft housing.

Detach cylinder head bolts in sequence shown. Remove camshaft housing from cylinder head. Remove cam followers, thrust pieces and hydraulic valve lifter – note location of each piece for reassembly in the same location. Remove cylinder head and gasket from cylinder block.

Clean

Clean sealing surfaces, bore holes and thread of cylinder head bolts.

Inspect

Check cylinder head and cylinder block for plane surface – see operations ”Cylinder Head, Check for Plane Surface” and ”Cylinder Block, Check for Plane Surface”.

Install, Connect

Install cylinder head gasket – mark ”OBEN/TOP” on top and towards timing side of engine.

Place cylinder head on cylinder block. Insert hydraulic valve lifters, thrust pieces and cam followers with MoS2 paste (grey) – note allocation.

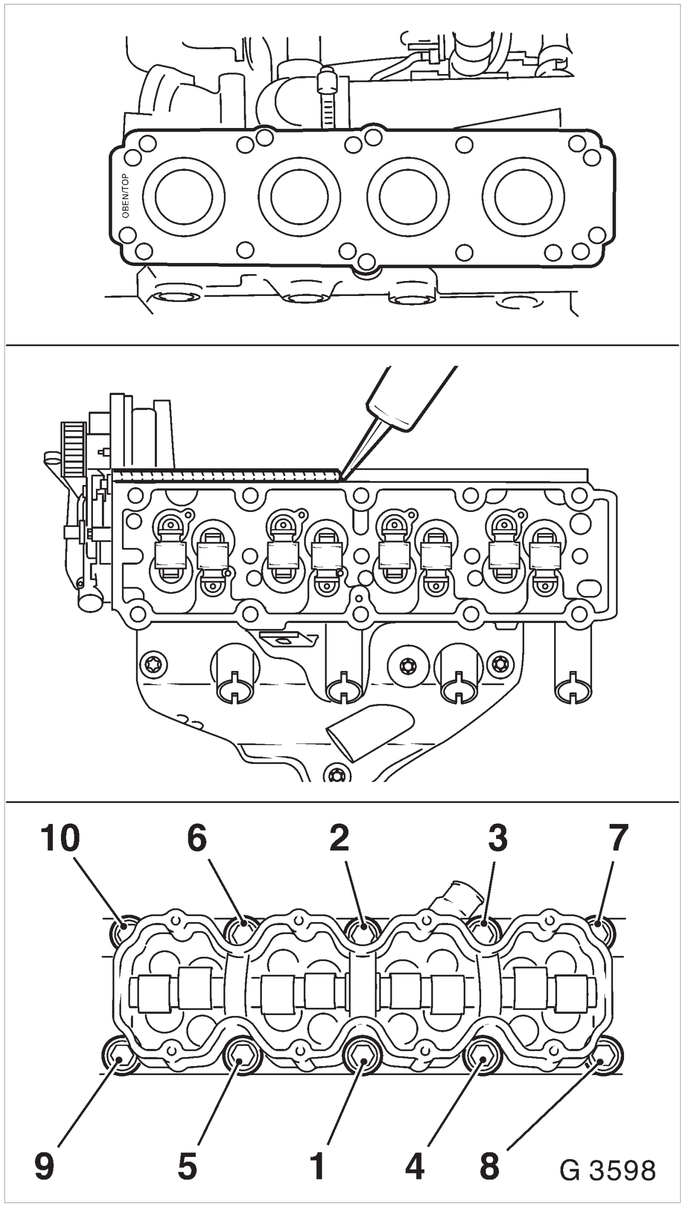
Apply a bead of surface sealant (green) to sealing surfaces of cylinder head.

Place camshaft housing on cylinder head.

Tighten cylinder head bolts in order shown – use torque wrench and KM–470–B.

Attach cylinder head and camshaft housing with new cylinder head bolts to cylinder block – tightening torque 25 Nm / 18 lbf. ft. + 60° + 60° + 60°.

Attach rear toothed belt cover to oil pump and camshaft housing – tightening torque 6 Nm / 4 lbf. ft.



Install, Connect

Attach camshaft sprocket to camshaft – hold with open–ended wrench on hex of camshaft – tightening torque 45 Nm / 33 lbf. ft.

Install camshaft housing cover at camshaft housing – tightening torque 8 Nm / 6 lbf. ft.

Attach engine damping block support to cylinder block – tightening torque 50 Nm / 37 lbf. ft.

Slide toothed belt drive gear onto crankshaft journal – note installation position.

Attach toothed belt tension roller to oil pump – tightening torque 20 Nm / 15 lbf. ft.

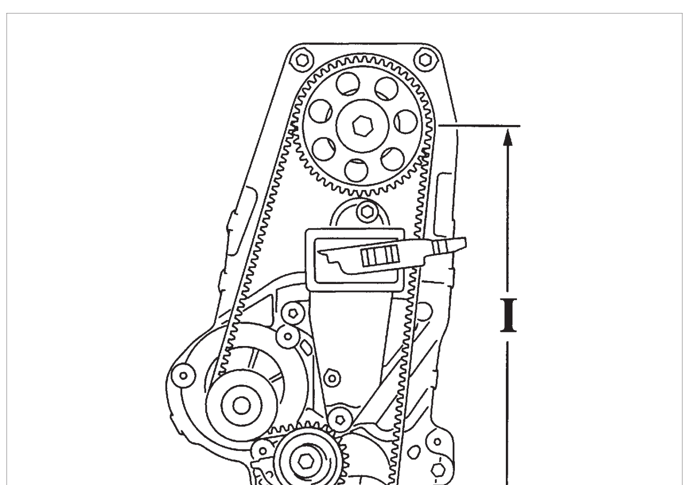
Install toothed belt – ensure that tensioned side (I) is taut.

Note timing marks! – see operation ”Timing, Adjust”.

Adjust toothed belt tension – see operation ”Toothed Belt Tension, Adjust”.

Attach engine damping block to right of side member – tightening torque 35 Nm / 26 lbf. ft.

Attach engine damping block bracket to auxiliary engine damping blocks support – tightening torque 55 Nm / 41 lbf. ft.



Install, Connect

Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Connect spark plug connectors to spark plugs.
Attach coolant hose to thermostat housing.
Attach engine vent hose to camshaft housing and engine vent flange.

Install, Connect

Connect wiring harness plug to DIS ignition module – note cable routing.
Attach engine vacuum hose to camshaft housing cover.
Attach or connect all wiring harness plugs, ground connections and hose connections to intake manifold – see operation ”Intake Manifold, Remove and Install”.

Install, Connect

For version with hex bolts: Attach front exhaust pipe with new gasket and bolts coated with assembly paste (white) to exhaust manifold –
tightening torque 35 Nm / 26 lbf. ft.
For version with hex nuts: Attach front exhaust pipe with new gasket and new nuts to exhaust manifold – tightening torque 45 Nm / 33 lbf. ft.

Install, Connect

Close coolant drain bolt.
Attach alternator to alternator shackle – tightening torque 20 Nm / 15 lbf. ft.
Attach alternator support to alternator and intake manifold – tightening torque 20 Nm / 15 lbf. ft.
Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.
Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Install air cleaner housing with air intake cover.
Connect ground cable to battery.

Cylinder Head, Check for Plane Surface

Clean

Clean sealing surface and remove sealant remnants.

Inspect

Check length and width of cylinder head sealing surfaces for deformation and diagonals for warpage – use straight edge.

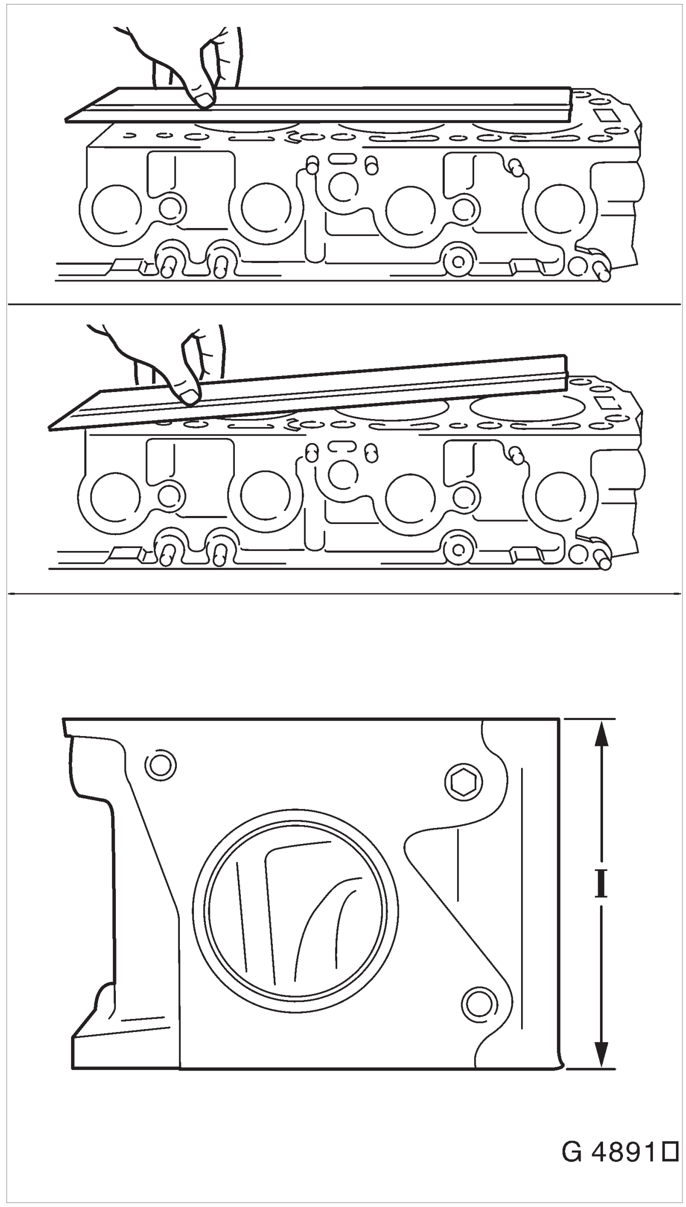
Important!

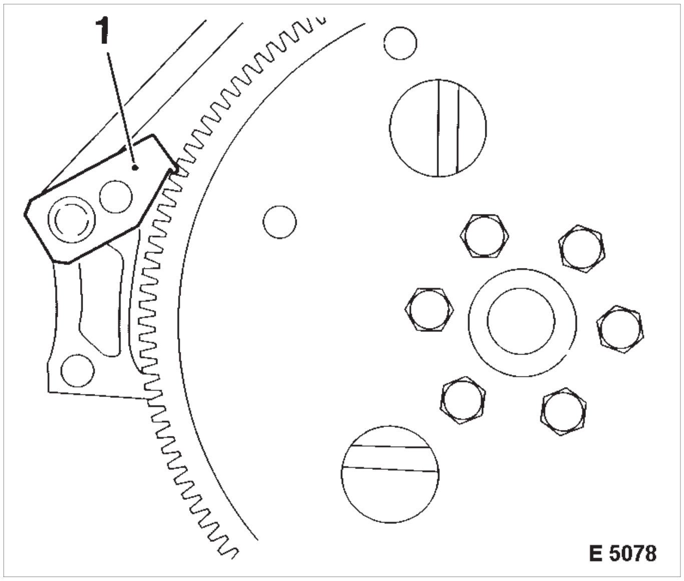
Resurfacing of the cylinder head is not permitted.

Measure

Height of cylinder head (sealing surface to sealing surface)

Dimension I: 95.90 to 96.10 mm





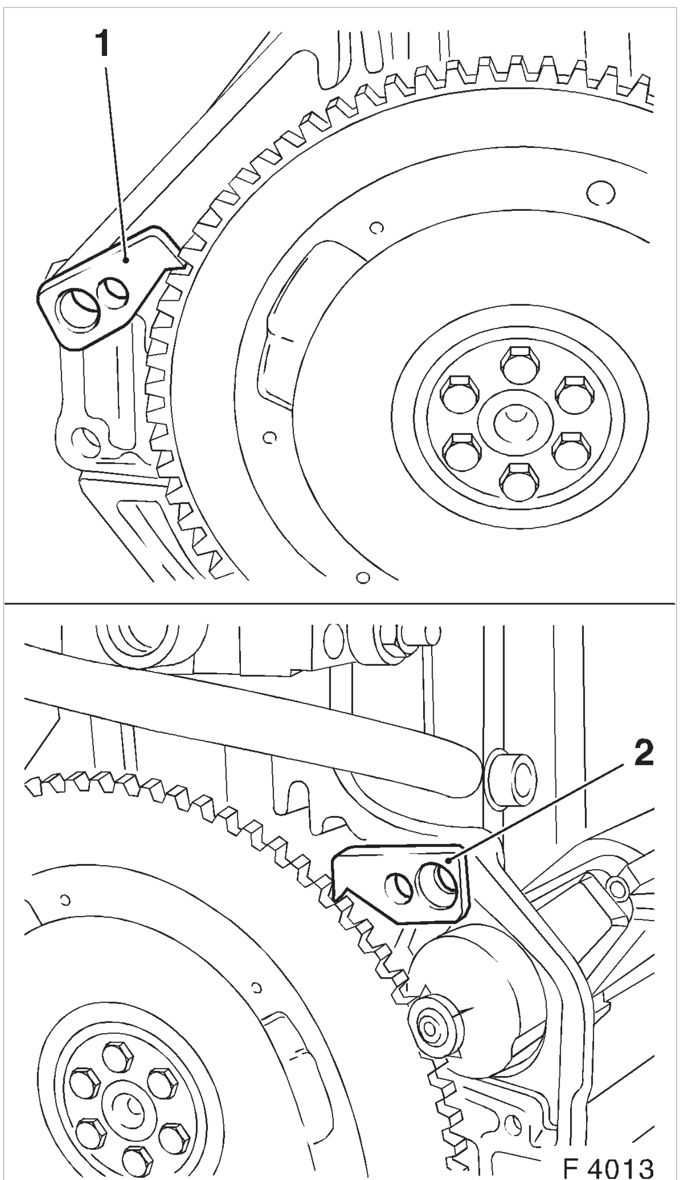
Flywheel/Flexplate, Remove and Install

Remove, Disconnect

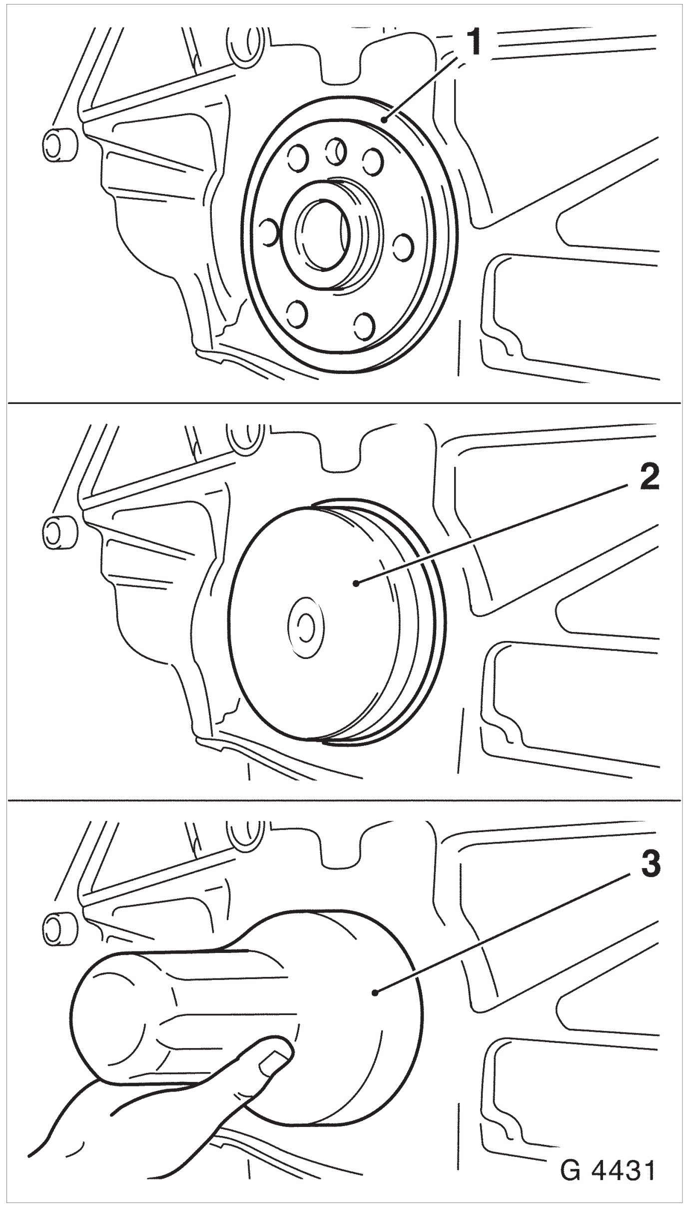
Hold flywheel with KM–652 (1) and remove from crankshaft.

Install, Connect

Attach flywheel to crankshaft with new bolts – tightening torque 35 Nm / 26 lbf. ft. + 30° + 15° – lock flywheel with KM–652 (2).



Seal Ring – Rear Crankshaft, Replace



Remove, Disconnect

Remove flywheel – see operation ”Flywheel, Remove and Install”.
Edge out seal ring (1) with suitable tool. Do not damage sealing surfaces.

Clean

Clean sealing surfaces and remove gasket remnants.

Install, Connect

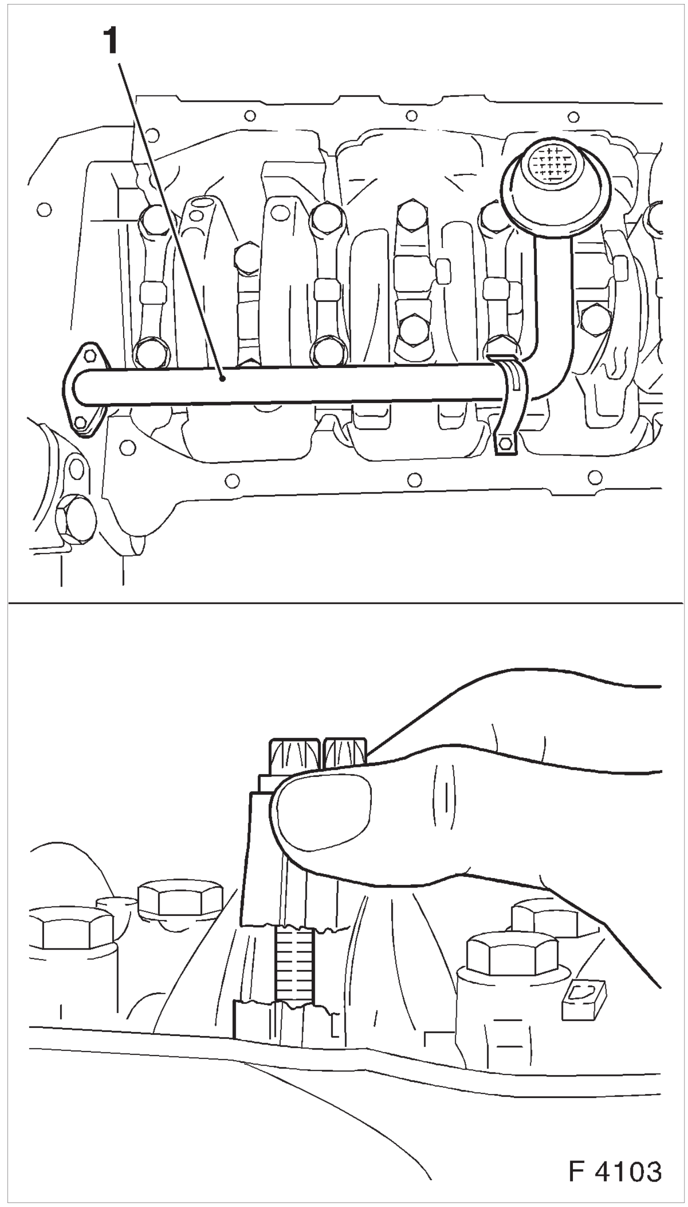
Coat sealing lip of new seal ring with silicon grease (white) and position with sealed side on Protective Sleeve KM–658–2 (2).
Connect protective sleeve with attached seal ring to crankshaft journal and press in flush. Place Installer Sleeve KM–658–1 (3) on Protective Sleeve KM–658–2 (2) and drive in seal ring until it sits flush in housing.
Install flywheel – see operation ”Flywheel, Remove and Install”.

Piston with Con–rod, Remove and Install

Remove, Disconnect

Remove oil pan – see operation ”Oil pan, Remove and Install”. Remove cylinder head – see operation ”Cylinder Head, Remove and Install”.

Remove oil intake tube (1) from oil pump and cylinder block.



Important!

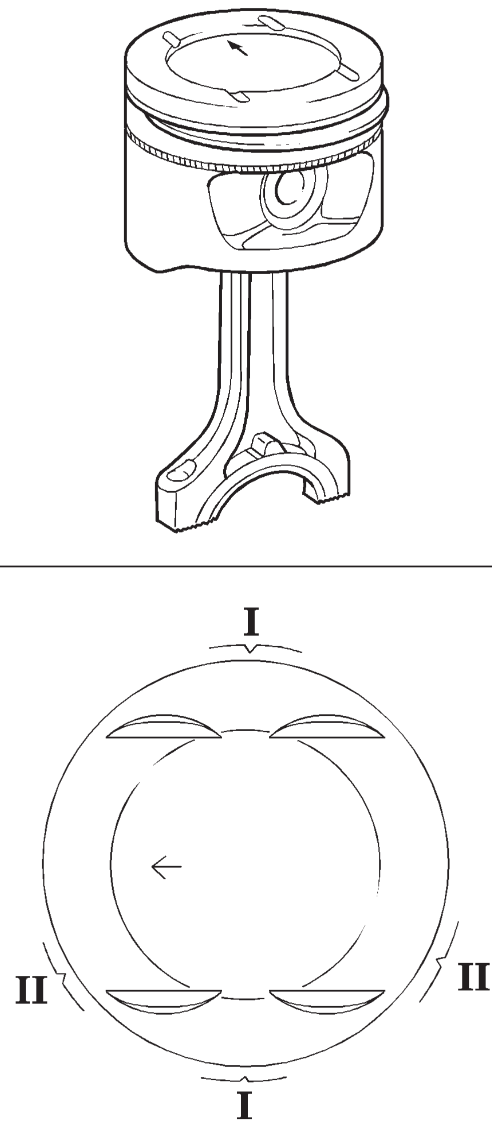
Mark order of con–rod bearing caps.

Remove con–rod bearing cap from con–rod.

The mating surfaces of the cod–rods and the con–rod bearing caps form an individual fit and as a result must not be damaged or replaced under any circumstances.

Do not lay con–rods and con–rod bearing caps on mating surfaces in order to avoid damage.

Remove combustion residue from upper part of cylinder bore.



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Remove, Disconnect

Push piston with con–rod upwards from cylinder bore.

Clean

Inspect

Check all parts, clean and if necessary, replace. Replace piston – see operation ”Piston, Replace”.

Adjust

Before inserting con–rod journal of crankshaft, set to BDC position and coat with engine oil.

Adjust piston ring gaps:

Oil scraper ring II: offset ring gaps of the steel band rings each 25 to 50 mm to the left or right of gap in intermediate ring. Piston rings I: offset ring gaps by approx. 120°. Second piston ring with identification ”TOP” uppermost.

Install, Connect

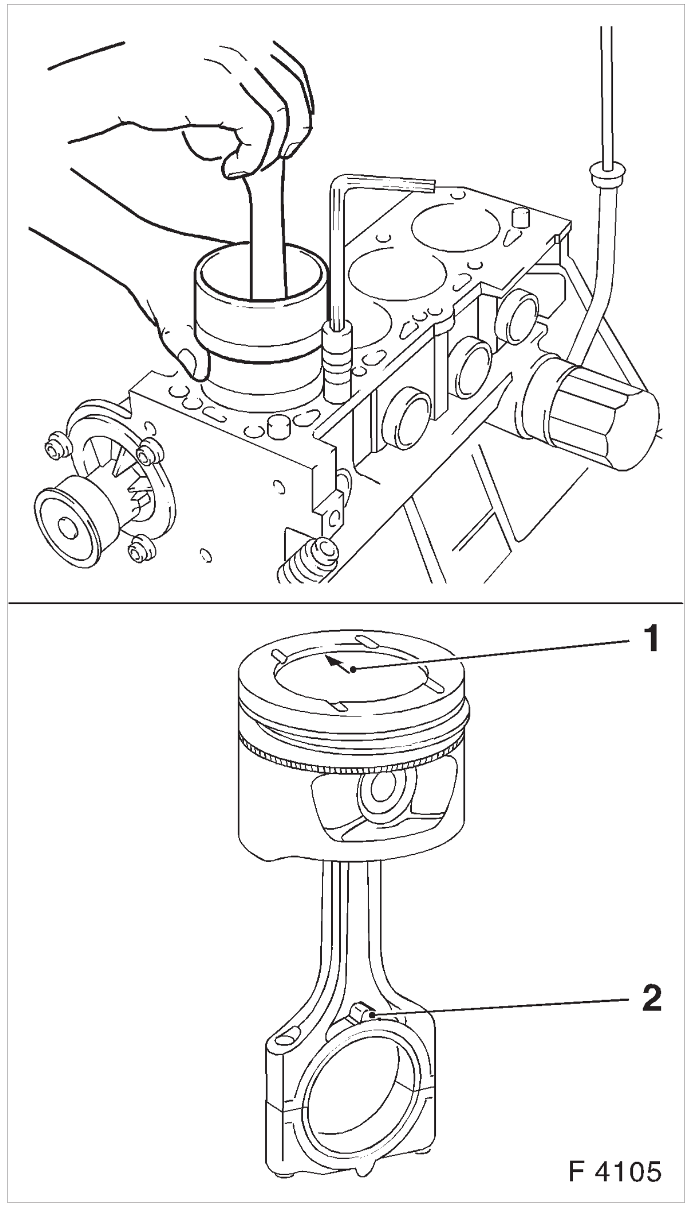
Coat piston rings with engine oil and compress with piston ring pliers.

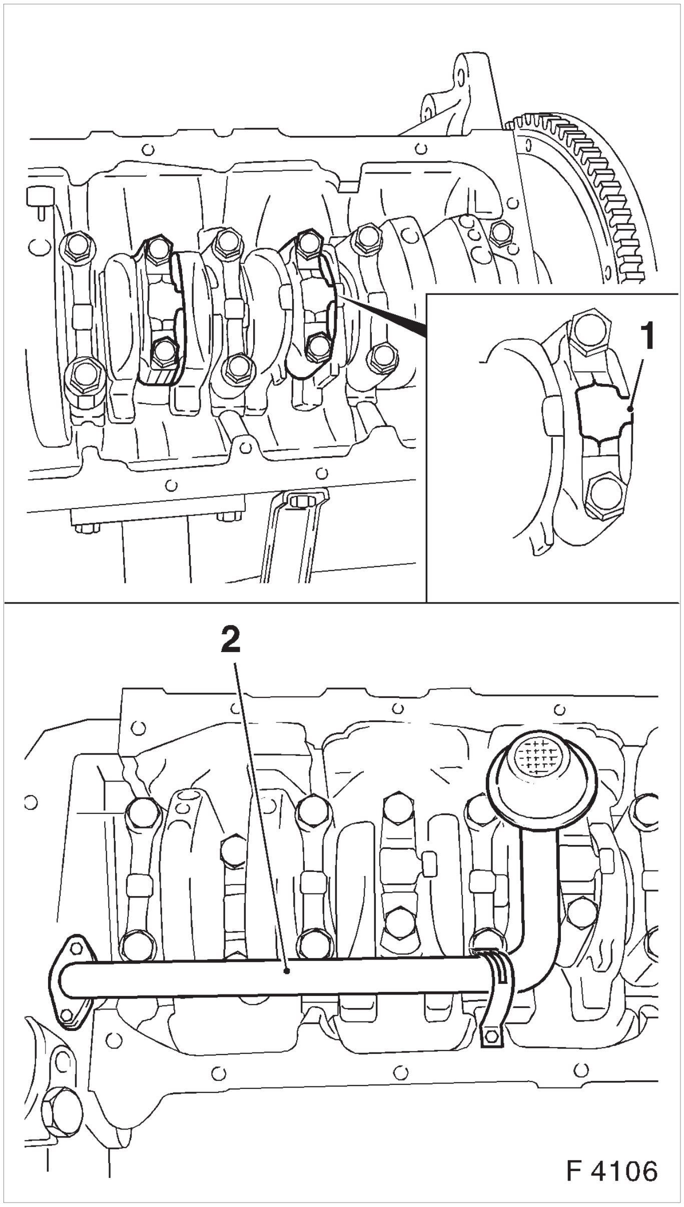
Push piston into cylinder bore with hammer handle.

Important!

Note installation position of piston and con–rod.

Arrow (1) on piston head points to engine timing side, bead (2) on con–rod points to transmission side of engine.





Install, Connect

Note sequence of con–rod bearing caps.

Install con–rod bearing cap – bead (1) of con–rod bearing caps points to transmission side.

Attach con–rod bearing cap to con–rod with new bolts – tightening torque 25 Nm / 18.5 lbf. ft. + 30°.

Attach oil intake pipe (2) with new seal ring to oil pump – 8 Nm / 6 lbf. ft.1).

Attach oil intake manifold to cylinder block – tightening torque 8 Nm / 6 lbf. ft.

Install cylinder head – see operation ”Cylinder Head, Remove and Install”.

Install oil pan – see operation ”Oil Pan, Remove and Install”.

1) Recut thread before reuse and insert bolts with screw locking compound (red). The installation time including the torque check is max. 10 min.

Piston Rings, Remove and Install

Remove, Disconnect

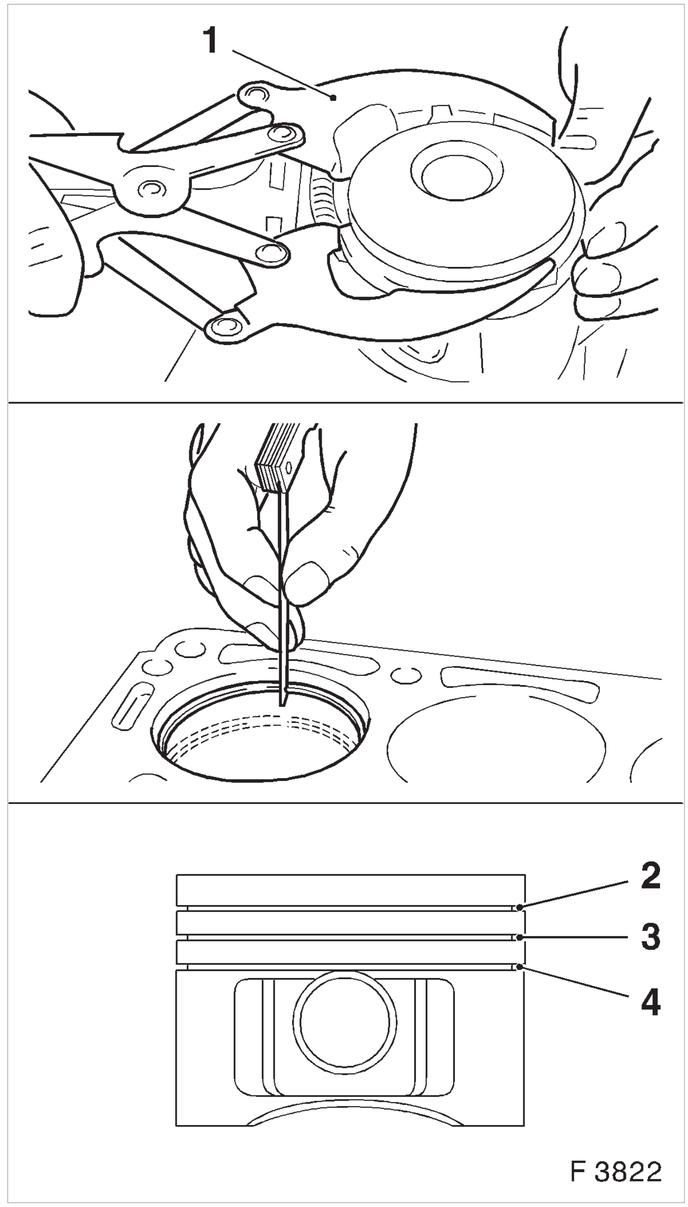
Remove piston with con–rod – see operation ”Piston with Con–rod, Remove and Install”.
Remove piston rings with piston ring pliers (1).

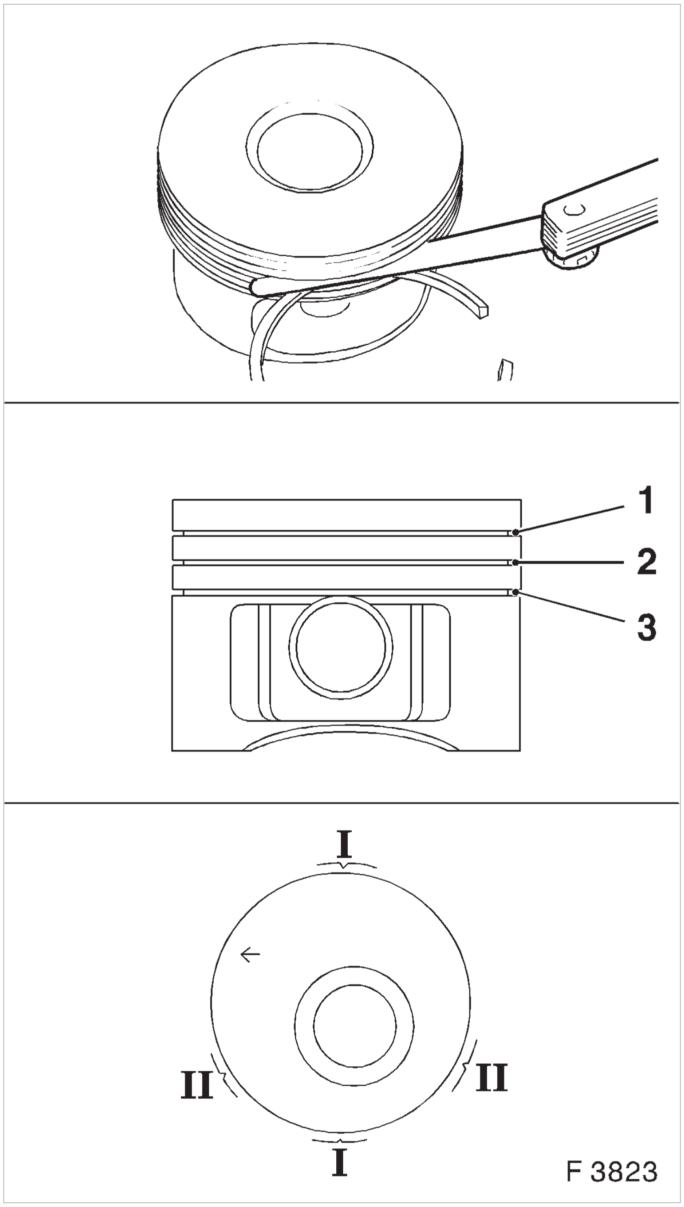
Clean

Clean piston ring grooves – use ground–down side of old piston ring.

Inspect

Check piston ring gap with feeler gauge by inserting piston ring at narrowest point of the cylinder bore.
Permissible ring gap:
Squared ring (2): 0.30-0.50 mm (0.011-0.020 in)
Tapered ring (3): 0.30 to 0.50 mm (0.011-0.020 in)
Oil scraper ring (4): 0.40 to 1.40 mm (0.015-0.055 in)





Inspect

Check piston ring vertical play with feeler gauge in piston ring groove.

Permissible vertical play:

Squared ring (1): 0.02-0.04 mm (0.0008-0.0015 in)

Tapered ring (2): 0.04-0.06 mm (0.0015-0.002 in)

Oil scraper ring (3): 0.01-0.03 mm (0.0004-0.001 in)

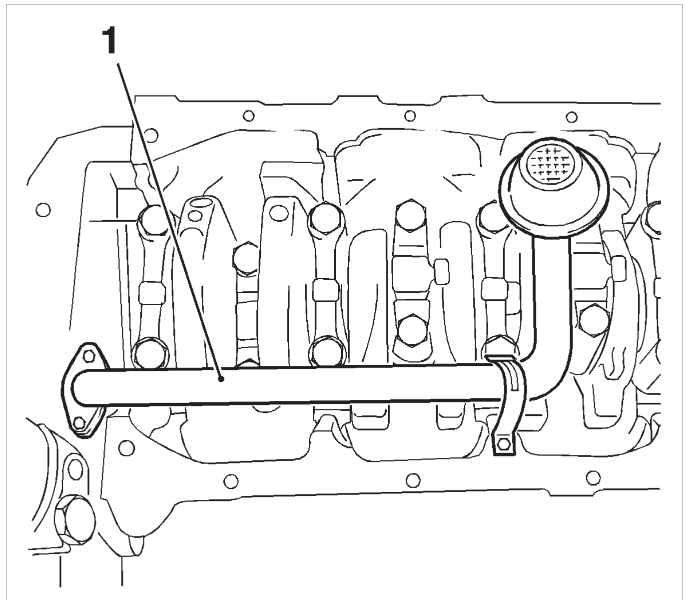
Install, Connect

Insert piston rings with piston ring pliers and identification ”TOP” upwards in piston.

Piston ring positioning – piston rings (I) (rectangular and tapered compression ring) offset 120°. Oil scraper rings (II) – offset 25 to 50 mm to left and from right of gap in intermediate ring.

Install piston with con–rod – see operation ”Piston with Con–rod, Remove and Install”.

Con–rod Bearing, Replace

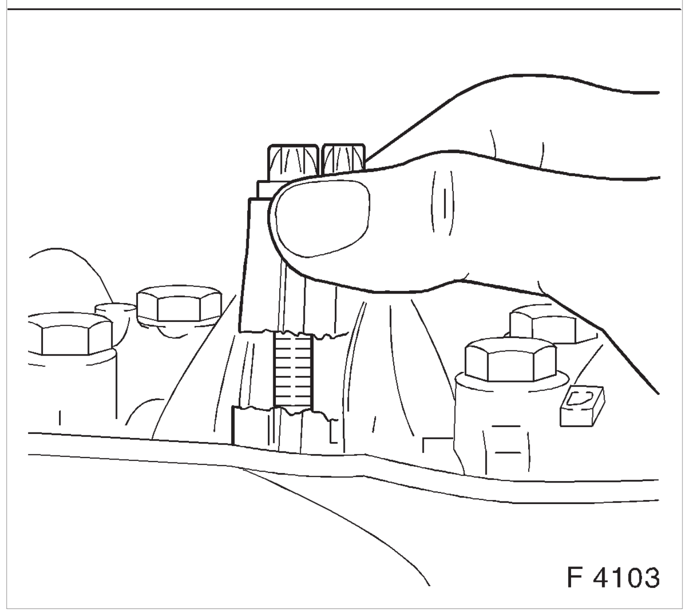


Remove, Disconnect

Remove oil pan – see operation ”Oil Pan, Remove and Install”.
Remove oil intake tube (1) from oil pump and cylinder block.

Important

Mark order of con–rod bearing caps.
Remove con–rod bearing cap from con–rod.
The mating surfaces of the cod–rods and the con–rod bearing caps form an individual fit and as a result must not be damaged or replaced under any circumstances.
Do not lay con–rods and con–rod bearing caps on mating surfaces in order to avoid damage.
Press con–rod bearing out of con–rod and con–rod bearing cap.

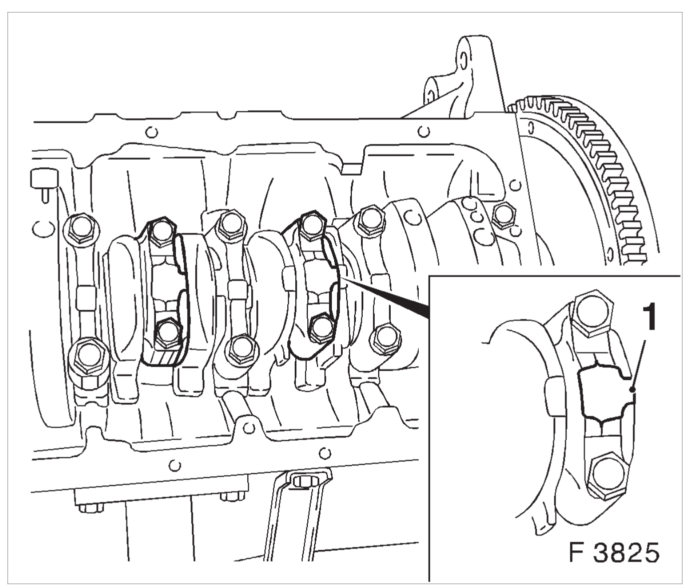


Clean

Con–rod bearing journals and con–rod bearing caps.

Insert, Connect

Insert new con–rod bearing shells with engine oil.
Note sequence of con–rod bearing caps. Con–rod bearing caps – bead (1) of con–rod bearing caps points to transmission side.
Attach con–rod bearing cap to con–rod with new bolts – tightening torque 25 Nm / 18.5 lbf. ft. + 30°.
Attach oil intake manifold to oil pump with new seal ring – tightening torque 8 Nm / 6 lbf. ft.1).
Attach oil intake manifold to cylinder block – tightening torque 8 Nm / 6 lbf. ft.
Apply a bead of adhesive sealing compound (black) to joints of oil pump and rear crankshaft bearing cap.
Install oil pan – see operation ”Oil Pan, Remove and Install”.
1) Recut thread before reuse and insert bolts with screw locking compound (red). The installation time including the torque check is max. 10 min.



Con–rod Bearing Clearance, Check (Determine Bearing Clearance with Plastigage)

Remove, Disconnect

Mark installation position (1) of con–rod bearing cap – remove con–rod bearing cap from con–rod.

Important!

To prevent the strip from tearing when removing the con–rod bearing cap, remove grease from the con–rod journal and lightly oil con–rod bearing shell. Do not turn the crankshaft.

Measure

Route Plastigage (malleable plastic strip) over the entire width of the con–rod bearing journal.

Torque-Angle Method

Con–rod bearing cap to con–rod – tightening torque 25 Nm / 18 lbf. ft. + 30°.

The bolts can be reused for checking the con–rod bearing clearance.

Measure

Remove con–rod bearing cap again. Compare width of flattened plastic thread (arrow) with measuring scale. Permissible con–rod bearing clearance: 0.019-0.071 mm (0.0007-0.003 in)

Note:

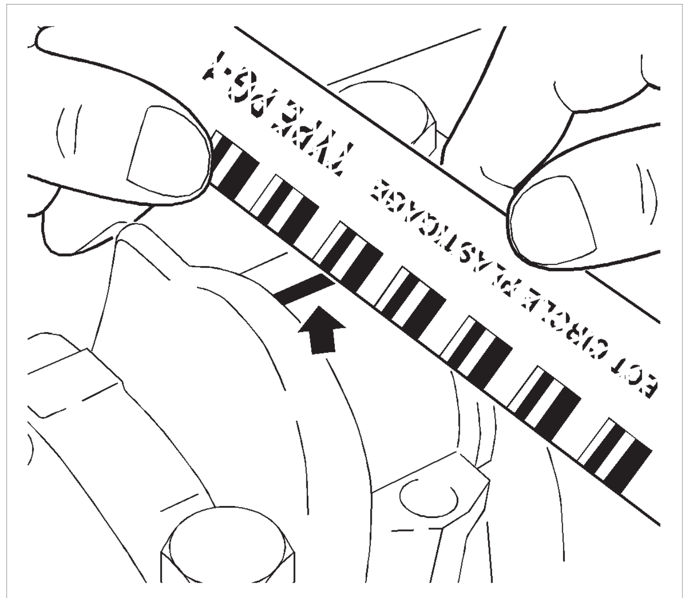
When reading the value, do not confuse millimeters and inches on the measuring scale.

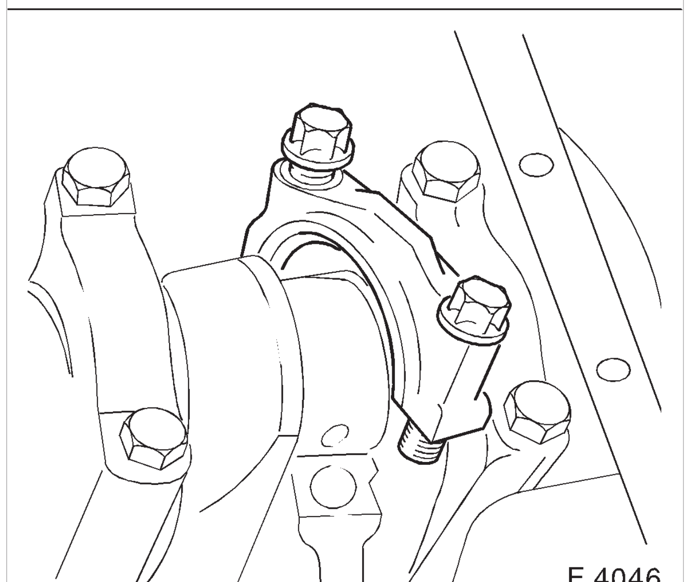
Install, Connect

Clean con–rod bearing journal and con–rod bearing shell and lubricate lightly.

Con–rod bearing cap to con–rod – note installation position of the con–rod bearing cap.

Attach con–rod bearing cap to con–rod with new bolts – tightening torque 25 Nm / 18.5 lbf. ft. + 30°.





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Con–rod Bearing Clearance, Check (Determine Bearing Clearance with Micrometer and Inside Micrometer)

Note:

Con–rod and crankshaft are removed.

Install, Connect

Con–rod bearing cap with con–rod bearing shell to con–rod – tightening torque 25 Nm / 18 lbf. ft. + 30°.

The bolts can be reused for checking the con–rod bearing clearance.

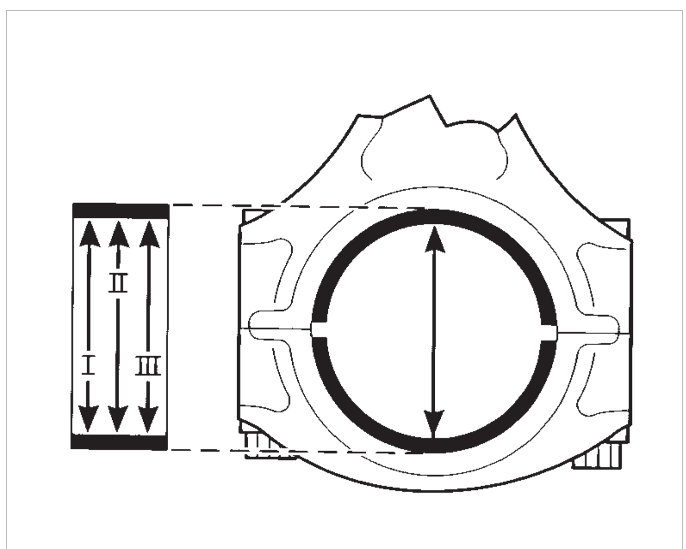
Install, Connect

Formula for calculating the average con–rod bearing diameter: $\frac{I + II + III}{3}$

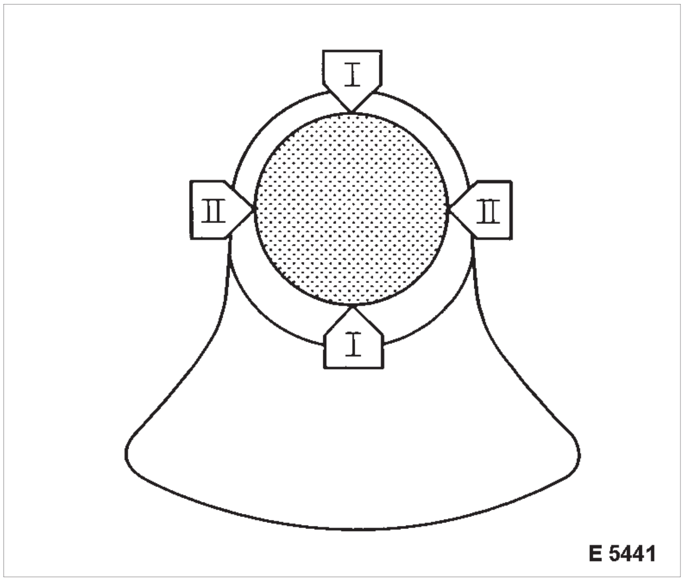
Example:

I	42.738 mm
II	42.732 mm
III	+ 42.741 mm
	128.211 mm / 3 = 42.737 mm

The average con–rod bearing diameter is 42.737 mm.



E 4444



E 5441

Measure

The con–rod bearing journal diameter is measured with a micrometer at points I and II and then calculated.

Formula for calculating the average con–rod bearing journal diameter: $\frac{I + II}{2}$

Example:

I		42.729 mm
II	+	42.725 mm
		85.454 mm / 2 = 42.727 mm

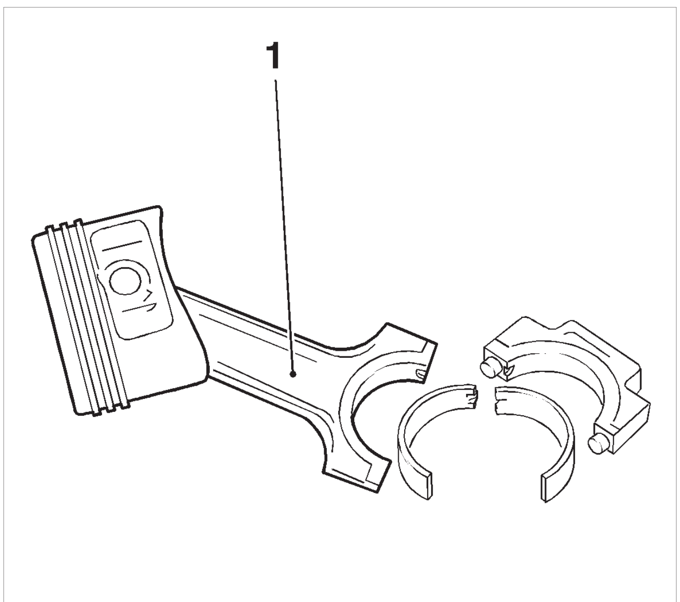
The average con–rod bearing journal diameter is 42.727 mm.

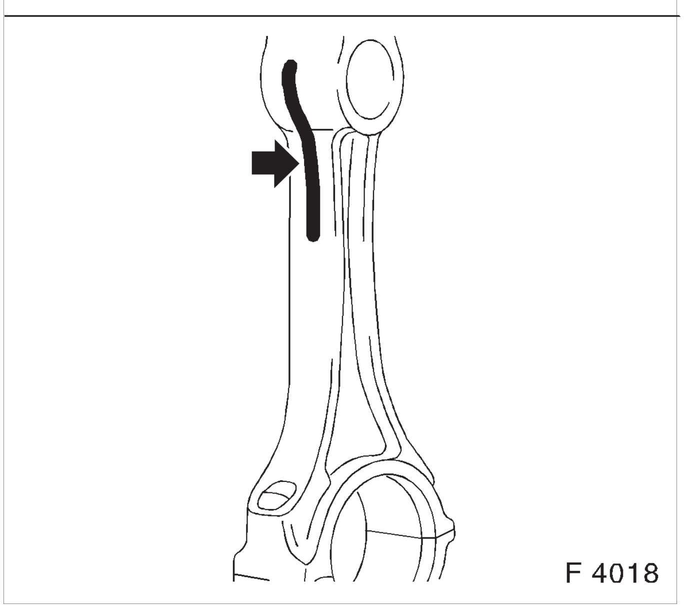
The con–rod bearing clearance is calculated from the difference in diameter between the con–rod bearing bore and the con–rod bearing journal.

Example:

Avg. con–rod bearing dia.		42.737 mm
Avg. con–rod bearing journal dia.	-	42.727 mm
		0.010 mm

Permissible con–rod bearing clearance: 0.019-0.071 mm (0.0007-0.003 in)




F 4018

Piston, Replace

Note:

Pushing out of the piston pin is not permitted. If the piston, the piston pin or the con–rod defective, all above–mentioned parts must be replaced.

Remove, Disconnect

Remove piston with con–rod (1) – see operation ”Piston with Con–rod, Remove and Install”.

Install, Connect

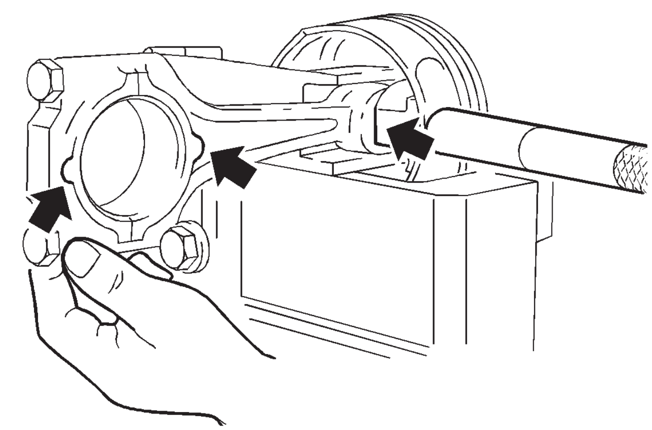
Coat con–rod eye and upper part of the con–rod shaft with thermocolor pencil. The green coloring turns black when the required assembly temperature is reached. The colored mark (arrow) is not permitted to discolor over the entire length, but only up to the start of the con–rod shaft. Heat new con–rod at upper con–rod eye with heater plate. Assembly temperature: 280 °C / 536 °F to max. 320 °C / 608 °F.

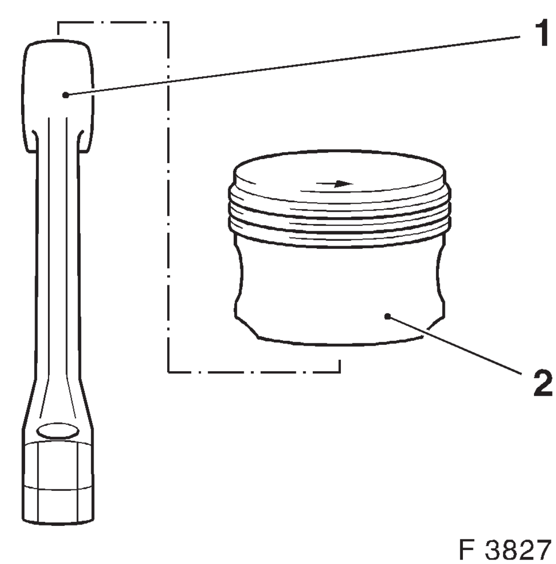
Important!
Installation position: Bead (arrow) on con–rod points to flattened area (arrow) of the piston pin eye.

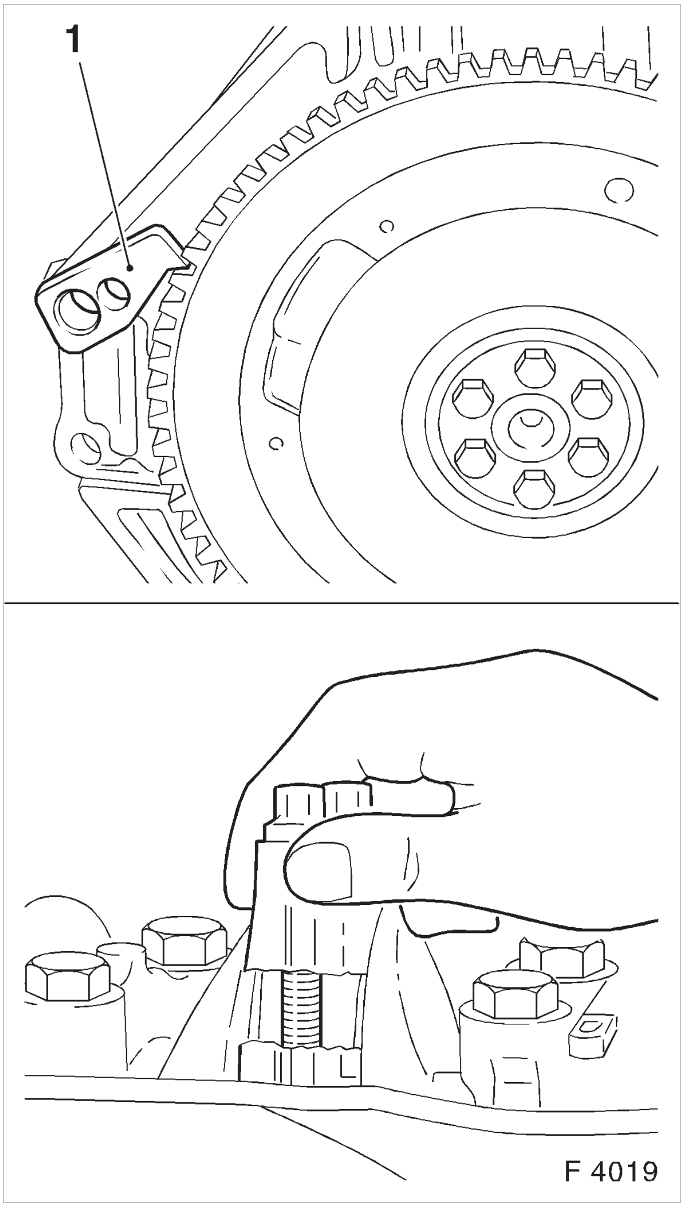
Note:
Firmly seated piston pin cannot be pressed further. Perform assembly quickly.

Assemble
Con–rod (1), piston pin, piston (2).
Slide new piston pin to stop in piston with guide drift.

Install, Connect
Install piston with con–rod – see operation ”Piston with Con–rod, Remove and Install”.







Crankshaft, Remove and Install

Remove, Disconnect

Remove engine – see operation ”Engine, Remove and Install”.

Mount engine with Adapter KM–412–10–A on Assembly Stands KM–412.

Remove oil pump – see operation ”Oil Pump, Remove and Install”.

Lock flywheel or drive disc with KM–652 (1) and remove from crankshaft.

Important!

Mark order of con–rod bearing caps. Remove con–rod bearing cap from conrod.

The mating surfaces of the cod–rods and the con–rod bearing caps form an individual fit and as a result must not be damaged or replaced under any circumstances.

Do not lay con–rods and con–rod bearing caps on mating surfaces in order to avoid damage.

Remove, Disconnect

Identify sequence of crankshaft bearing caps. Remove crankshaft bearing cap from cylinder block.
Remove crankshaft from cylinder block.

Clean

Clean all parts.

Inspect

Check crankshaft – see operation ”Crankshaft, Check”.

Install, Connect

Coat new bearing shells with engine oil and insert in cylinder block and bearing cap. Insert crankshaft carefully in cylinder block. Seat of crankshaft can be corrected by lightly tapping on crankshaft webs (1) with rubber hammer.

Install, Connect

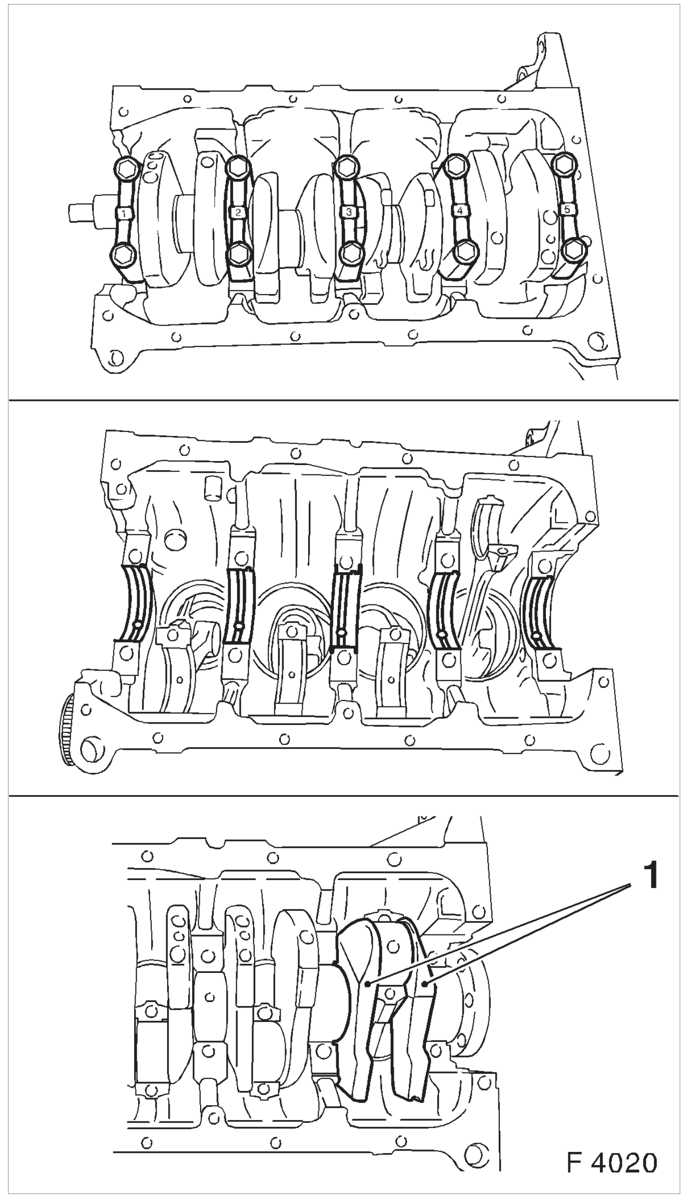
Apply a bead of adhesive sealing compound (black) to grooves of rear crankshaft bearing cap. Install crankshaft and con–rod bearing cap.
Note marks and installation position.

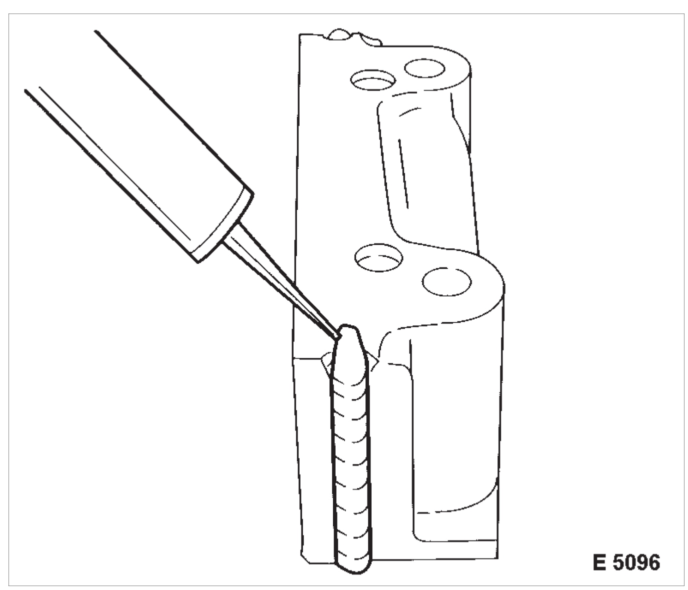
Torque – Angle Method

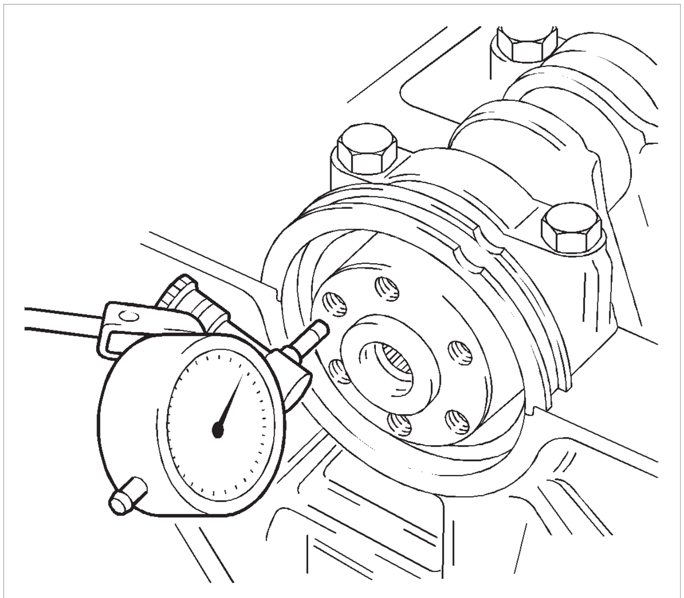
Crankshaft bearing cap to cylinder block – 50 Nm / 37 lbf. ft + 45° +15°1)2).
Con–rod bearing cap to con–rod – 25 Nm / 18.5lbf. ft. + 30°1)

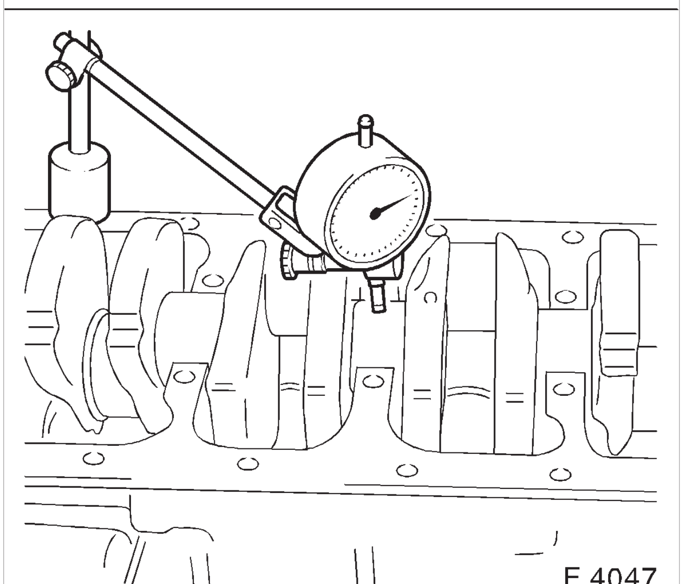
Install, Connect

Install crankshaft rear seal ring – see operation ”Seal Ring, Crankshaft, Rear Replace”.
Lock flywheel with KM–652. Flywheel with new bolts to crankshaft – tightening torque 35 Nm / 26 lbf. ft. + 30° + 15°. Install oil pump – see operation ”Oil Pump, Remove and Install”. Remove engine from Overhaul Stand KM–412 and remove Adapter KM–412–10 from engine. Install engine – see operation ”Engine, Remove and Install”.
1) Use new bolts.
2) After assembly of bearing cap, press in adhesive sealing compound (black) from above again until adhesive sealing compound (black) escapes from the joints.

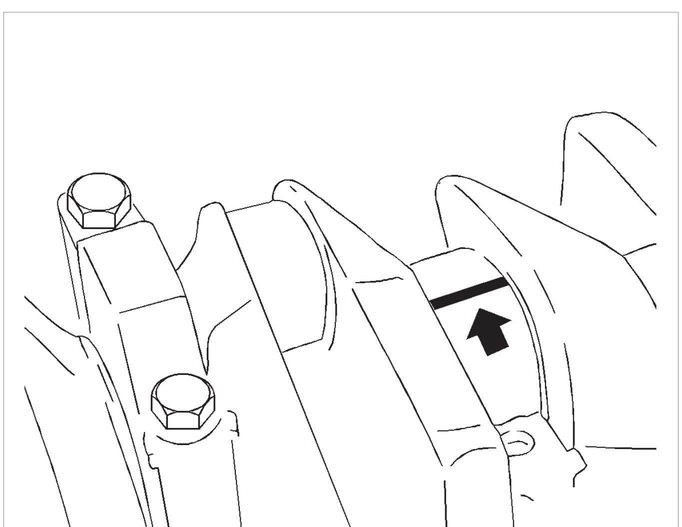








F 4047



F 4048

Crankshaft, Check
Crankshaft End Clearance, Check

Measure

Attach Dial Gauge MKM–571–B with dial gauge bracket to one face of cylinder block and position probe of dial gauge on crankshaft. Slide crankshaft in longitudinal direction. Permissible crankshaft longitudinal play: 0.100-0.202 mm (0.004-0.008 in)

Crankshaft Out–of–round, Check

Inspect

Remove crankshaft bearing cap.
Attach Dial Gauge MKM–571–B with dial gauge bracket to cylinder block. Apply probe of the Dial Gauge MKM–571–B to crankshaft bearing journal. Turn crankshaft uniformly. Max. perm. out–of–round: 0.03 mm (0.001 in).
Crankshaft bearing cap with new bolts to cylinder block – 50 Nm / 37 lbf. ft. + 45° + 15°.

Crankshaft Bearing Play, Check (Determine Bearing Play with Plastigage)

Inspect

Bearing play – crankshaft bearing cap removed.

Important!

To prevent thread from tearing when removing con–rod bearing cap, remove grease from con–rod journal and lightly oil con–rod bearing shell. Do not turn crankshaft.

Measure

With ”Plastigage” (deformable plastic thread).
Cut thread to bearing width and lay axially between crankshaft journal and bearing shell (arrow). Install crankshaft bearing cap with torque – tightening torque 50 Nm / 37 lbf. ft. + 45° + 15°.

Note:

The bolts can be reused for checking crankshaft bearing clearance.

Remove, Disconnect

Remove crankshaft bearing cap.

Measure

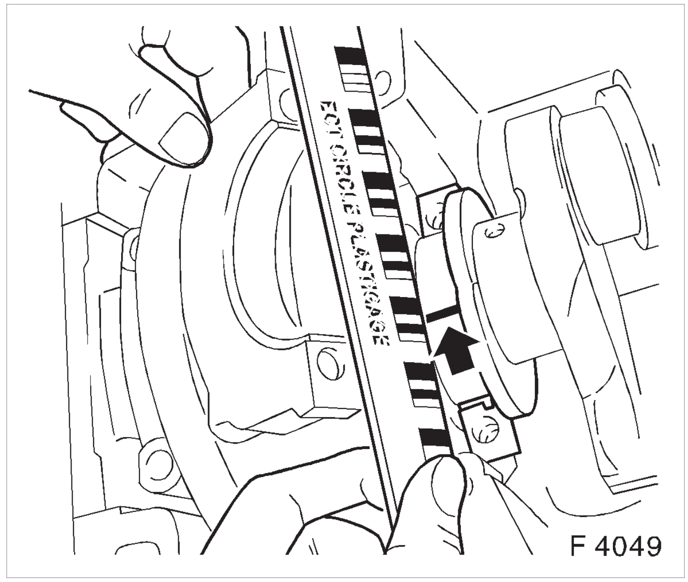
Compare width of flattened plastic thread (arrow) with measuring scale.

””Plastigage” is available for various measuring ranges.

Perm. crankshaft bearing play: 0.015-0.041 mm (0.0005-0.005 in).

Torque – Angle Method

Attach crankshaft bearing cap to cylinder block with new bolts – 50 Nm / 37 lbf. ft. + 45° + 15°.



F 4049

Crankshaft Bearing Clearance, Check (Determine Crankshaft Bearing Clearance Using External Micrometer and Inside Micrometer)

The crankshaft is removed.

Install, Connect

Install crankshaft bearing cap with crankshaft bearing shell at cylinder block – tightening torque 50 Nm / 37 lbf. ft. + 45° + 15°. To check the crankshaft bearing play, bolt can be reused.

Measure

The average crankshaft bearing diameter is determined using an inside micrometer at points I, II and III and then calculated.

Formula for calculating the average crankshaft bearing diameter: $\frac{I + II + III}{3}$

Example:

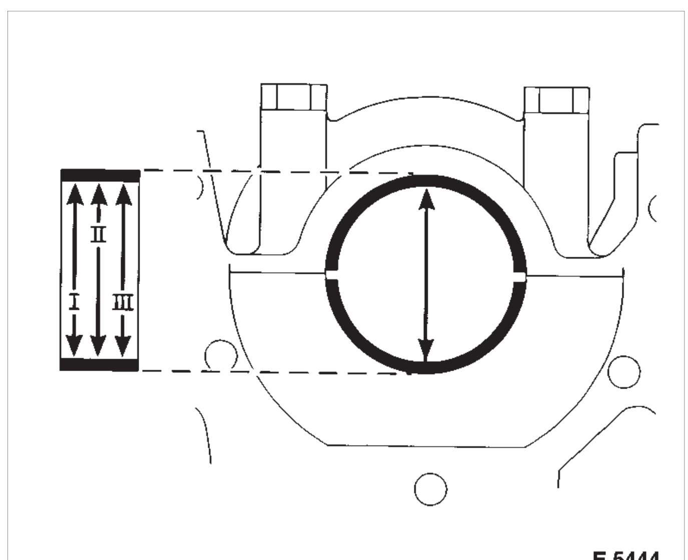
I 54.972 mm

II 54.981 mm

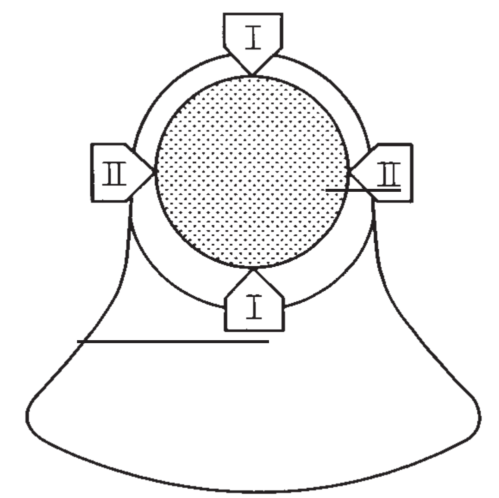
III + 54.984 mm

164.937 mm / 3 = 54.979 mm

The average crankshaft bearing diameter is 54.979 mm.



E 5444



E 5441

Measure

The crankshaft journal diameter is measured with a micrometer at points I and II and then calculated.

Formula for calculating the average crankshaft bearing journal diameter: $\frac{I + II}{2}$

Example:

I		54.962 mm
II	+	54.964 mm
		109.926 mm / 2 = 54.963 mm

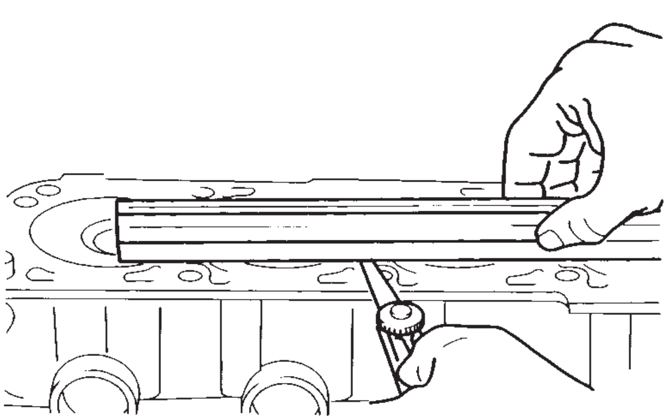
The average crankshaft journal diameter is 54.963 mm.

The crankshaft clearance is calculated from the difference in diameter between the crankshaft bearing bore and crankshaft journal.

Example:

Average crankshaft bearing dia.	54.979 mm
Average crankshaft journal dia.	– 54.963 mm
	0.016 mm

Permissible crankshaft bearing play: 0.015-0.041 mm (0.0005-0.0015 in)


E 5097

Cylinder Block, Check for Plane Surface

Clean

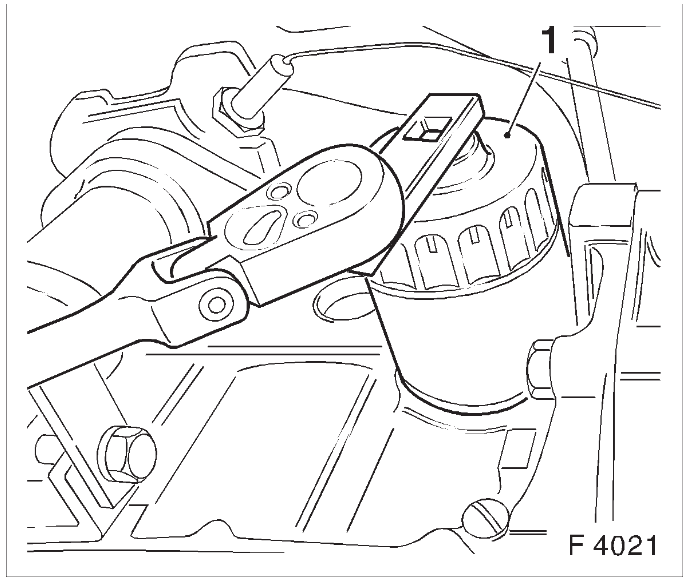
Clean sealing surface and remove sealant remnants.

Inspect

Check sealing surfaces in length and width for deformation and check for warping along the diagonals – use straight edge.

Oil Circuit

Oil Filter, Replace



Remove, Disconnect

Remove oil filter with KM–726–A (1) – place collecting basin underneath.

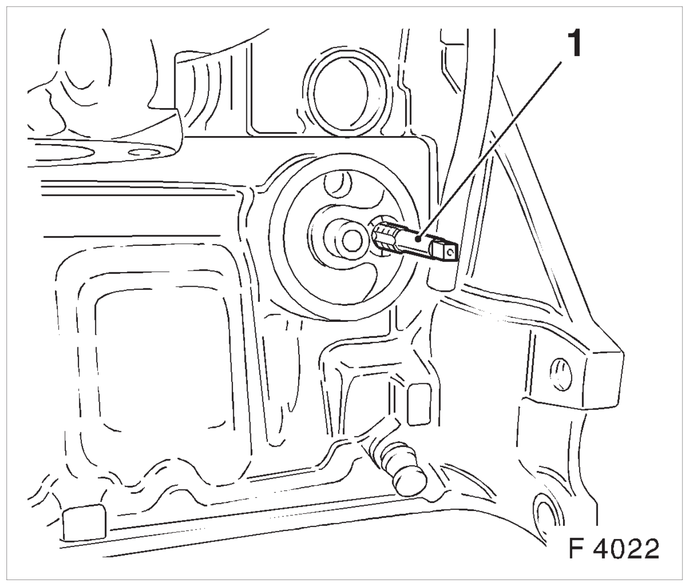
Install, Connect

Coat seal ring of new oil filter lightly with engine oil and attach to cylinder block – tightening torque 15 Nm / 11 lbf. ft.

Inspect

Check engine oil level and correct if necessary.

Bypass Valve, Replace



Remove, Disconnect

Remove oil filter – see operation ”Oil Filter, Replace”.

Using tap (1) (M10 – 3rd speed) cut thread in bypass valve, screw in M10 bolt and remove bypass valve from seat.

Install, Connect

Drive in bypass valve up to stop using drift (j approx. 15 mm).

Install oil filter – see operation ”Oil Filter, Replace”.

Inspect

Check engine oil level and correct if necessary.

Seal Ring – Oil Pump, Replace

Front Seal Ring – Crankshaft, Replace

Remove, Disconnect

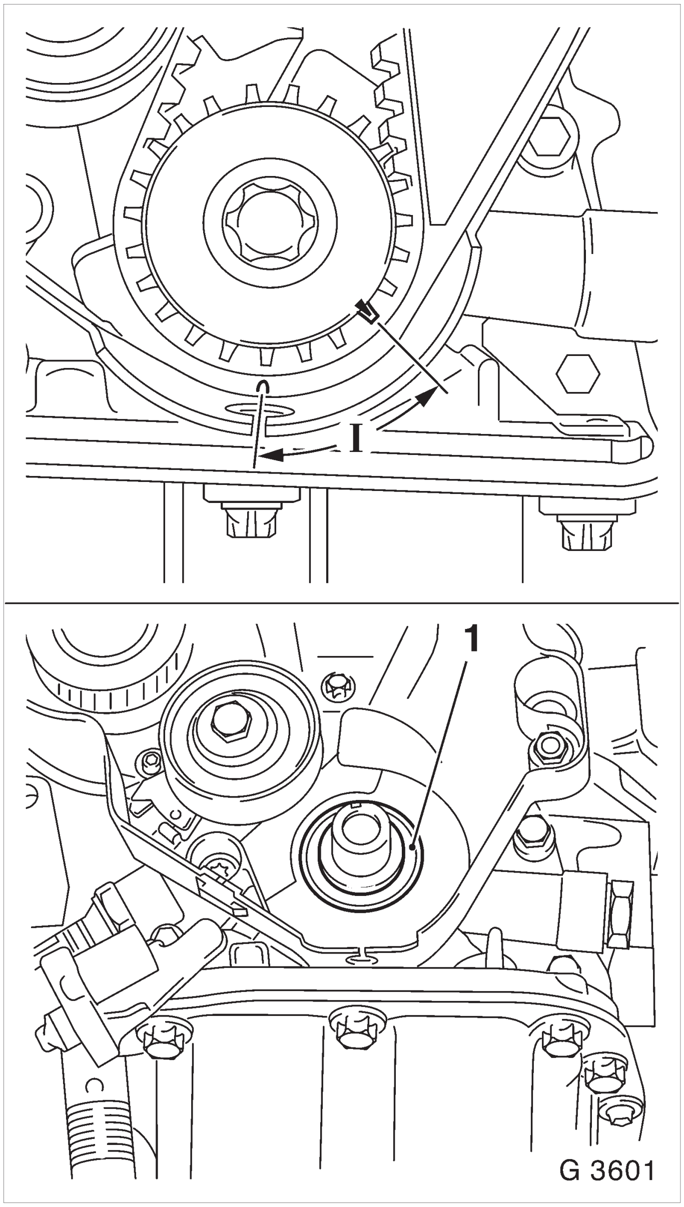
Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.



Important!

Before dismantling the toothed belt – screw fastening bolt for toothed belt drive gear into crankshaft and move crankshaft in engine rotational direction by 60° (dimension I) to before TDC mark.

Remove, Disconnect

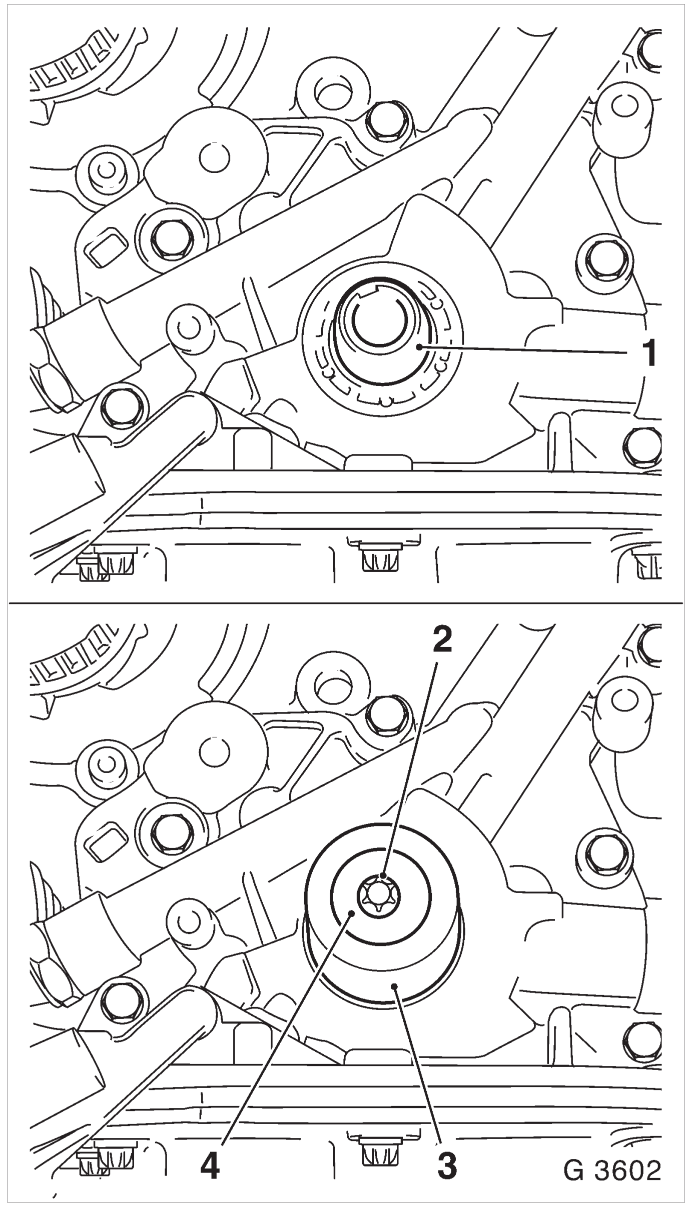
Remove toothed belt – see operation ”Toothed Belt, Remove and Install”.

Remove fastening bolt from toothed belt drive gear and pull toothed belt drive gear from crankshaft.

Edge out crankshaft seal ring (1) with suitable tool.

Important!

Do not damage sealing surfaces.



Install, Connect

Slide Protective Sleeve KM–417 (1) onto crankshaft journal. Lightly coat sealing lip of the new seal ring with silicon grease (white) and slide over the protective sleeve onto crankshaft journal.

Remove, Disconnect

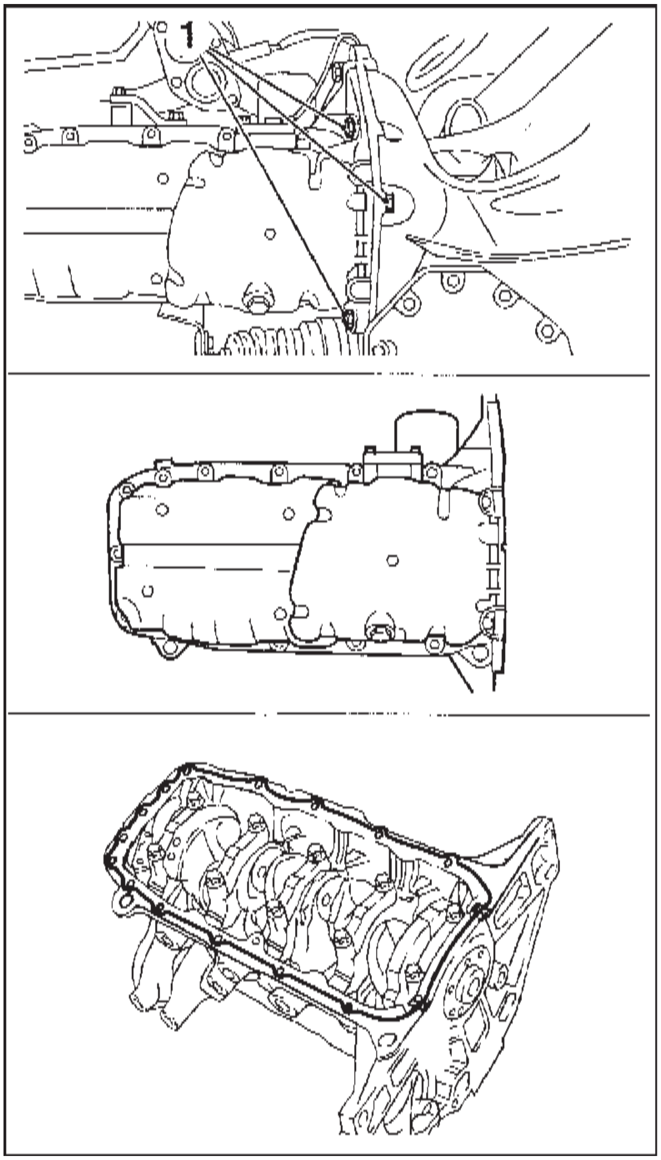
Remove protective sleeve of KM–417 from crank journal.

Install, Connect

Press seal ring with KM–417 (3) in oil pump – use bolt (2) and washer (4) of toothed belt drive gear.
Slide toothed belt drive gear onto crankshaft.
Install toothed belt – see operation ”Toothed Belt, Remove and Install”.

Install, Connect

Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.
Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Install air cleaner housing with air intake cover.



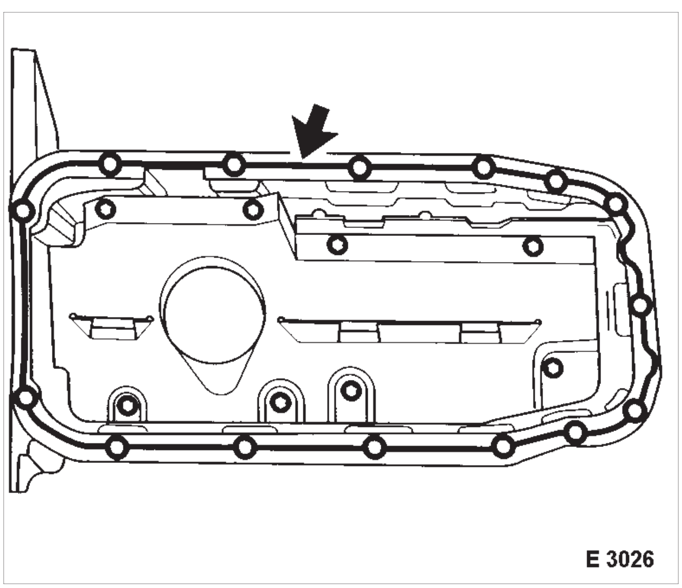
Oil Pan, Remove and Install

Remove

Open oil drain bolt – place collecting basin underneath.
Remove fastening bolts (1) from transmission housing.
Remove oil pan from cylinder block and oil pump.

Clean

Clean sealing surfaces and remove gasket remnants.



Install, Connect

Apply a bead of adhesive sealing compound around oil pan sealing flange. Install oil pan to oil pump, cylinder block. Attach oil drain bolt to oil pan with new seal ring – tightening torque 55 Nm / 40.6 lbf. ft.

Important!

Installation sequence:

1. Tighten all bolts loosely.
2. Tighten bolts on cylinder block and oil pump – tightening torque 10 Nm / 7.5 lbf. ft.1).
3. Tighten bolts on transmission housing – tightening torque 40 Nm / 29.5 lbf. ft.

1) Recut thread before reuse and insert bolts with screw locking compound (red). The installation time including the torque check is max. 10 min.

Install, Connect

For version with hex bolts – tightening torque 35 Nm / 26 lbf. ft.1).

For version with hex nuts – tightening torque 45 Nm / 33 lbf. ft.2).

Fill engine oil up to ”MAX” at dipstick.

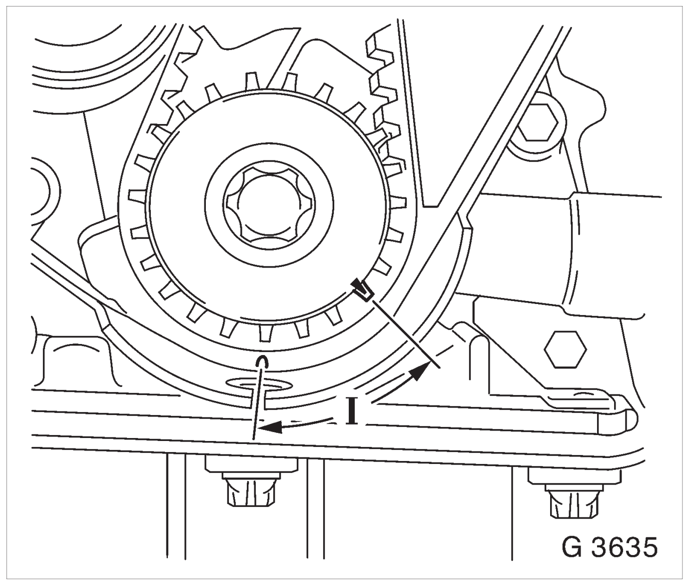
1) Insert bolts with mounting paste (white).

2) Use new nut(s).

Oil Pump, Remove and Install

Important!

Prior to removing toothed belt – set crankshaft to approx. 60° (dimension I) before TDC mark.



Remove, Disconnect

Remove oil pan – see operation ”Oil Pan, Remove and Install”.

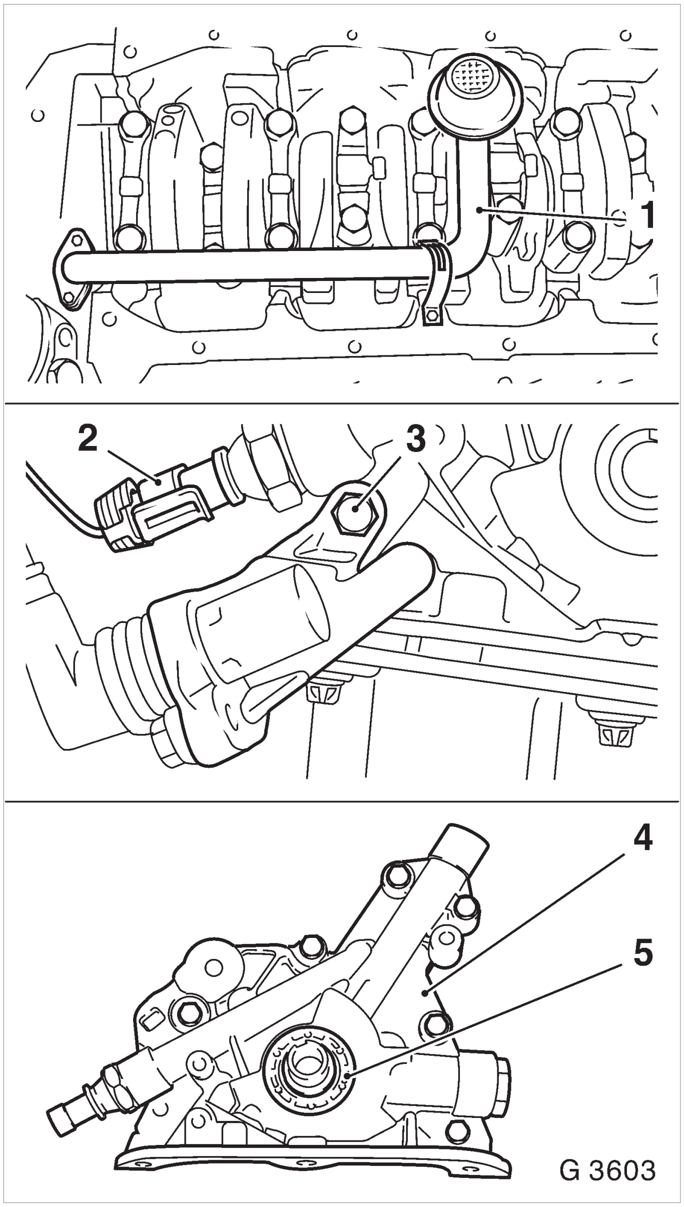
Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.



Remove, Disconnect

Remove toothed belt – see operation ”Toothed Belt, Remove and Install”.

Remove toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.

Rear toothed belt cover – see operation ”Toothed Belt Cover – Rear, Remove and Install”.

Remove oil intake tube (1) from oil pump and cylinder block.

Disconnect wiring harness plug (2) from oil pressure switch.

Remove crankshaft position sensor bolt (3).

Detach oil pump (4) from cylinder block.

Edge seal ring (5) out of oil pump.

Clean

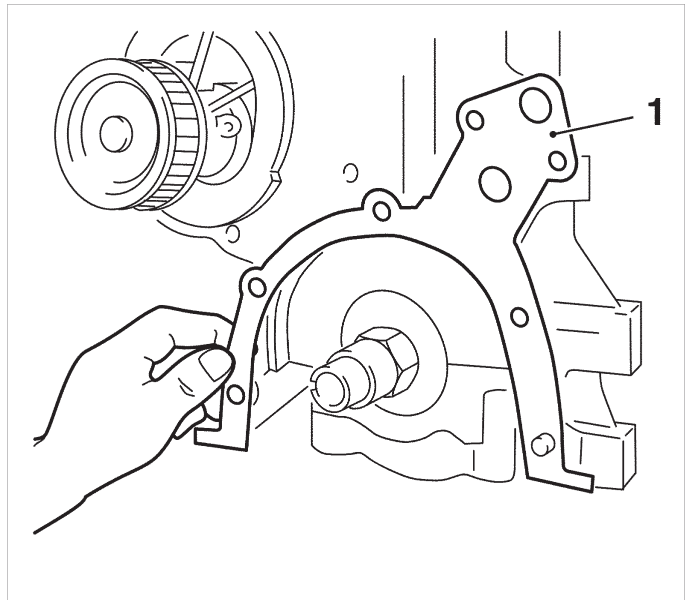
Clean sealing surfaces and remove gasket remnants.

Install, Connect

Attach oil pump with new seal (1) to cylinder block – tightening torque 10 Nm / 7 lbf. ft.

Slide Protective Sleeve KM–417 onto crankshaft journal.

Lightly coat sealing lip of the new seal ring with silicon grease (white) and slide over the protective sleeve onto crankshaft journal.

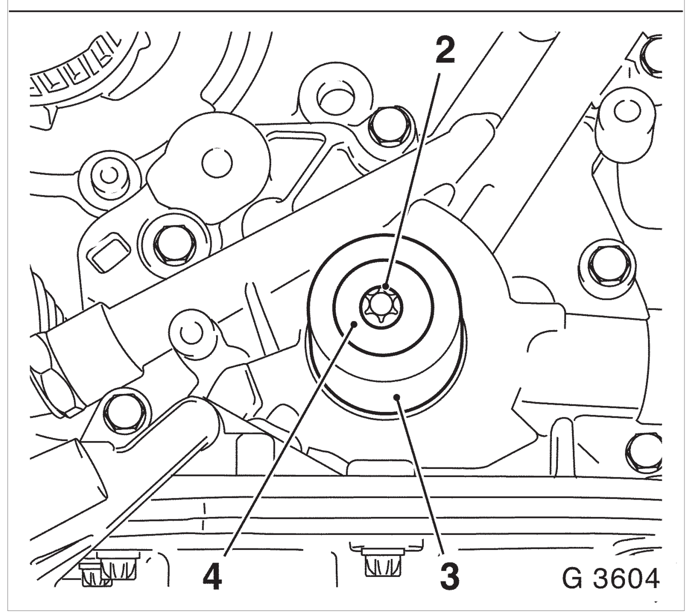


Remove, Disconnect

Remove protective sleeve from crankshaft journal.

Install, Connect

Press seal ring with KM–417 (3) in oil pump – use bolt (2) and washer (4) of toothed belt drive gear.



Install, Connect

Connect wiring harness plug to oil pressure switch.

Attach crankshaft position sensor oil intake manifold to oil pump with new seal ring – tightening torque 8 Nm / 6 lbf. ft.1).

Attach oil intake manifold to cylinder block – tightening torque 8 Nm / 6 lbf. ft.

Install rear toothed belt cover – see operation ”Toothed Belt Cover – Rear, Remove and Install”.

Install toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.

Install toothed belt – see operation ”Toothed Belt, Remove and Install”.

Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.

Install oil pan – see operation ”Oil Pan, Remove and Install”.

1) Recut thread before reuse and insert bolts with screw locking compound (red). The installation time including the torque check is max. 10 min.

Oil Pump, Check

Remove, Disconnect

Remove oil pan – see operation ”Oil Pan, Remove and Install”.

Remove air cleaner housing with air intake cover.

Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.

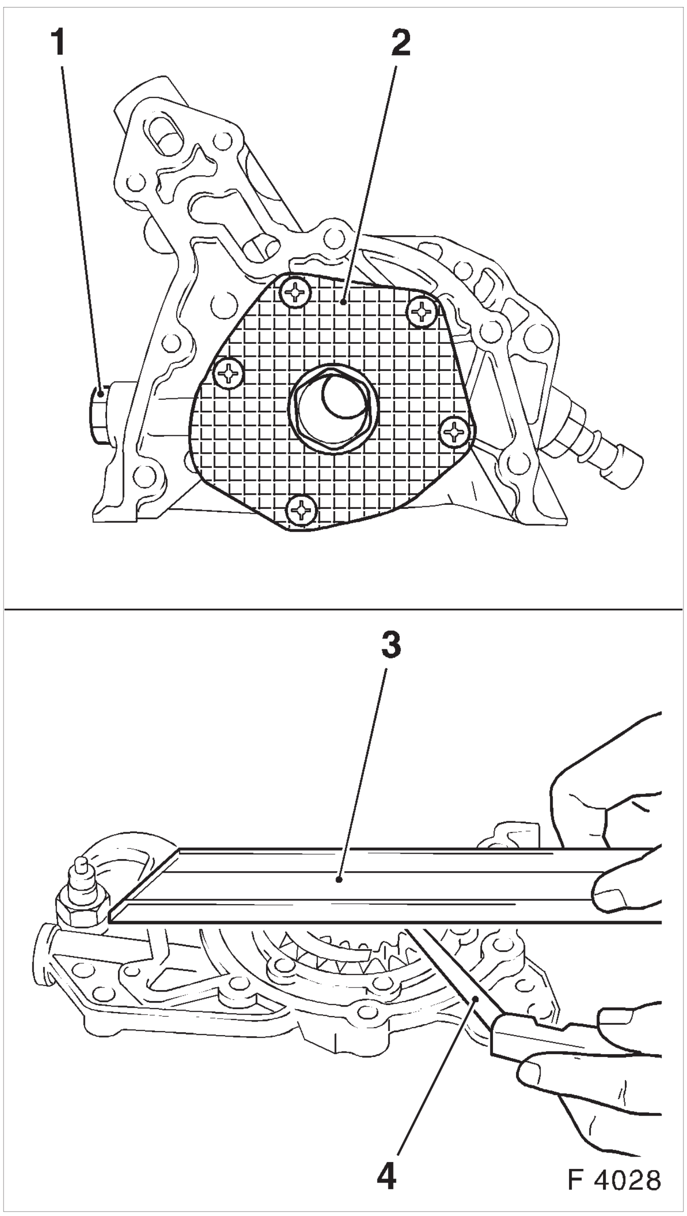
Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

Remove toothed belt – see operation ”Toothed Belt, Remove and Install”.

Remove toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.

Rear toothed belt cover – see operation ”Toothed Belt Cover – Rear, Remove and Install”.



Remove, Disconnect

Remove oil pump – see operation ”Oil Pump, Remove and Install”.

Remove safety valve (1) and oil pump cover (2) from oil pump.

Inspect

Check gap of gear pair with feeler gauge (4) and straight edge (3). Dimension – 0.08-0.15 mm (0.003-0.005 in). Check oil pump, oil pump cover and safety valve for signs of wear.

Install, Connect

Oil pump cover to oil pump Attach – tightening torque 6 Nm / 4 lbf. ft. safety valve with new seal ring in oil pump Install – tightening torque 50 Nm / 37 lbf. ft.

Install oil pump – see operation ”Oil Pump, Remove and Install”.

Install, Connect

Install rear toothed belt cover – see operation ”Toothed Belt Cover – Rear, Remove and Install”.

Install toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.

Install toothed belt – see operation ”Toothed Belt, Remove and Install”.

Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.

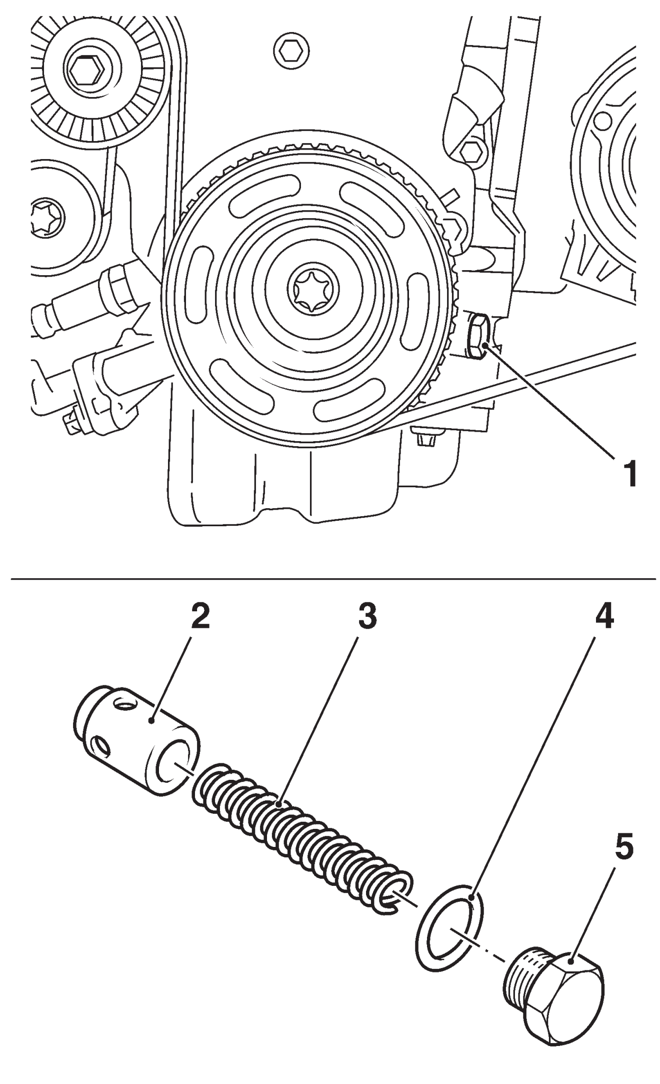
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.

Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.

Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.

Install air cleaner housing with air intake cover.

Install oil pan – see operation ”Oil Pan, Remove and Install”.



G 3605

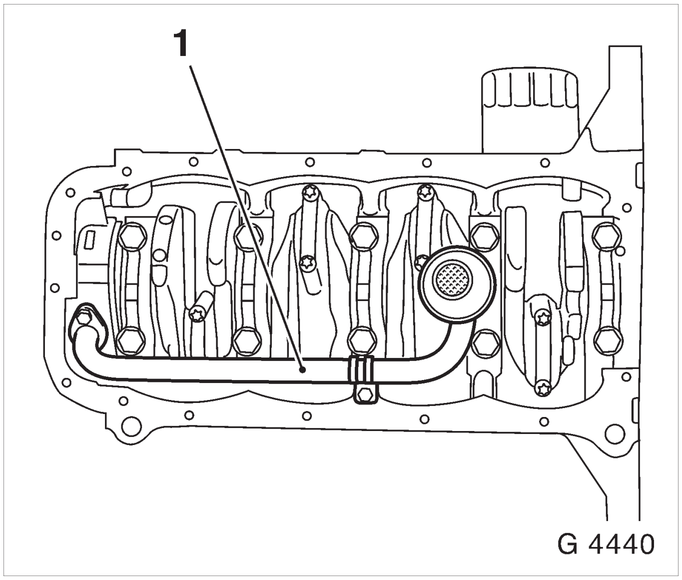
Safety Valve, Remove and Install

Remove, Disconnect

Remove closure plug (1) from oil pump – remove seal ring, spring, piston from oil pump.

Install, Connect

Insert piston (2) – ensure installation position is correct. Insert spring (3) in oil pump. Attach closure plug (5) to oil pump with new seal ring (4) – tightening torque 50 Nm / 37 lbf. ft.



Oil Intake Pipe, Remove and Install

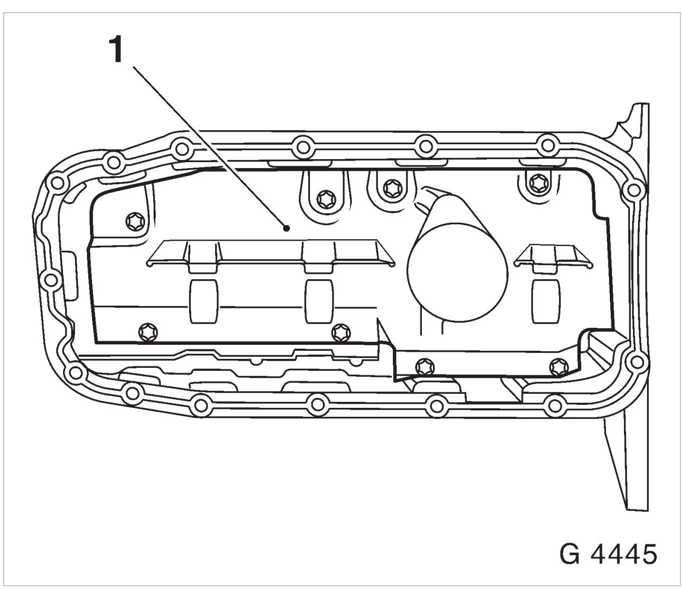
Remove, Disconnect

Remove oil pan – see operation ”Oil Pan, Remove and Install”.
Remove oil intake tube (1) from oil pump and cylinder block.

Install, Connect

Attach oil intake manifold to oil pump with new seal ring – tightening torque 8 Nm / 6 lbf. ft.1).
Attach oil intake manifold to cylinder block – tightening torque 8 Nm / 6 lbf. ft.
Install oil pan – see operation ”Oil Pan, Remove and Install”.

1) Recut thread before reuse and insert bolts with screw locking compound (red). The installation time including the torque check is
max. 10 min.



Oil Baffle Plate, Remove and Install

Remove, Disconnect

Remove oil pan – see operation ”Oil Pan, Remove and Install”.
Remove oil baffle plate (1).

Install, Connect

Attach oil baffle plate to oil pan – tightening torque 8 Nm / 6 lbf. ft.
Install oil pan – see operation ”Oil Pan, Remove and Install”.

Oil Pressure Switch, Remove and Install

Remove, Disconnect

Detach wiring harness plug (1) from oil pressure switch.

Disconnect oil pressure switch (2) from oil pump – place collection pan underneath.

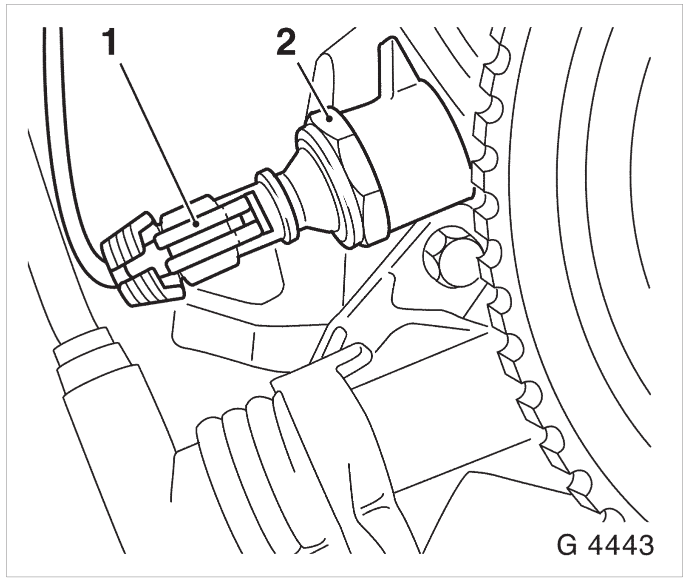
Install, Connect

Attach oil pressure switch to oil pump with new seal ring – tightening torque 30 Nm / 22 lbf. ft.

Connect wiring harness plug to oil pressure switch.

Inspect

Check engine oil level and correct if necessary.



Oil Dipstick Guide Tube, Remove and Install

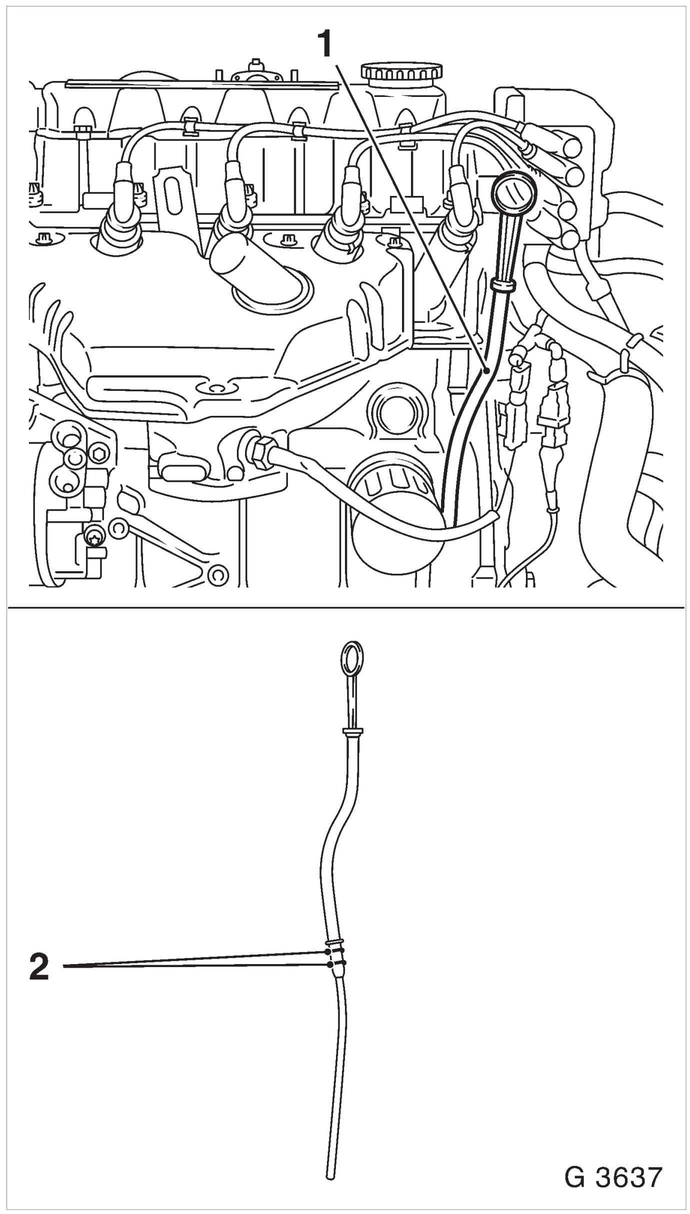
Remove, Disconnect

Withdraw oil dipstick guide tube (1) from cylinder block.

Install, Connect

Push new seal ring (2) onto oil dipstick guide tube and lightly coat with engine oil.

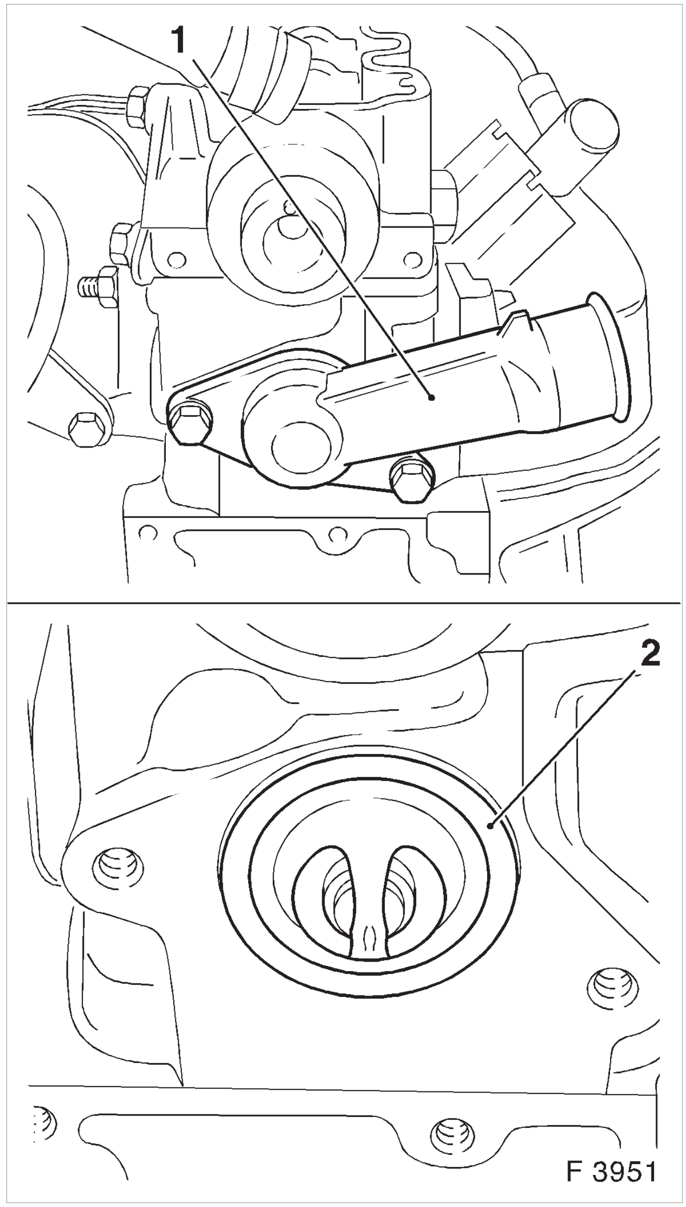
Insert oil dipstick guide tube up to stop in cylinder block.



Thermostat, Remove and Install

Remove, Disconnect

Open coolant drain bolt – collect escaping coolant.
Remove coolant hose from thermostat housing.
Remove air cleaner housing with air intake cover.
Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.
Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.
Remove toothed belt – see operation ”Toothed Belt, Remove and Install”.
Remove toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.



Remove, Disconnect

Rear toothed belt cover – see operation ”Toothed Belt Cover – Rear, Remove and Install”.
Remove thermostat housing (1) from cylinder head.
Remove thermostat (2) from cylinder head.

Clean

Clean sealing surfaces and remove gasket remnants.

Install, Connect

Install thermostat (2) into cylinder head with new seal ring.
Attach thermostat housing to cylinder head – 10 Nm / 7 lbf. ft.

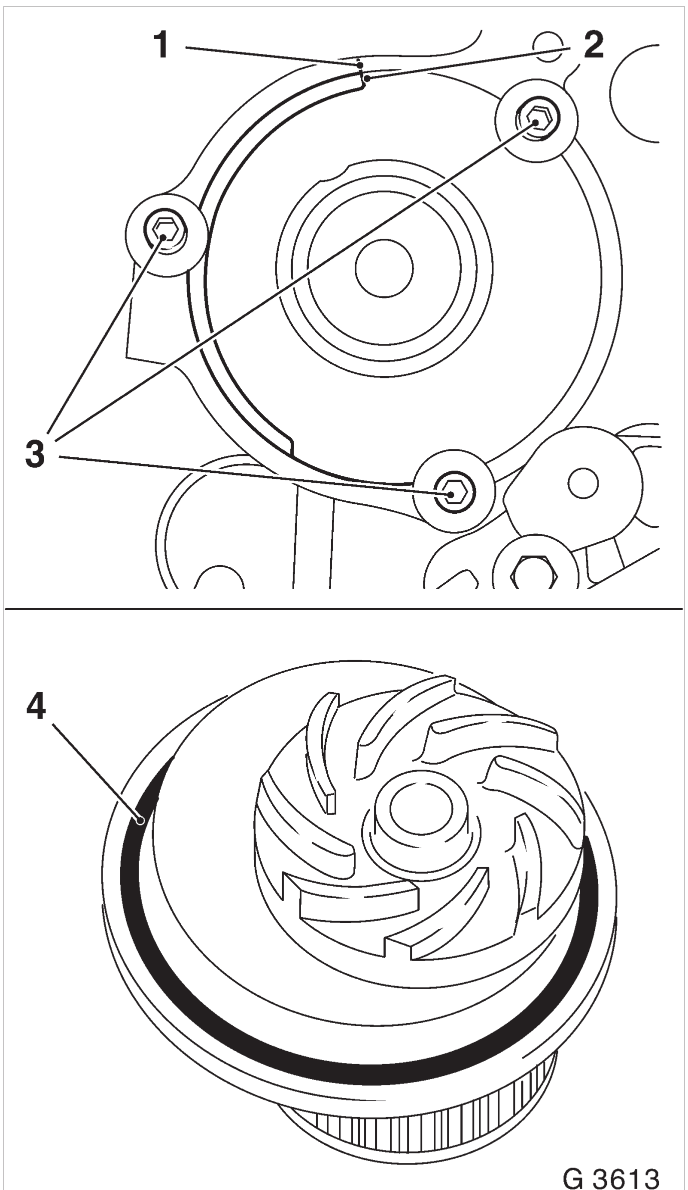
Install, Connect

Install rear toothed belt cover – see operation ”Toothed Belt Cover – Rear, Remove and Install”.
Install toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.
Install toothed belt – see operation ”Toothed Belt, Remove and Install”.
Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.
Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Install air cleaner housing with air intake cover.
Attach coolant hose to thermostat housing.
Close coolant drain bolt.

Coolant Pump, Remove and Install

Remove, Disconnect

Open coolant drain bolt – collect escaping coolant.
Remove air cleaner housing with air intake cover.
Remove upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Remove ribbed V–belts – see operation ”Ribbed V–belts, Remove and Install”.
Remove ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Remove lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.
Remove toothed belt – see operation ”Toothed Belt, Remove and Install”.
Remove toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.



G 3613

Remove, Disconnect

Remove rear toothed belt cover – see operation ”Rear Toothed Belt Cover, Remove and Install”. Remove fastening bolts (3) from coolant pump and remove coolant pump.

Clean

Remove gasket remnants and clean sealing surfaces.

Install, Connect

Before installing coolant pump, coat sealing surface (4) with silicon grease (white).
Attach coolant pump with new seal ring to cylinder block – tightening torque 8 Nm / 6 lbf. ft.
Mark (1) on cylinder block must align with mark (2) on coolant pump.
Install rear toothed belt cover – see operation ”Toothed Belt Cover – Rear, Remove and Install”.

Install, Connect

Install toothed belt tension roller – see operation ”Toothed Belt Tension Roller, Remove and Install”.
Install toothed belt – see operation ”Toothed Belt, Remove and Install”.
Install lower part of toothed belt cover – see operation ”Toothed Belt Cover – Lower Part, Remove and Install”.
Install ribbed V–belt tensioner – see operation ”Ribbed V–belt Tensioner, Remove and Install”.
Install ribbed V–belt – see operation ”Ribbed V–belt, Remove and Install”.
Install upper part of toothed belt cover – see operation ”Toothed Belt Cover – Upper Part, Remove and Install”.
Install air cleaner housing with air intake cover.
Close coolant drain bolt.

Inspect

Top up cooling system.

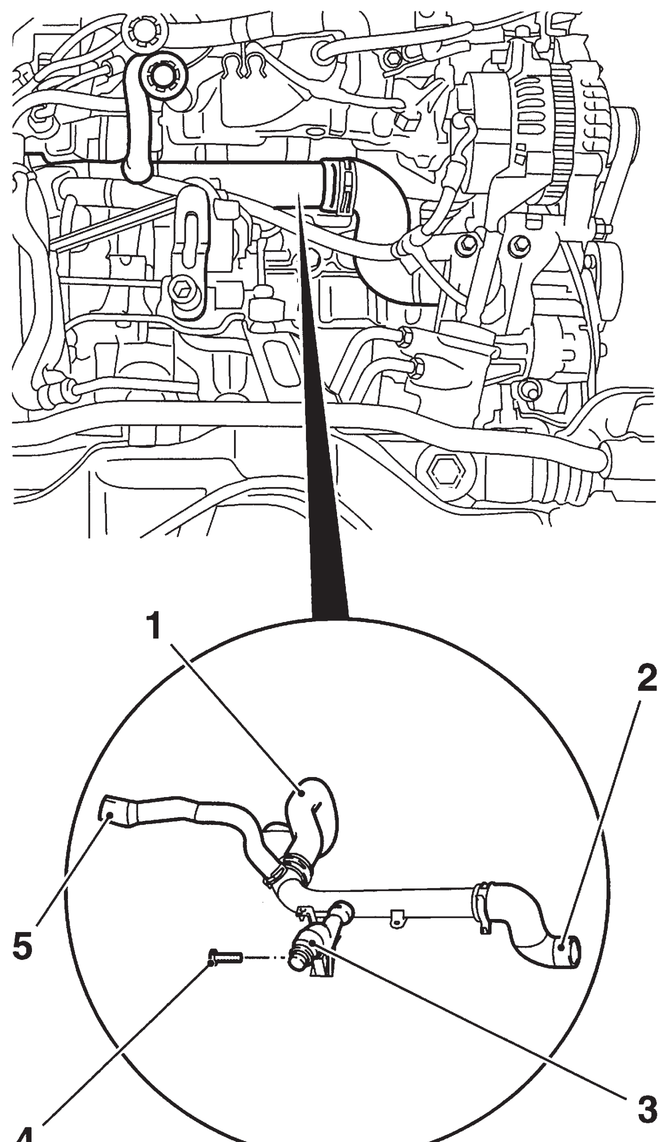
Coolant Pipe, Remove and Install

Note:

For a clearer representation, illustration L 1286 shows the coolant pipe on removed engine.

Remove, Disconnect

Remove air intake cover with air intake hose.
Remove lower coolant hose (1) from radiator – place collection pan underneath.
Release coolant hose (3) and detach from heater core.
Remove coolant hose (5) from coolant compensation tank and coolant hose (2) from coolant pump connection.
Remove all requisite cable ties and clips from coolant pipe.
Detach or disconnect knock sensor wiring harness plug and odometer sensor – expose wiring harness.
Remove fastening bolt (4) and remove coolant pipe.



L 1286

Install, Connect

Insert coolant pipe and attach to transmission – tightening torque 60 Nm / 44 lbf. ft.

Connect knock sensor wiring harness plug and odometer sensor – note cable routing.

Attach coolant hoses to coolant pump connection, coolant compensation tank and radiator – ensure correct hose positioning and seating.

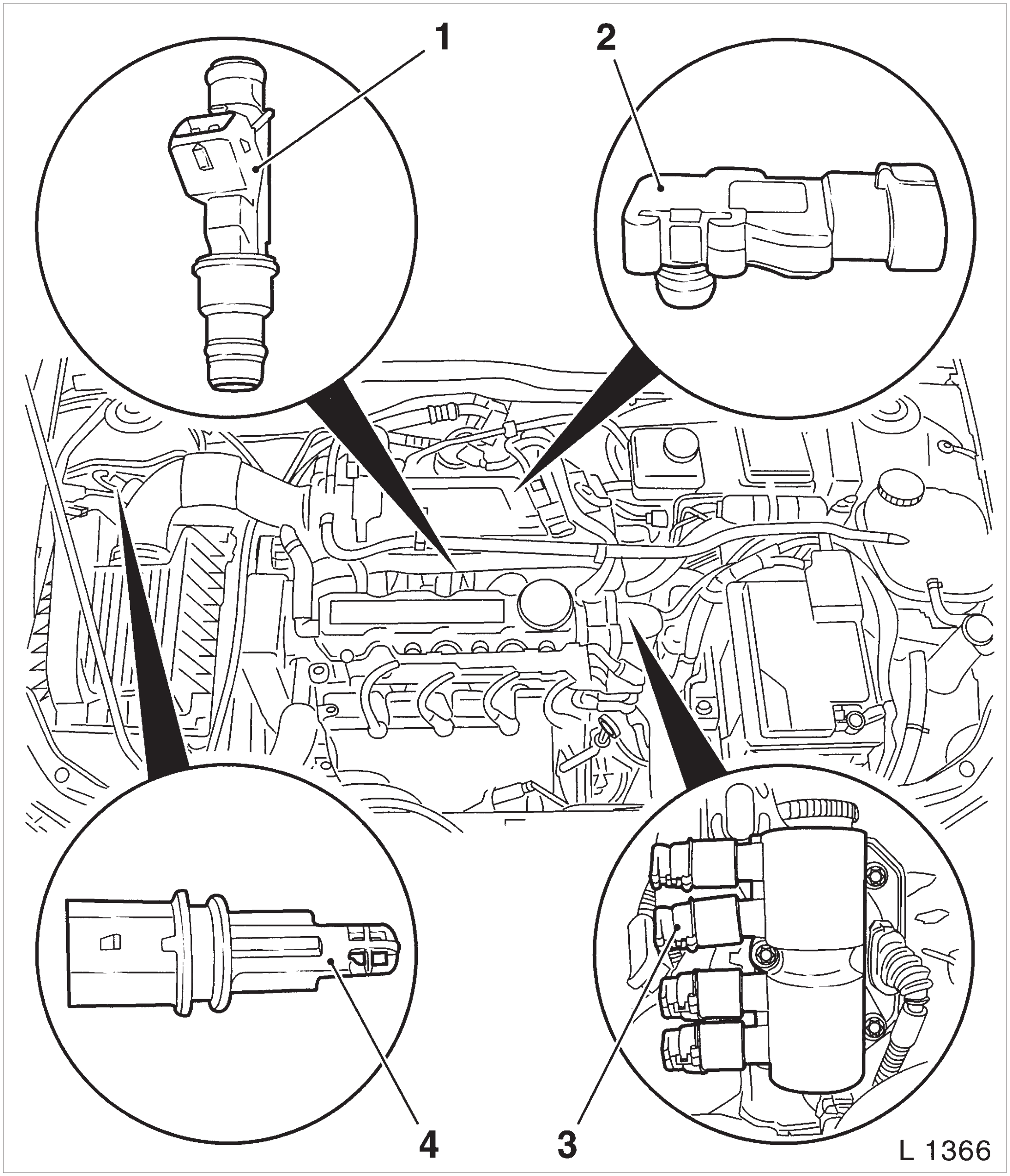
Attach and lock coolant hose to heater core.

Attach cable ties and clips at original point.

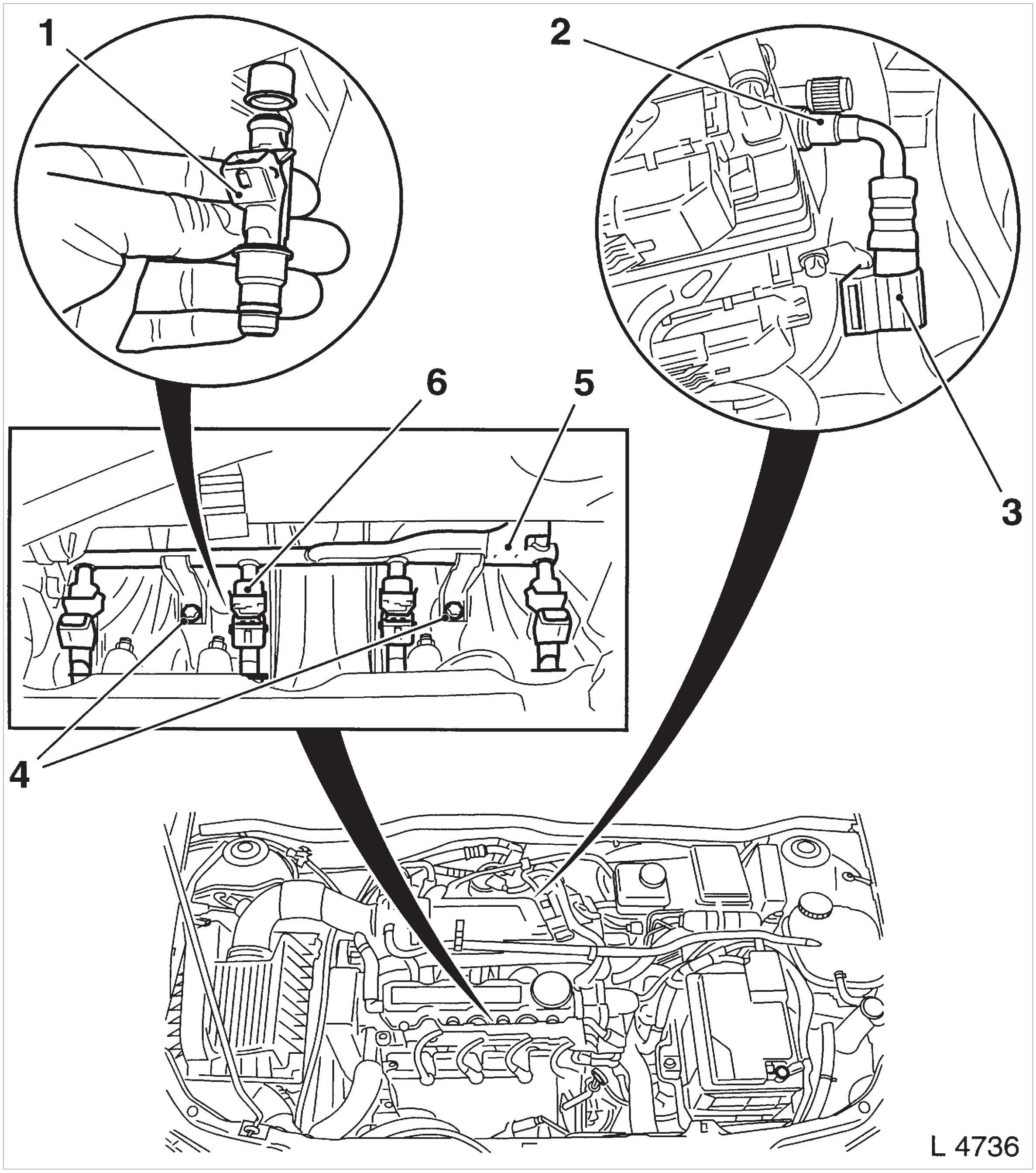
Install air intake cover with air intake hose.

Inspect

Top up cooling system – see operations ”Cooling System, Top Up and Bleed” and ”Cooling System, Check for Leaks”.



Engine Compartment Survey (Continued)
1. Injectors
2. Intake manifold pressure sensor
3. DIS ignition module
4. Intake air temperature sensor



Fuel Injector/Rail Remove

Remove, Disconnect

Detach fuel line (2) from fuel distributor pipe (5) and unclip from bracket (3).

Remove fuel distributor pipe fastening bolts (4) and pull fuel distributor pipe with injectors from intake manifold.

Remove each injector (1) from fuel distributor pipe remove spring clip (6).

Fuel Injector/Rail Install

Install, Connect

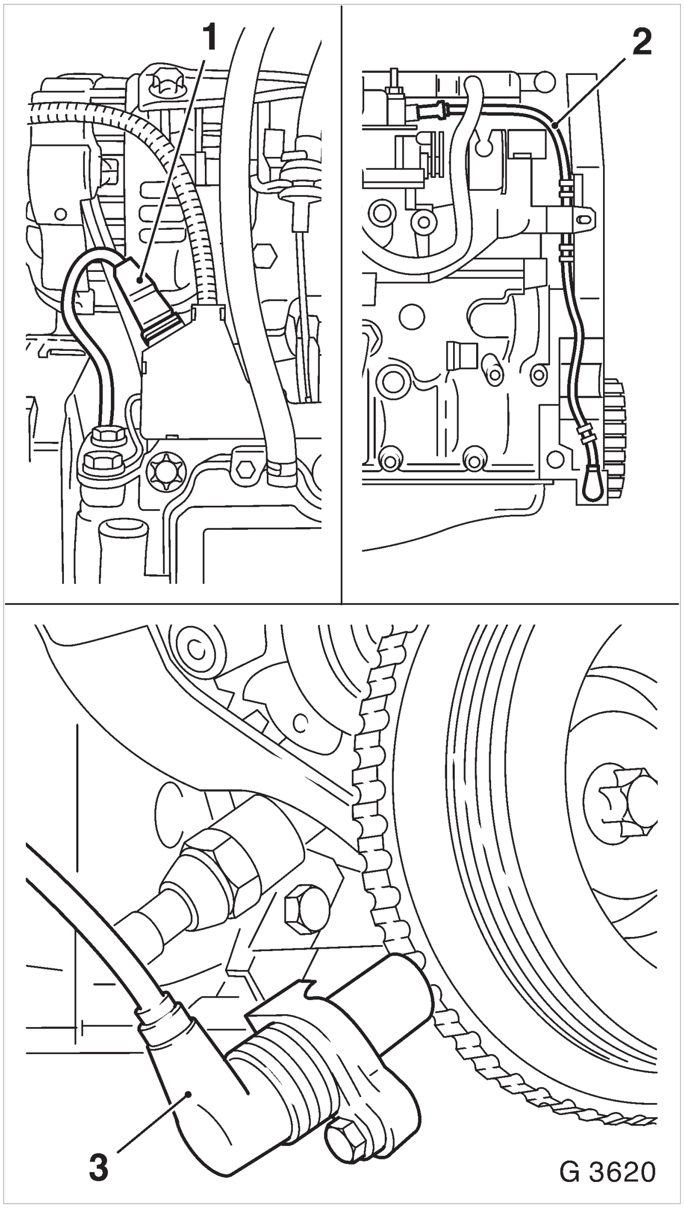
Insert injector in fuel distributor pipe with new seal rings – secure with spring clip.

Insert fuel distributor pipe with injectors in intake manifold and attach to intake manifold with fastening bolts – tightening torque 4 Nm / 3 lbf. ft.

Install, Connect

Attach fuel line to fuel distributor pipe and clip in bracket.

Connect wiring harness plugs to injectors and route wiring harness.



Crankshaft Position Sensor, Remove and Install

Remove, Disconnect

Remove air cleaner housing with air intake cover. Disconnect wiring harness plug for crankshaft pulse pickup (1). Remove cable for crankshaft pulse pickup (2) from the rear toothed belt cover. Remove crankshaft position sensor (3) from bracket.

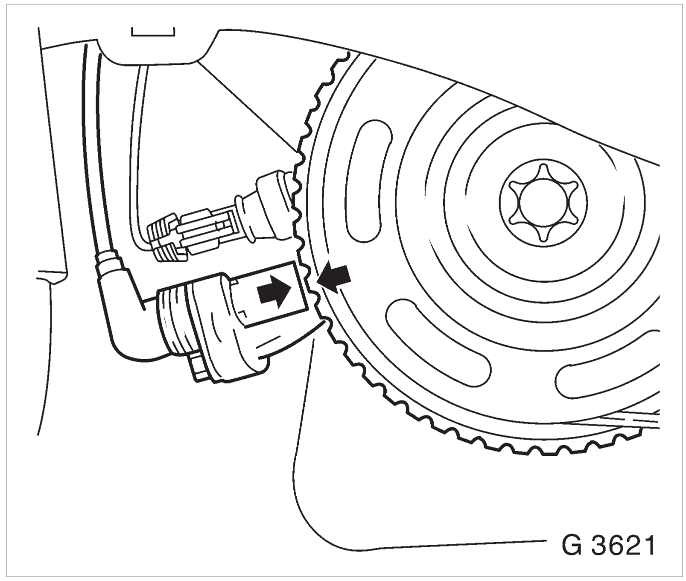
Install, Connect

Attach crankshaft position sensor to bracket – 8 Nm / 6 lbf. ft. Insert crankshaft pulse pickup cable in rear toothed belt cover. Connect wiring harness plug for crankshaft position sensor – ensure that cable routing is correct.
Install air cleaner housing with air intake cover.

Inspect

Check gap between crankshaft position sensor and reluctor ring – see operation ”Gap between Crankshaft Position Sensor and Reluctor Ring.

Reference Gap Between Crankshaft Pulse Pickup and Increment Disc, Check



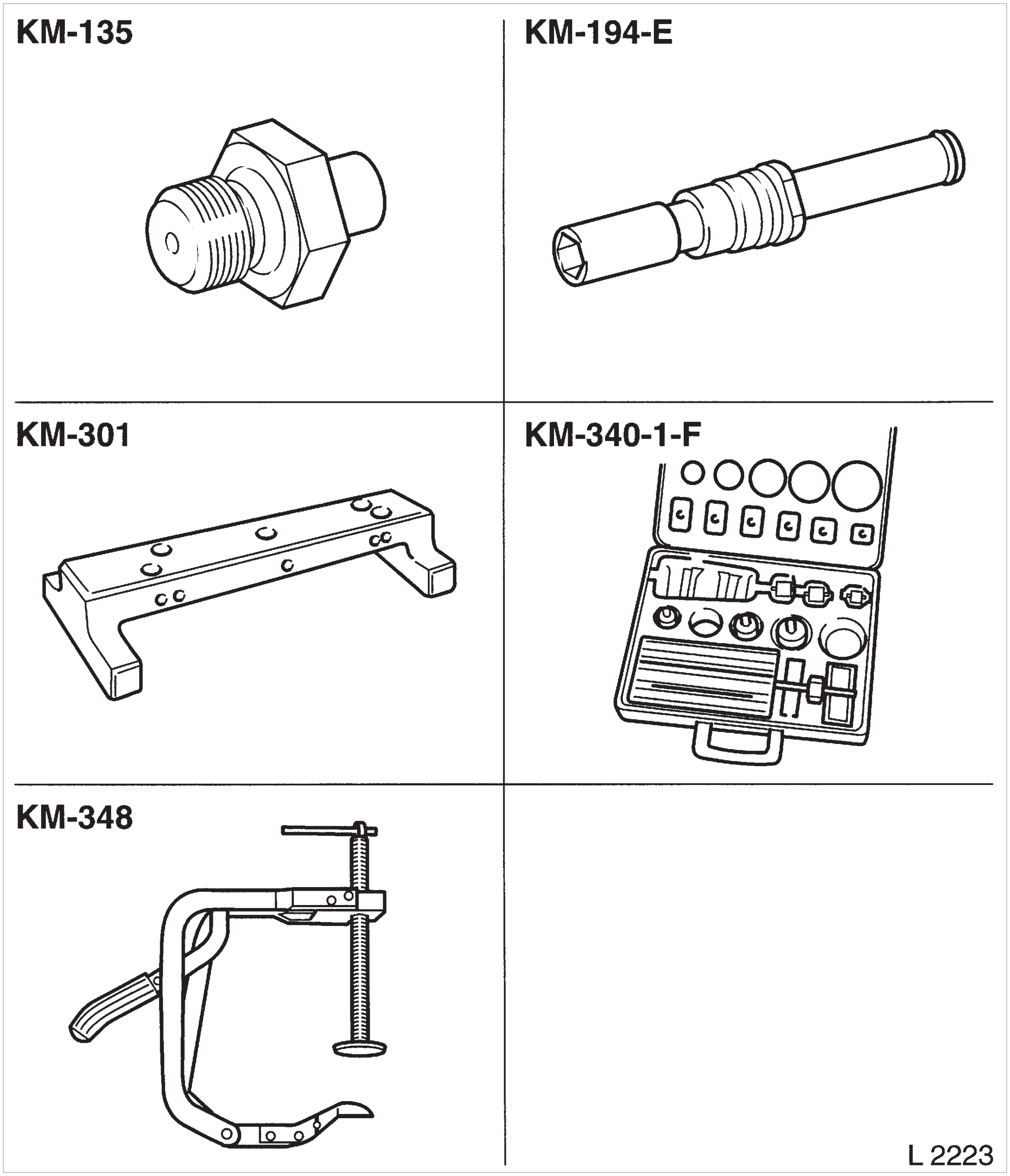
Measure

Measure distance between crankshaft position sensor and reluctor ring with feeler gauge.
Nominal value: 1,0 +/-0.7 mm.
With incorrect gap – replace bracket for crankshaft position sensor.

Tighten (Torque)

Crankshaft position sensor bracket to oil pump housing – 10 Nm / 7 lbf. ft.

Special Service Tools



KM–135 Adapter
To measure engine oil pressure in conjunction with KM–498–B

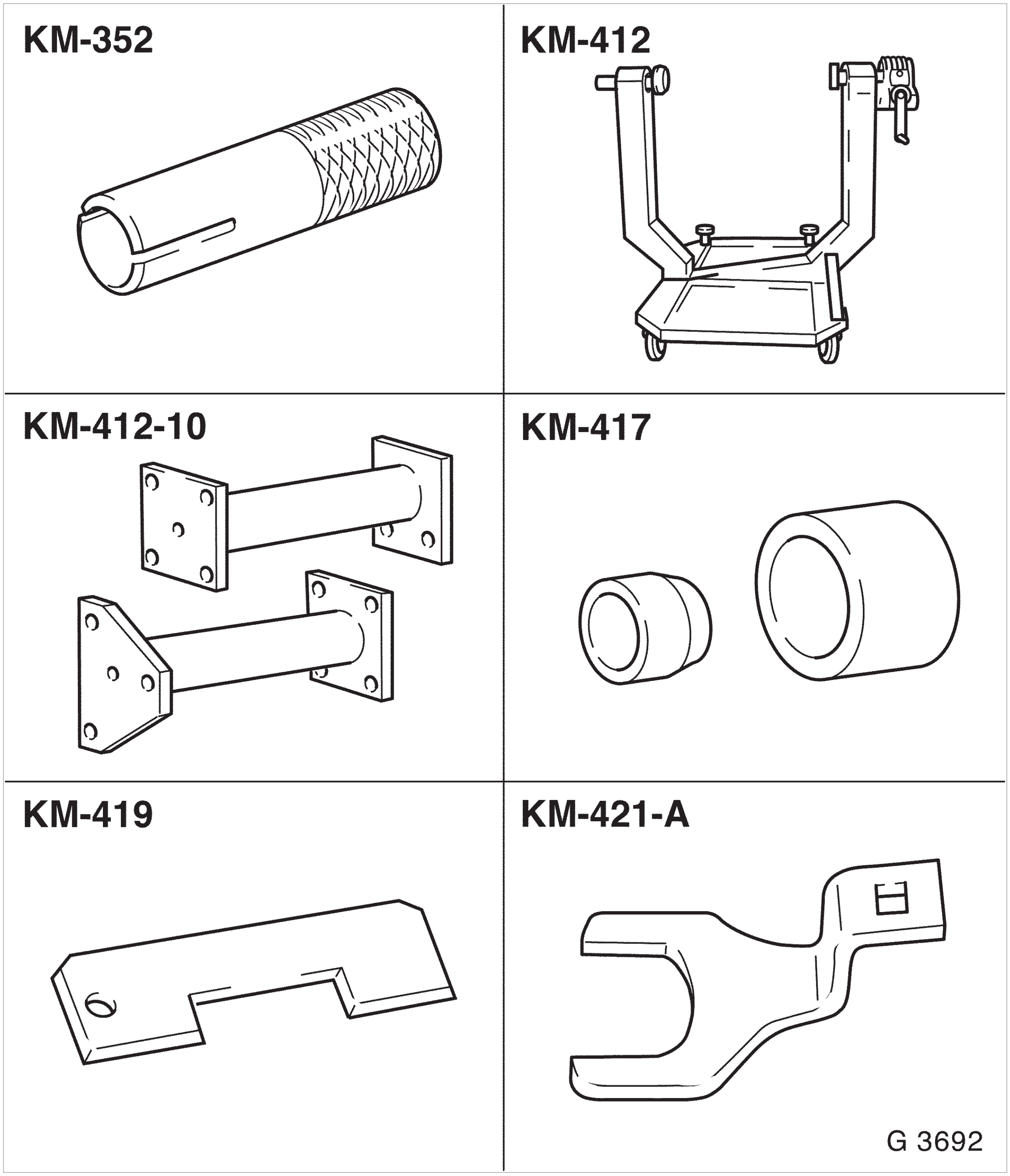
KM–194–E Spark Plug Key
To remove and install spark plugs, A/F 16 mm

KM–301 Gauge Bar
To check piston projection

KM–340–1–F Cutter Set
To mill, rework valve seats

KM–348 Spring Compressor
To compress valve springs, cylinder head removed

Special Service Tools (Continued)



KM–352 Installer
To install valve stem sealing

KM–412 Engine Overhaul Stand
To hold removed engine

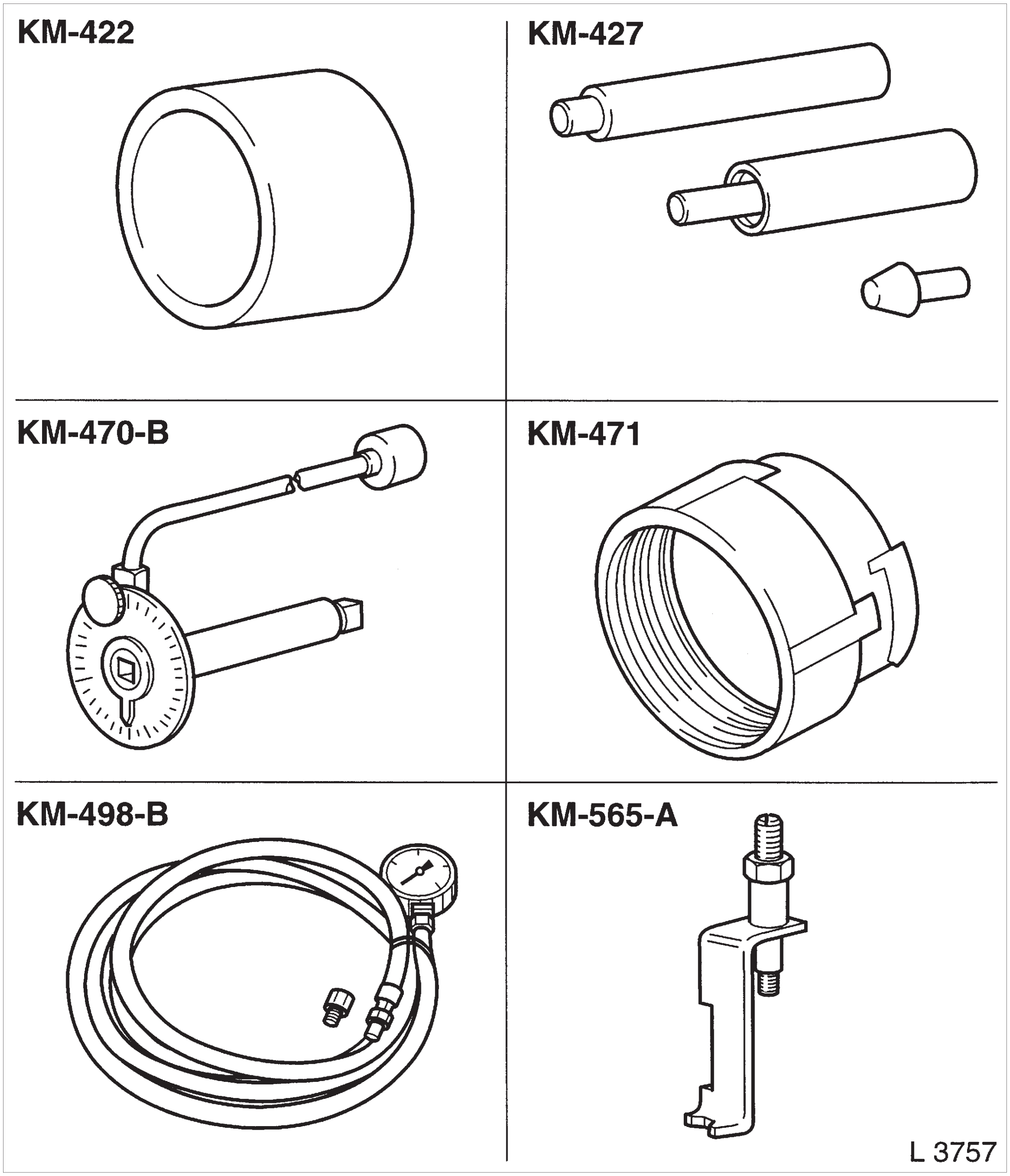
KM–412–10 Adapter
To hold engine in conjunction with KM–412

KM–417 Assembly Sleeves
To press crankshaft seal ring into oil pump housing

KM–419 Distance Gauge
To check valve stem projection

KM–421–A Adjusting Wrench
To adjust toothed belt tension

Special Service Tools (Continued)



KM–422 Installer
To press seal ring in camshaft housing

KM–427 Remover / Installer
To install guide pins into engine block

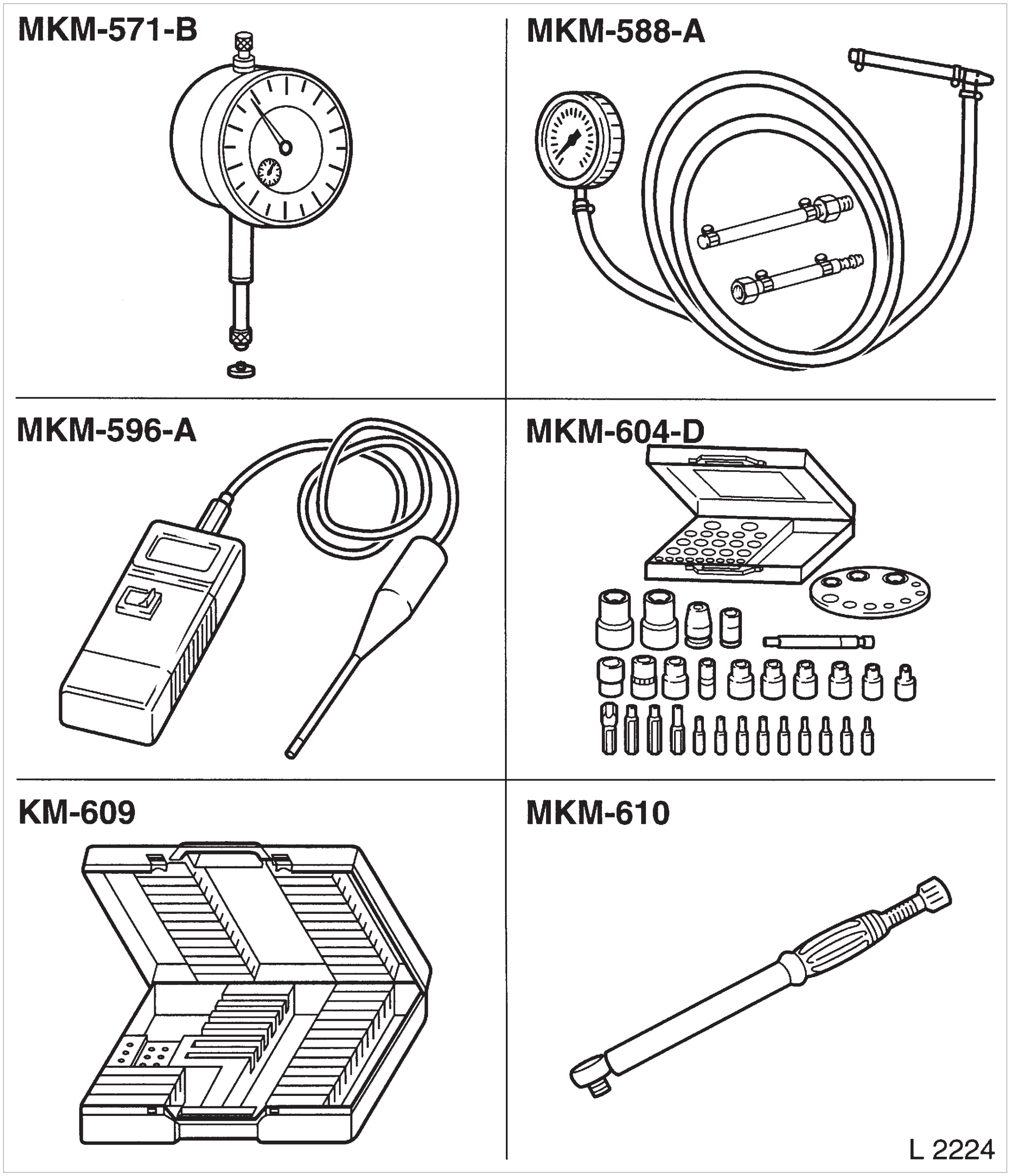
KM–470–B Angular Torque Wrench
To tighten cylinder head bolts

KM–471 Adapter
To check pressurized cooling system in conjunction with cooling system tester

KM–498–B Oil pressure gauge
To check engine oil pressure in conjunction with KM–135

KM–565–A Remover / Installer
To remove and install rocker arms and valve play compensator

Special Service Tools (Continued)



MKM–571–B Dial Gauge
To measure piston projection

MKM–588–A Pressure Gauge
To check fuel pressure

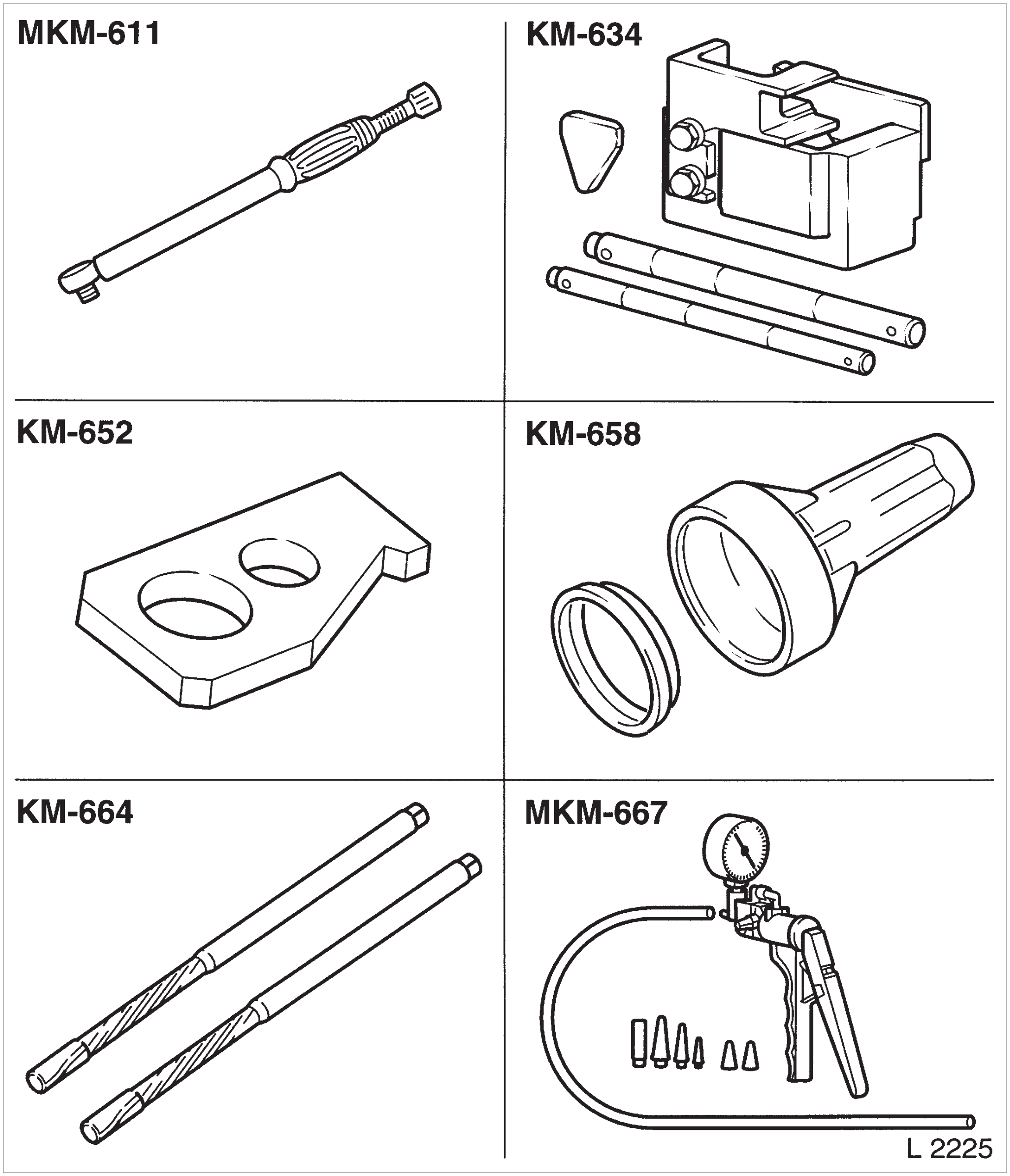
MKM–596–A Temperature Gauge
To measure oil temperature, exhaust gas special test (German AU)

MKM–604–D Torx Bit and Socket Set
To remove/install Torx bolts

KM–609 Electronic Kit I
Diagnosis of electric and electronic systems

MKM–610 Torque Wrench, 1/2”
Range 30 – 130 Nm / 22 – 96 lb. ft.

Special Service Tools (Continued)



MKM–611 Torque Wrench, 3/8”
Range 10 – 60 Nm / 7 – 44 lb. ft.

KM–634 Remover / Installer
To remove/install piston pin

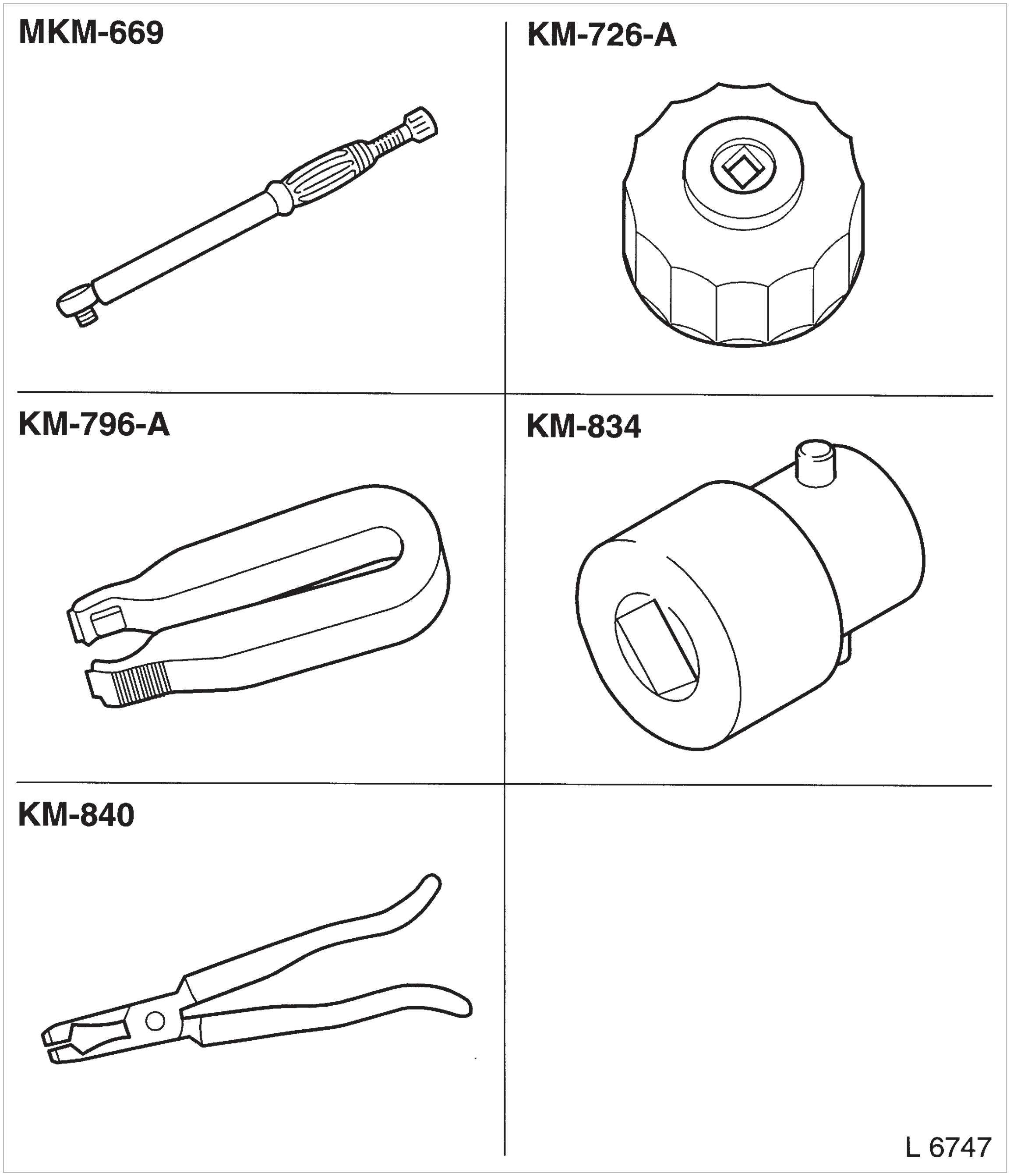
KM–652 Flywheel Holder
To lock flywheel/drive disc

KM–658 Installer
To install crankshaft rear seal ring

KM–664 Reamer Set 7 mm
Valve guide ream (j 7 mm)

MKM–667 Pressure and Vacuum Pump
To check for leaks in vacuum unit

Special Service Tools (Continued)



MKM–669 Torque Wrench, 1/2”
Range 50 – 300 Nm / 37 – 221 lbf. ft.

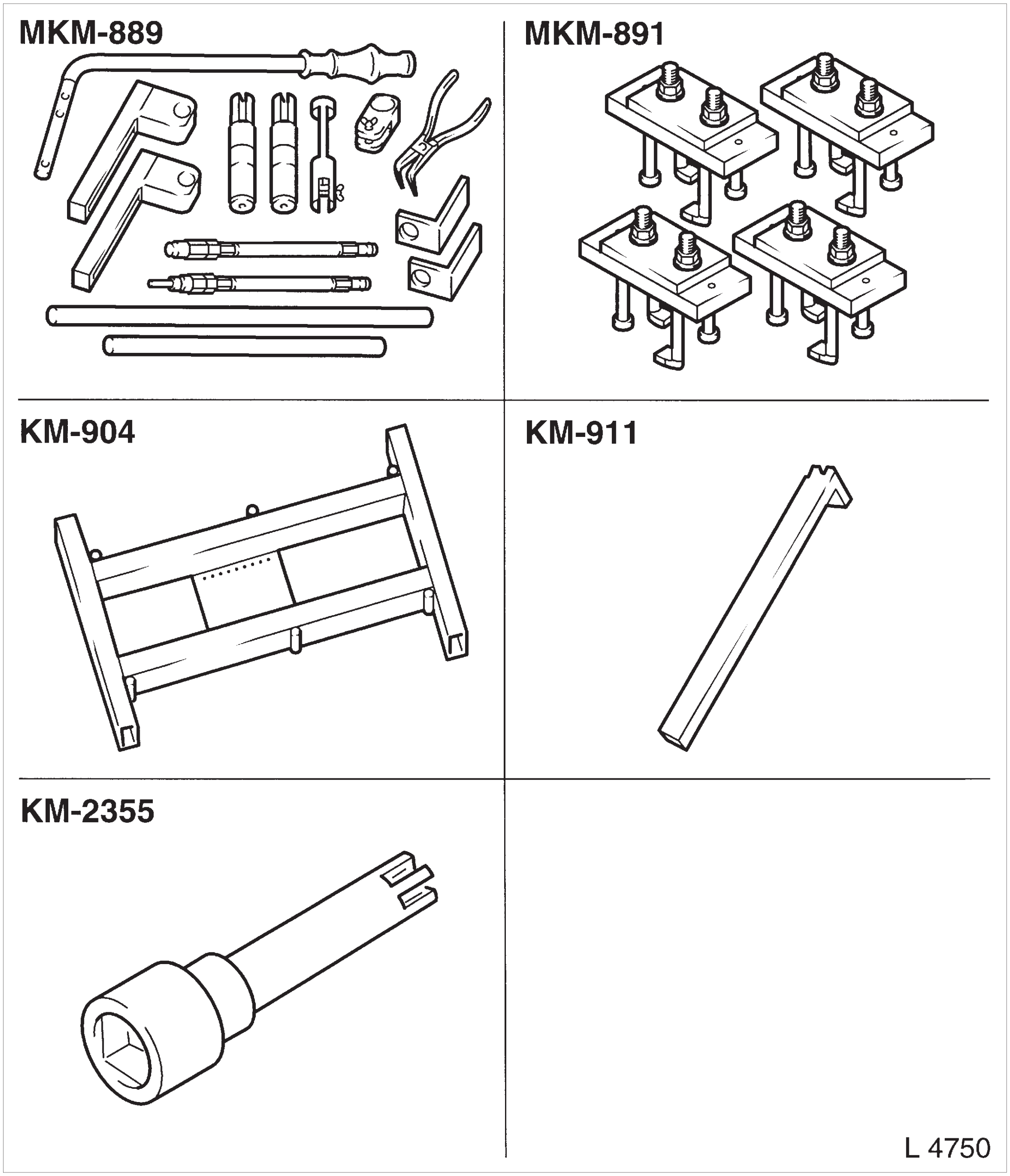
KM–726–A Oil Filter Wrench
To remove/install the oil filter

KM–796–A Remover
To open quick fittings for fuel lines

KM–834–A Remover / Installer
To remove and install heat sleeves

KM–840 Remover
To remove valve stem seal

Special Service Tools (Continued)



MKM–889 Automatic Valve Spring Lever

To remove/install the valve stem seals (cylinder head installed)

MKM–891 Valve Lifter Depressor

To remove/install camshaft (cylinder head installed)

KM–904 Base Frame

To remove and install various vehicle components with additional adapters

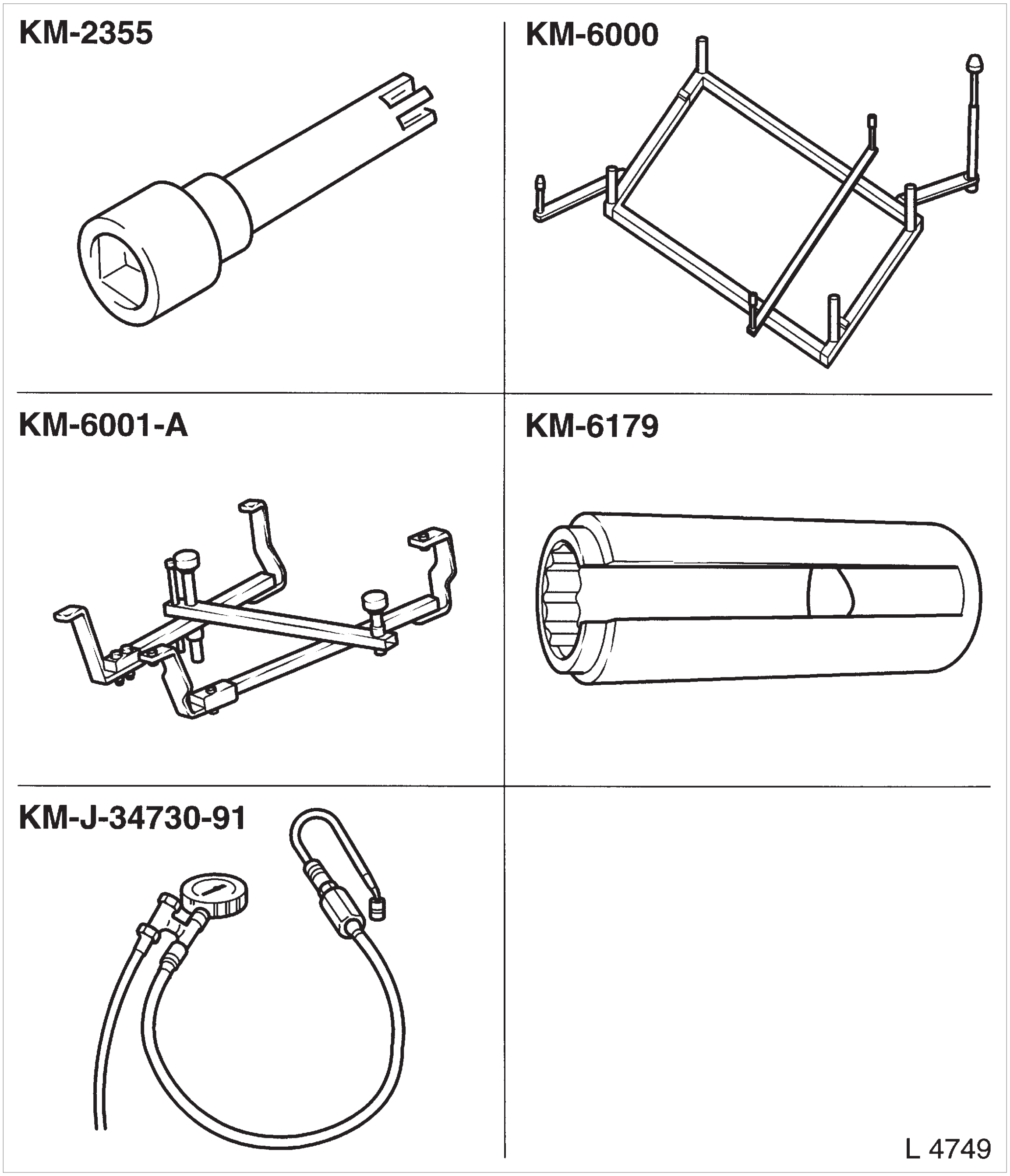
KM–911 Flywheel Holder

To lock flywheel/drive disc

KM–2355 Socket Wrench T55

To loosen/tighten cylinder head bolts

Special Service Tools (Continued)



KM–6000 Centering Tool

To remove and install front axle in conjunction with KM–904

KM–6001–A Engine Mount

To align engine to body in conjunction with KM–6173

KM–6173 Engine Mount

To support engine on front axle body in conjunction with KM–6001–A

KM–6179 Remover / Installer

To remove and install oxygen sensor

KM–J–34730–91 Pressure Tester

To check fuel pressure

Sealants, Lubricants and Locking Compounds

Description	Applications	Catalogue Number	Part number
Surface sealant (green)	To install camshaft housing	15 03 170	90 542 114
Adhesive sealing compound (black)	To install oil pan, oil pump and 5th crankshaft bearing cap	15 03 295	90 485 251
MoS_2 – lubricating paste (grey)	Lubricating paste for hydraulic valve lifter, cam follower and camshaft	19 48 565	90 018 024
Screw locking compound (red)	Locking compound for adhesion of screw connections	15 10 181	90 542 117

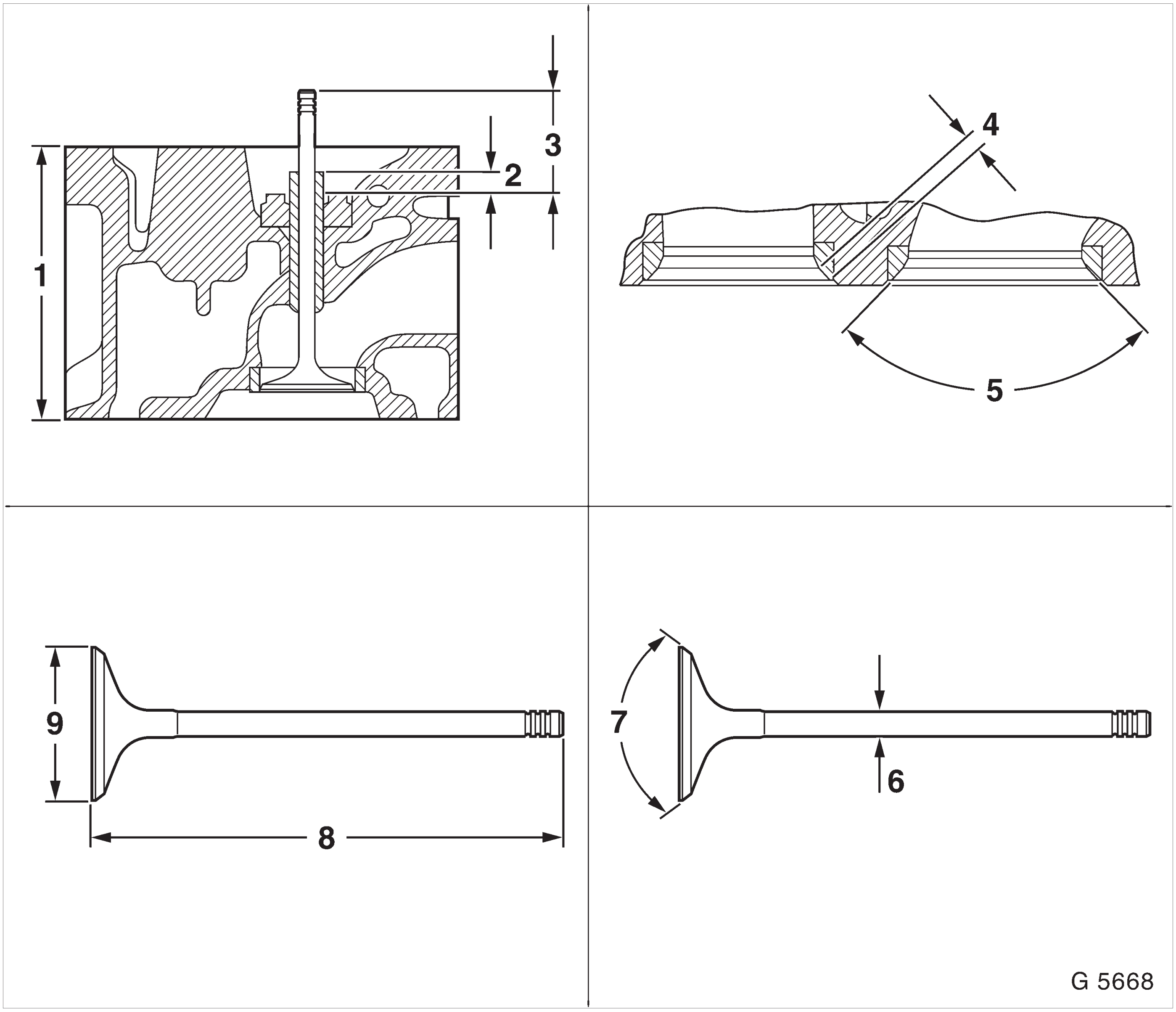
Sealants, Lubricants and Locking Compounds (Continued)

Description	Applications	Catalogue Number	Part number
Silicon grease (white)	To install seal rings	19 70 206	90 167 353
Special grease (black)	Installation of oxygen sensor	19 48 602	90 295 397
Assembly paste (white)	To install heat shield sleeves and front exhaust pipe (bolts)	19 48 569	90 513 210
Grease (brown)	Multi–purpose grease for alternator, starter, etc.	19 48 606	90 510 336

Technical Data

Specifications

Engine		Z 16 SE
No. of cylinders/layout		4 in line
No. of valves		8
Capacity	cm^3	1599
Bore diameter	mm	79
Stroke	mm	81.5
Power output	kW / rpm	62 / 5400
Torque	Nm / rpm	138 / 2600
Compression		9.6 : 1



Cylinder Head

Illustration
1 Cylinder head height
2 Installation height of valve guide
3 Installation height of valve
4 Valve seat width in cylinder head
5 Valve seat angle in cylinder head
6 Valve stem diameter
7 Valve seat angle at valve
8 Valve length
9 Valve head – diameter

Cylinder Head (Continued)

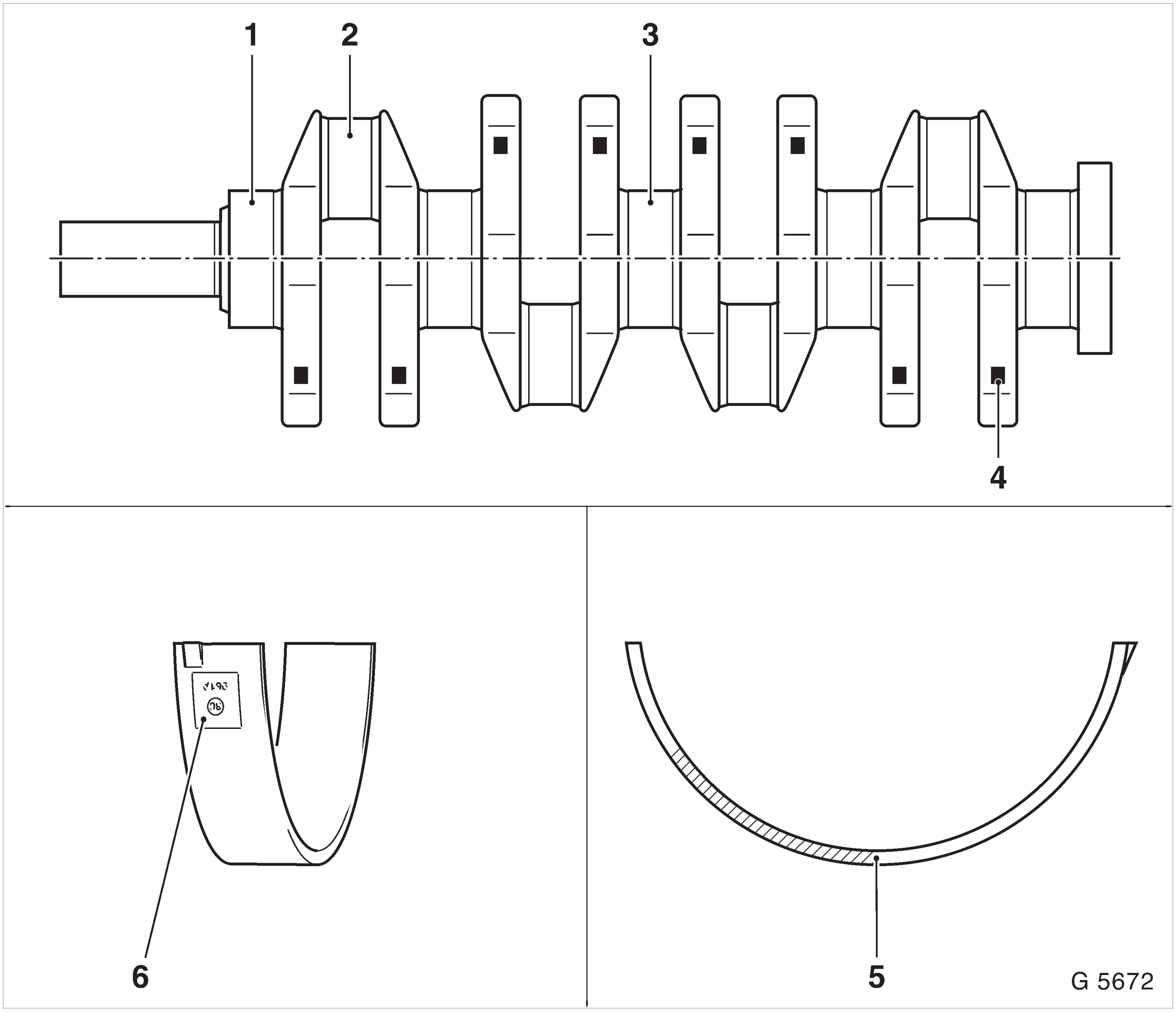
Engine		1.6L
Cylinder head height [1]	mm	95.90 – 96.10
Valve seat width in cylinder head		
Intake valve	mm	1.3 – 1.5
Exhaust valve	mm	1.6 – 1.8
Valve seat angle in cylinder head		90°
Valve guide inside diameter		
Standard size	mm	7.030 – 7.050
Oversize (0.075)	mm	7.105 – 7.125
Oversize (0.150)	mm	7.180 – 7.200
Length of valve guide		
Intake valve	mm	45.5
Exhaust valve	mm	45.5
Installation height of valve guide	mm	80.85 – 81.25
Installation height of valves	mm	13.75 – 14.35

Engine		1.6L
Valve length		
Standard size		
Intake valve (GM)	mm	101.65 – 101.95
Exhaust valve (GM)	mm	101.15 – 101.85
Oversize (0.075)		
Intake valve (GM K1)	mm	101.25 – 101.55
Exhaust valve (GM K1)	mm	100.75 – 101.45
Oversize (0.150)		
Intake valve (GM K2)	mm	101.25 – 101.55
Exhaust valve (GM K2)	mm	100.75 – 101.45
Valve stem		
Standard size		
Intake valve (GM)	mm	6.998 – 7.012
Exhaust valve (GM)	mm	6.978 – 6.992
Oversize (0.075)		
Intake valve (GMK1)	mm	7.073 – 7.087
Exhaust valve (GMK1)	mm	7.053 – 7.067
Oversize (0.150)		
Intake valve (GM K2)	mm	7.148 – 7.162
Exhaust valve (GM K2)	mm	7.128 – 7.142

Cylinder Head (Continued)

Engine		1.6L
Valve stem play		
Intake valve	mm	0.018– 0.052
Exhaust valve	mm	0.038– 0.072
Perm.runout of the valve stem	mm	0.03
ØValve head		
Intake valve	mm	35.0
Exhaust valve	mm	31.0
Valve seat angle at valve head		92°
Valve rotator		
Intake valve		none
Exhaust valve		none

Engine		1.6L
Camshaft		
Camlift		
Intake	mm	9.09
Exhaust	mm	9.99



Crank Drive, Cylinder Block

Illustration

1 Main Bearing Journals
2 Con–rod bearing journal
3 Main Bearing Journals (Guide Bearing)
4 Crankshaft color code
5 Bearing shell color code
6 Bearing shell identification

Crank Drive, Cylinder Block (Continued)

Engine		1.6L	
Crankshaft dimensions		Main Bearing Journals 1 – 5	Color code
Standard size	mm	54.980 – 54.997	brown
	mm	54.980 – 54.997	green
Undersize (0.25)	mm	54.730 – 54.747	brown / blue
	mm	54.730 – 54.747	green / blue
Undersize (0.50)	mm	54.482 – 54.495	brown / white
	mm	54.482 – 54.495	green / white
		Con–rod bearing journal 1 – 4	
Standard size	mm	42.971 – 42.987	–
Undersize (0.25)	mm	42.721 – 42.737	blue
Undersize (0.50)	mm	42.471 – 42.487	white
		Wide main bearing journals3 (guidebearing)	
Standard size	mm	26.000 – 26.052	–
Undersize (0.20)	mm	26.200 – 26.252	–
Undersize (0.40)	mm	26.400 – 26.452	

Crank Drive, Cylinder Block (Continued)

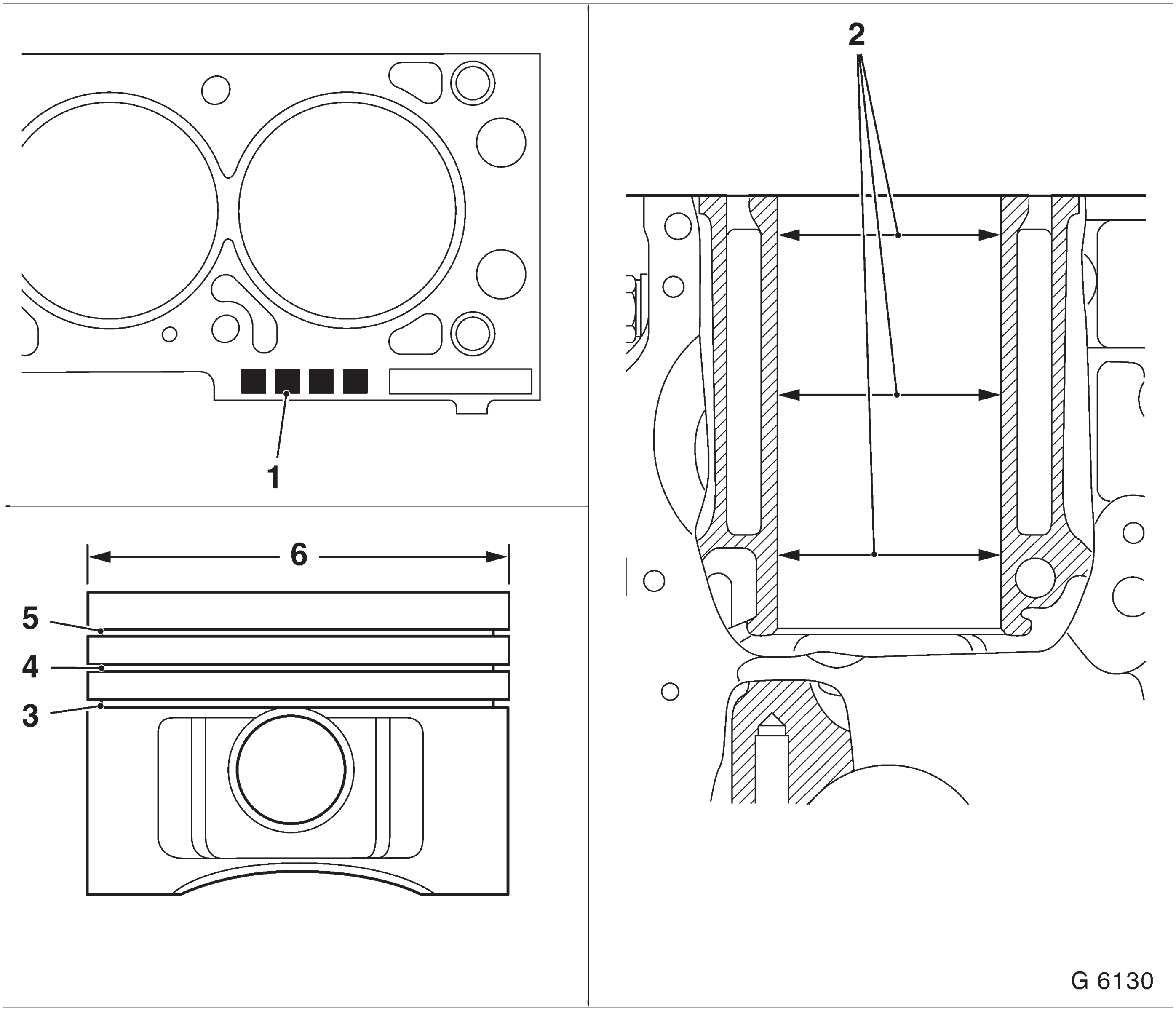
Engine		1.6L		
Crankshaft bearing 1, 2, 4, 5		Lower crankshaft bearing shell		
		Color code	Thickness	Code GM 400
Standard size	mm	brown	1.989–1.995	221 N
	mm	green	1.995–2.001	201 N
Undersize (0.25)	mm	brown / blue	2.114–2.120	222A
	mm	green/ blue	2.120–2.126	202A
Undersize (0.50)	mm	brown / white	2.239–2.245	223B
	mm	green/ white	2.245–2.251	203B
		Upper crankshaft bearing shell		
Standard size	mm	brown	1.989–1.995	221 N
	mm	green	1.995–2.001	201 N
Undersize (0.25)	mm	brown / blue	2.114–2.120	222A
	mm	green/ blue	2.120–2.126	202A
Undersize (0.50)	mm	brown / white	2.239–2.245	223B
	mm	green/ white	2.245–2.251	203B
Perm.crankshaft bearing clearance	mm	0.015–0.041		
Perm. crankshaft end clearance	mm	0.100–0.202		
Perm. out–of–round	mm	0.03		

Engine		1.6L		
Crankshaft bearing 3 (guide bearing)		Lower crankshaft bearing shell		
		Color code	Thickness	Code GM 400
Standard size	mm	brown	1.989–1.995	225 N
	mm	green	1.995–2.001	205 N
Undersize (0.25)	mm	brown / blue	2.114–2.120	225A
	mm	green/ blue	2.120–2.126	205A
Undersize (0.50)	mm	brown / white	2.239–2.245	227 B
	mm	green/ white	2.245–2.251	207 B
		Upper crankshaft bearing shell		
Standard size	mm	brown	1.989–1.995	225 N
	mm	green	1.995–2.001	205 N
Undersize (0.25)	mm	brown / blue	2.114–2.120	225A
	mm	green/ blue	2.120–2.126	205A
Undersize (0.50)	mm	brown / white	2.239–2.245	227 B
	mm	green/ white	2.245–2.251	207 B

Crank Drive, Cylinder Block (Continued)

Engine		1.6L		
3 wide main bearing journals (guide bearing)		Color code	Width	Code
Standard size	mm	green–brown	25.950–25.900	–
Undersize (0.25)	mm mm	brown / blue green/ blue	26.050–26.100	–
Undersize (0.50)	mm mm	brown / white green/ white	26.250–26.300	–

Engine		1.6L		
Con–rod bearing		Lower con–rod bearing shell		
		Color code	Thickness	Code GM 985.3
Standard size	mm	–	1.485–1.497	264 N
Undersize (0.25)	mm	blue	1.610–1.622	265 A
Undersize (0.50)	mm	white	1.735–1.747	266 B
		Upper con–rod bearing shell		
Standard size	mm	–	1.485–1.497	264 N
Undersize (0.25)	mm	blue	1.610–1.622	265 A
Undersize (0.50)	mm	white	1.735–1.747	266 B
Perm.con–rod play	mm	0.019–0.071		



Crank Drive, Cylinder Block (Continued)

Illustration

1 Index – identification of cylinder bore
2 Cylinder bore
3 Double bevelled ring with spiral–type expander
4 Tapered compression ring or double trapezoidal ring
5 Rectangular compression ring
6 Piston diameter

Crank Drive, Cylinder Block (Continued)

Engine			1.6L
Cylinderbore			
Standard size			
Index	8	mm	78.975–78.985
Index	99	mm	78.985–78.995
Index	00	mm	78.995–79.005
Index	01	mm	79.005–79.015
Index	02	mm	79.015–79.025
Oversize[1)]			
Index	7 + 0.5	mm	79.465–79.475
Piston			
Standard size			
Index	8	mm	78.955–78.965
Index	99	mm	78.965–78.975
Index	00	mm	78.975–78.985
Index	01	mm	78.985–78.995
Index	02	mm	78.995–79.005
Oversize			
Index	7 + 0.5	mm	79.445–79.455
Piston clearance		mm	0.01 – 0.03
Piston projection		mm	0.4

1) After reboring the old index must be invalidated and the new oversizing index must be embossed.

Crank Drive, Cylinder Block (Continued)

Engine		1.6L
Piston rings		
Rectangular compression ring		
Height	mm	1.20
Gap	mm	0.30– 0.50
Vertical play	mm	0.02– 0.04
Tapered compression ring		
Height	mm	1.50
Gap	mm	0.30– 0.50
Vertical play	mm	0.04– 0.06
Oil scraper ring		
Height	mm	3.00
Gap	mm	0.40–1.40
Vertical play	mm	0.01– 0.03
Ring gap distribution [1]		120

1) Arrange gap of upper oil scraper ring 25 to 50 mm offset to the left and gap of the lower ring 25 to 50 mm offset to the right relative to the gap of the lower intermediate ring.

Engine		1.6L
Pistonpin		
Length	mm	55
Diameter	mm	17.997– 18.000
Bearing		shrunkin con–rod
Clearance		
in piston	mm	0.009– 0.012
in con–rod	mm	0

Engine Management

Engine		1.6L
Designation		Multec–S
Ignition sequence		1-3-4-2
Spark plugs		FLR 8 LDCU

Recommended Torque Values

	Nm
Starter to transmission	40
Starter to cylinder block	25
Exhaust manifold to cylinder head	22 2)
Camshaft sensor fastening bolt to camshaft housing	16
DIS Ignition Module to camshaft housing carrier	8
Throttle body to intake manifold	9
Pressure plate to camshaft housing	8

1) Use new bolts.
2) Use new nut(s).

Recommended Torque Values (Continued)

	Nm
Dynamic oil level control to oil pan	8[1]
Intake manifold to cylinder head	22[2]
Alternator to altemator support	35
Alternator to alternator shackle	20
Transmission to cylinder block	60
Alternator support to cylinder block	35
Engine damping block support to cylinder block	50
Crankshaft position sensor bracket to oil pump	10
Wiring harness bracket to intake manifold	20

1) Recut thread before reuse and insert bolts with screw locking compound (red). The install tion time including the torque check is max. 10 min.
2) Use new nut(s).

Recommended Torque Values (Continued)

	Nm
Rear toothed belt cover to camshaft housing	6
Rear toothed belt cover to oil pump and camshaft housing	6
Heat shield to exhaust manifold	8
Crankshaft position sensor to bracket	8
Pulley/Reluctor ring to toothed belt drive gear	95 + 30° + 15° 1)

1) Use new bolts.

	Nm
Wiring trough to cylinderhead	8
V–belt tensioner to alternator support	25
Knock sensor to cylinder block	20
Fuel distributor tube to intake manifold	4
Fuel supply and return line to throttle valve guards	15
Coolant pump to cylinderblock	8
Coolant pipe to transmission	60
Coolant pipe to cylinder block	20
Crankshaft bearing cap to cylinder block	50 + 45° + 15° 1)
Oxygen sensor to exhaust manifold	40

1) Use new bolts.

Recommended Torque Values (Continued)

	Nm
Alternator shackle to intake manifold	20
Camshaft housing cover to camshaft housing	8
Camshaft sprocket to camshaft	45
Oil drain bolt to oil pan	55
Oil pressure switch to oil pump	30

Recommended Torque Values (Continued)

	Nm
Oil filter to oil pump	15
Oil pump to cylinder block	10
Oil pump cover to oil pump	6
Oil intake pipe to oil pump	8[1)]
Oil intake pipe to cylinder block	8
Oil baffle plate to oil pan	8
Oil pan to transmission	40
Oil pan to oil pump	10[1)]
Oil pan to cylinder block	10[1)]
Con–rod bearing cap to con–rod	25 + 30°[3)]

1) Recut thread before reuse and insert bolts with screw locking compound (red). The installa tion time including the torque check is max. 10 min.
2) Use new nut(s).
3) Use new bolts.

Recommended Torque Values (Continued)

	Nm
Hose clamps for air intake hose	3.5
Flywheel to crankshaft	35 + 30° + 15°[1]
Coolant temperature sensor to intake manifold	20
Support to alternator and intake manifold	20
Thermostat housing to cylinder head	10
Carrier plate (DIS ignition module) to camshaft housing	12
Closure bolt, safety valve to oil pump	50
Front exhaust pipe to exhaust manifold (hex bolts)	35[2]
Front exhaust pipe to exhaust manifold (hex nuts)	45[3]

1) Use new bolts.
2) Insert bolts with mounting paste (white).
3) Use new nut(s).

	Nm
Toothed belt cover – upper part to rear toothed belt cover	4
Toothed belt cover, lower part to rear toothed belt cover	4
Toothed belt tension roller to oil pump	20
Spark plug to cylinder head	25
Cylinder head and camshaft housing to cylinder block	25 + 60° + 60° + 60°[2]

1) Insert new bolt with screw locking compound (red).
2) Use new bolts.

PSI 1.6L PFI FUEL SYSTEM DESCRIPTION OF OPERATION

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DESCRIPTION AND OPERATION OF THE FUEL SYSTEMS

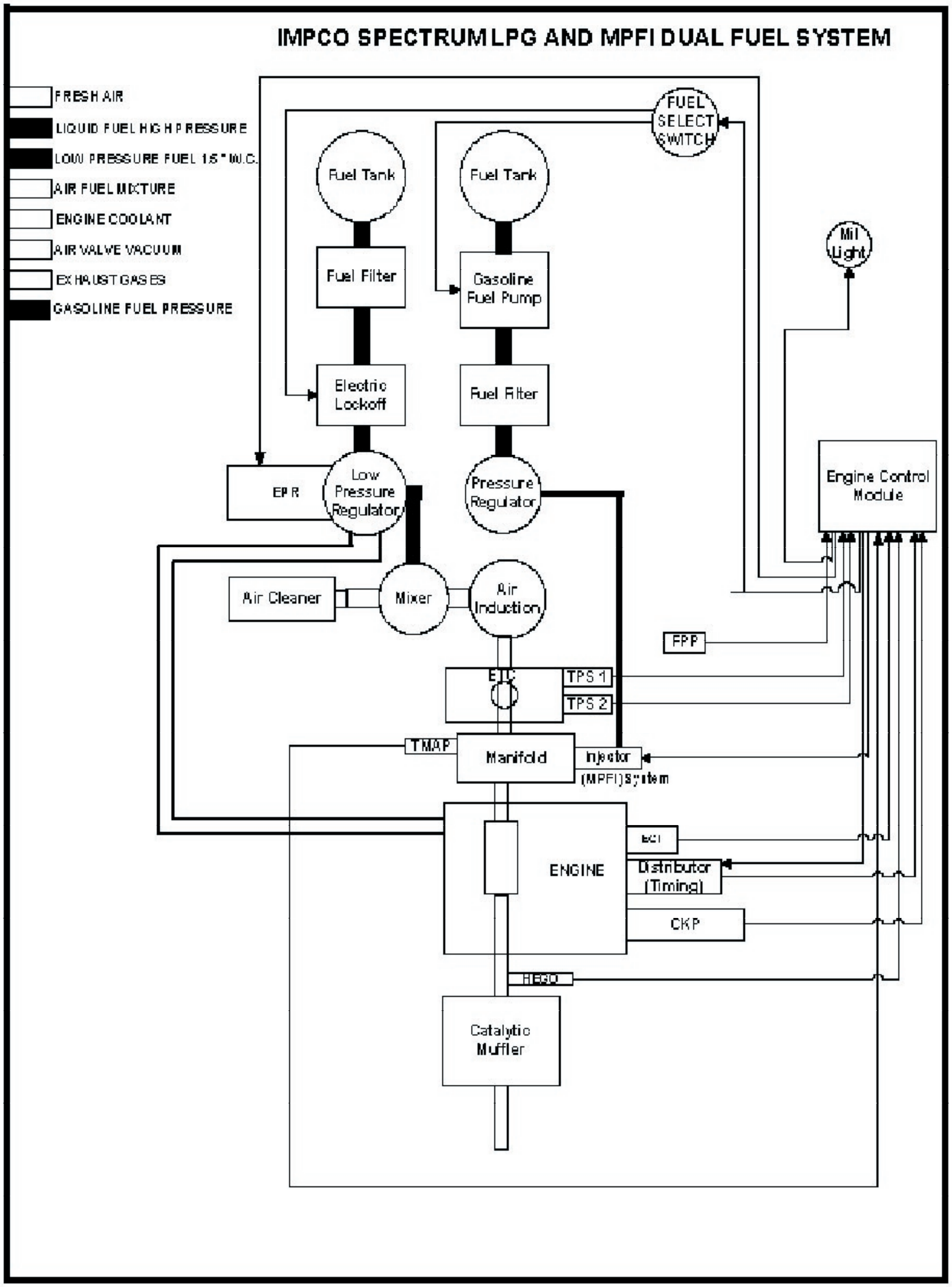


Figure 1 - *Typical IMPCO Dual Fuel System Schematic*

FUEL SYSTEM

The IMPCO 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.

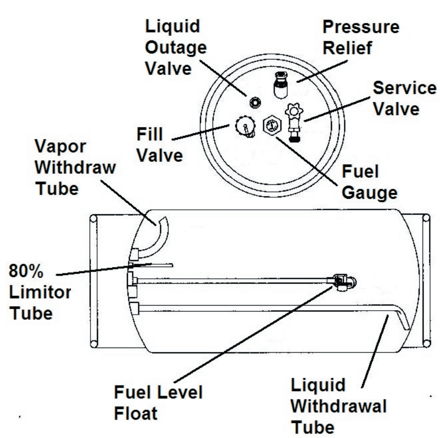


Figure 2
Typical Propane Cylinders

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.

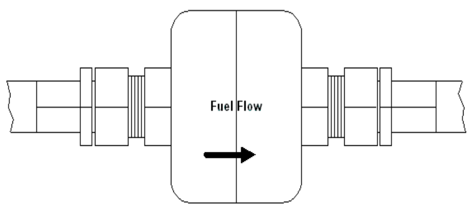


Figure 3
Inline Fuel Filter

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).

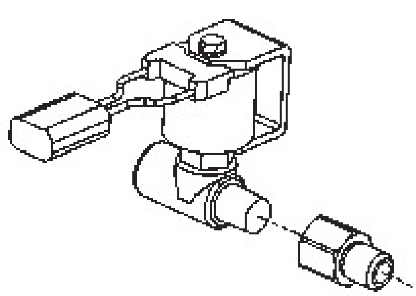
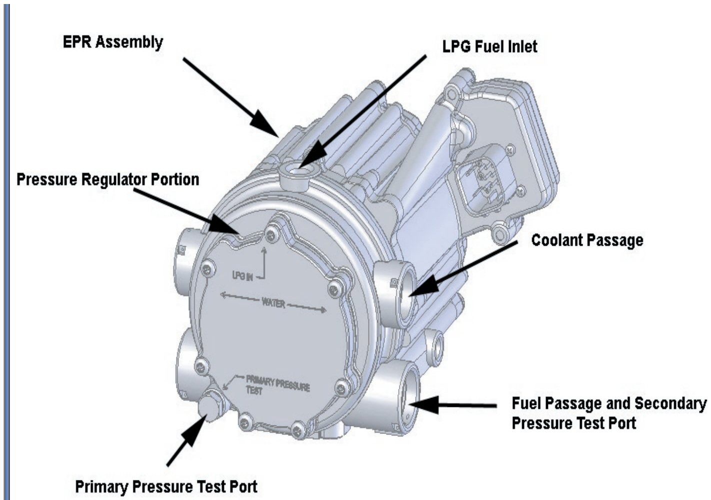


Figure 4
Electric Fuel Lock Off

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

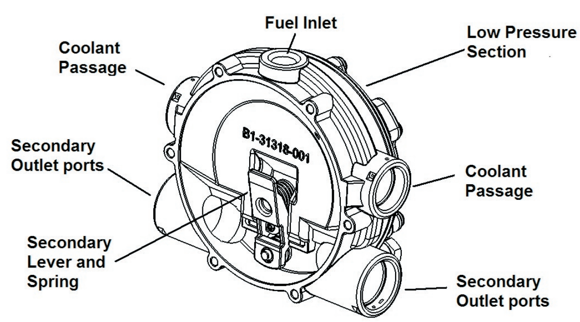


Figure 5
Low pressure regulators

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.

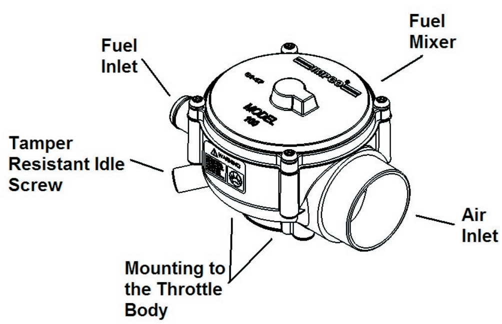


Figure 6
Air Fuel Mixer

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.

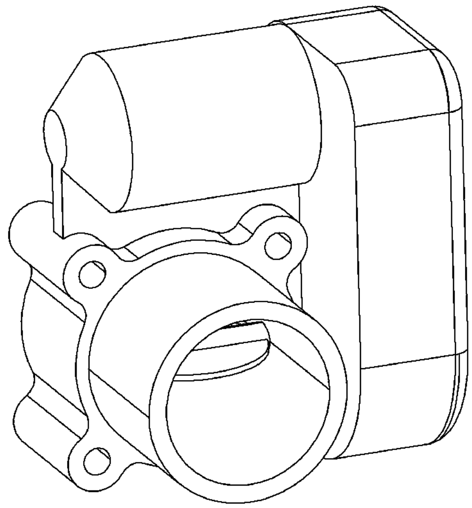


Figure 8
ETC throttle control device

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.

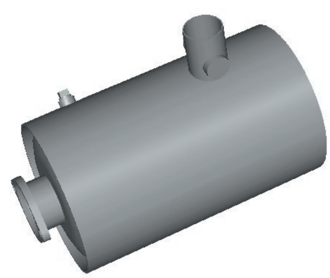


Figure 9
Three way catalytic converter

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.

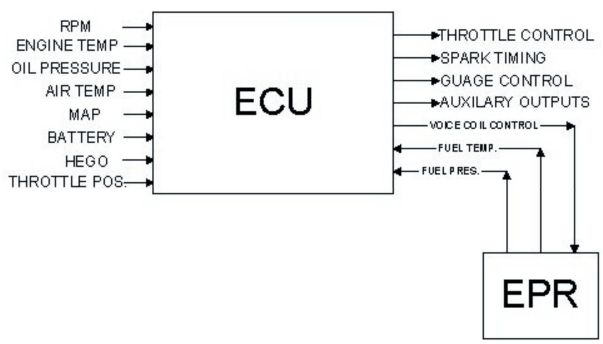


Figure 10
LPG Engine Control Unit (ECM)

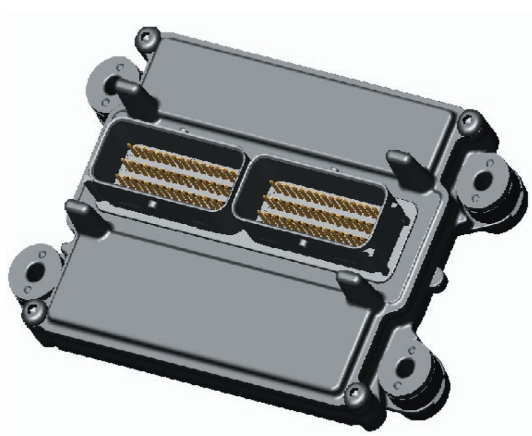


Figure 11
ECM Assembly

HEATED EXHAUST GAS OXYGEN SENSOR

The 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

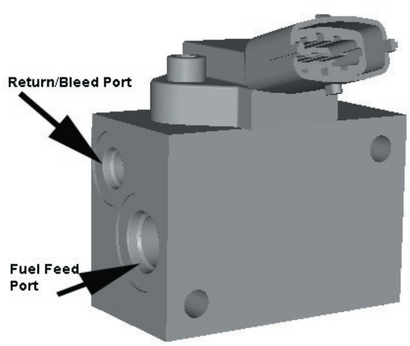
The gasoline fuel storage tank location may very on equipment applications. The fuel tank may be integrated into the chassis frame or may be a stand alone vessel mounted on the equipment. For precise location for the equipment application refer to the OEMs vehicle manual.

GASOLINE FUEL PUMP

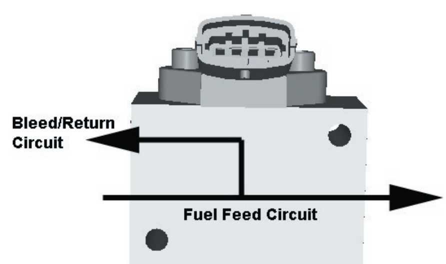
The Gasoline is stored as a liquid in the fuel tank and in drawn into the fuel system by a 12 volt electric fuel pump. Depending on the vehicle application the fuel pump may be mounted in the fuel tank or as a stand alone component. In either case the fuel pump will receive a signal from the ECM at Key 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 is comprised of a .020" orifice and a 6 psi check valve 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 circuit 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



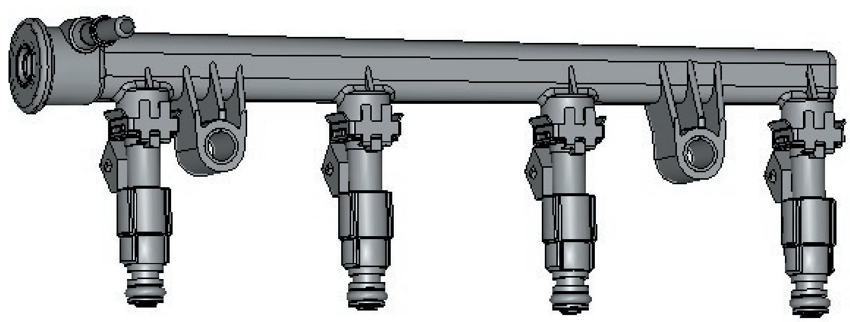
FUEL FILTER

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

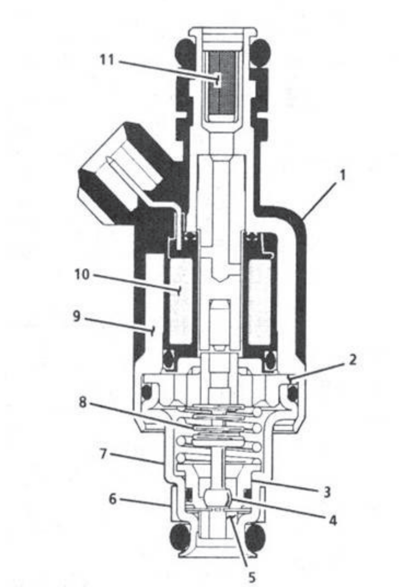
The fuel flows from the fuel pressure and temperature manifold assembly to the fuel injector rail where the fuel is delivered to the fuel injectors. The 1.6L engine uses a closed-end returnless type fuel rail as shown below.

1.6L Closed-End Fuel Injector Rail



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.



1	SOLENOID ASSEMBLY	7	HOUSING - SPRAY
2	SPACER & GUIDE ASM	8	SPRING - CORE
3	CORE SEAT	9	HOUSING - SOLENOID
4	VALVE - BALL	10	SOLENOID
5	PLATE - DIRECTOR	11	FILTER - FUEL INLET
6	BACKUP - O-RING		

PSI 1.6L PFI
FUEL SYSTEM REMOVE & REPLACE SECTION

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SPECTRUM by IMPCO

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.

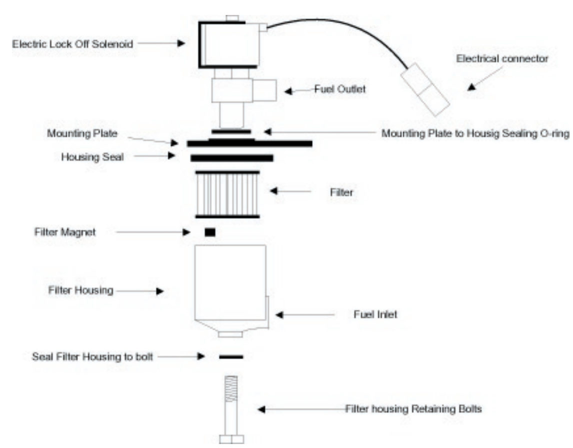
Important
- Residual vapor pressure will be present in the fuel system. Ensure the work area is well ventilated before disconnecting any fuel line.

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 FOR FILTER LOCK-OFF (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.**.

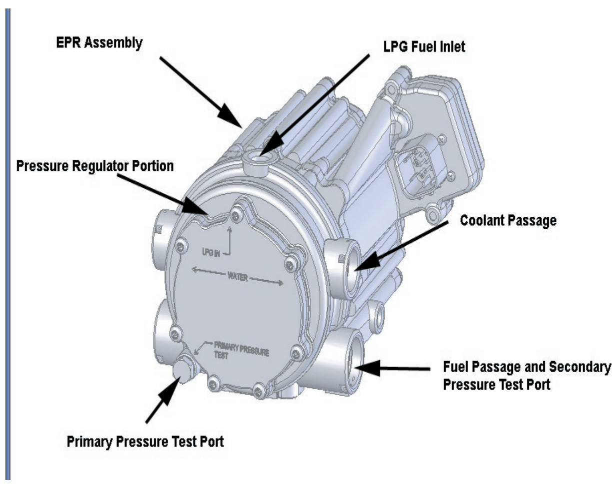


FIGURE 2
EPR Assembly

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. Make sure the cooling system is purged of any air that may have become trapped during this procedure.*

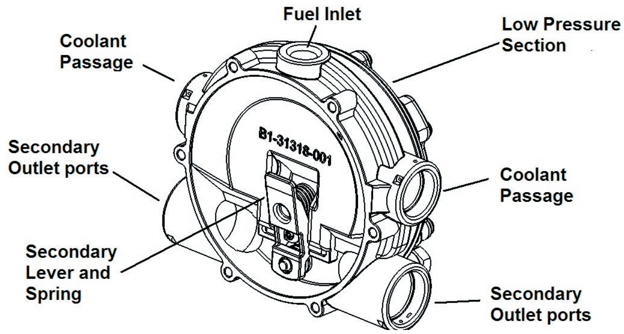
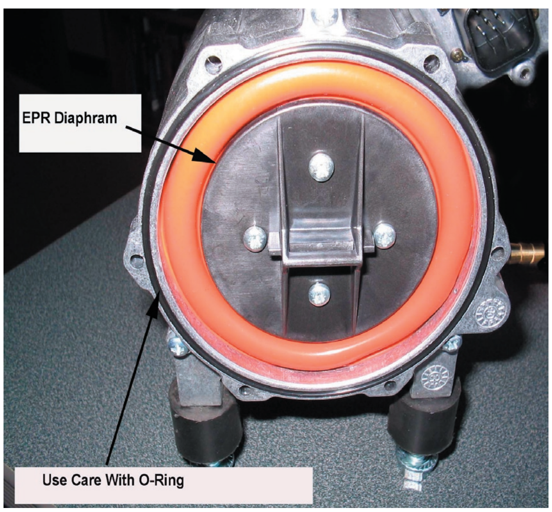
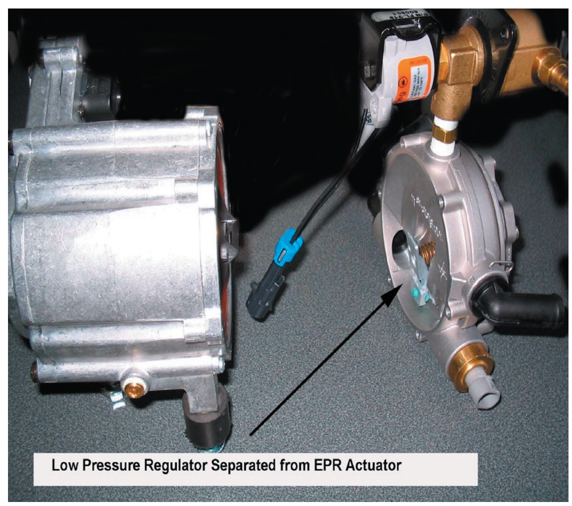


Figure 3
Pressure Regulator Section

Pressure Regulator Section Removal

1. Remove the EPR refer to *EPR Removal Procedure*
2. Remove the six (6) regulator to EPR Actuator 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

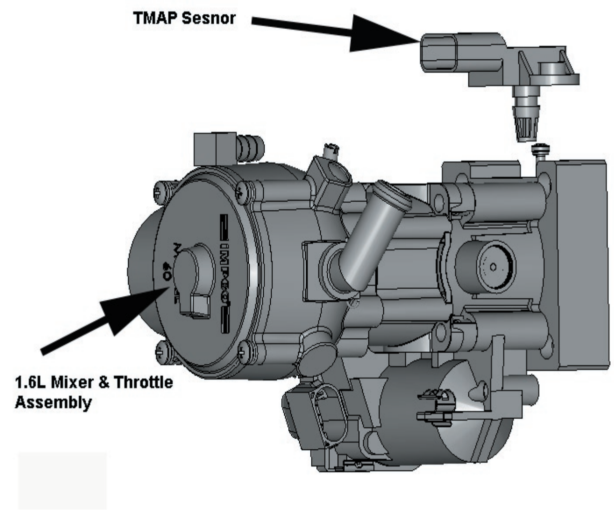


Figure 4
TMAP Sensor & Electronic Throttle Control (ETC)

ELECTRONIC THROTTLE CONTROL REPLACEMENT (FIGURE 4)

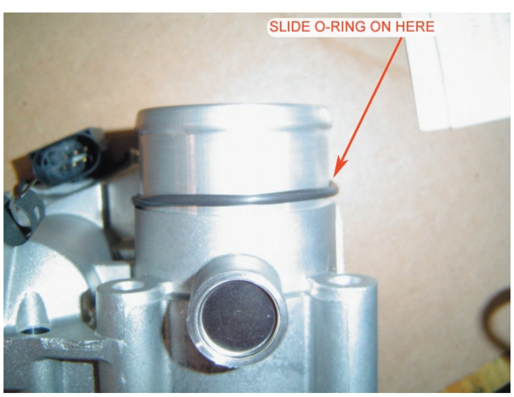
Removal Procedure

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

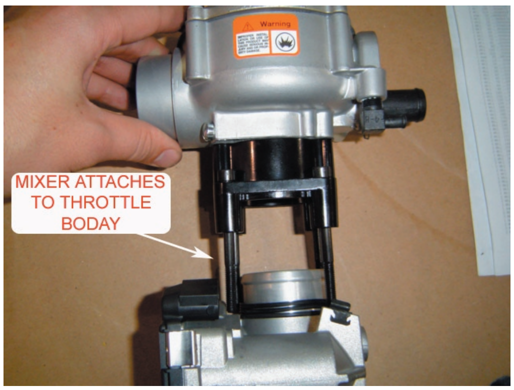
Important
- **Lightly Lubricate the both the O-rings of the throttle control device to adapter**

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.

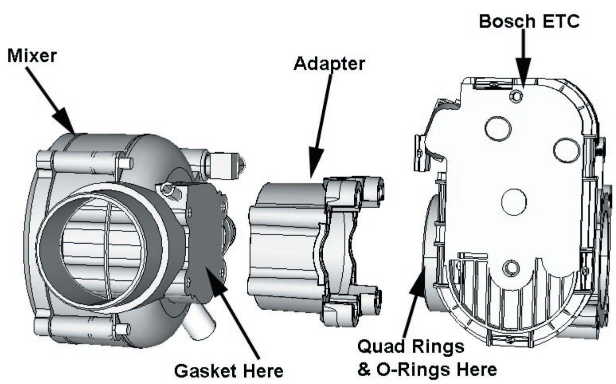


Figure 4A
Mixer Assembly

MIXER REPLACEMENT (FIGURE 4A)

1. Remove the Throttle control device *Refer to Electronic Throttle Body Replacement*

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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
6. Refill the cooling system. Start the engine and run until warm. Note: It may be necessary to remove trapped air form the vaporizer cooling circuit. Make sure system is purged of all air. Stop engine and readjust coolant level if necessary.

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
2. Remove the post catalyst O2 sensor from the catalyst muffler

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**

3. Install the TWC muffler using the OEM end product processes
4. Install post catalyst O2 sensor
5. Inspect and replace any gaskets and/or sealing rings as necessary
6. Start engine
7. Check for any DTC codes and clear
8. Verify engine is in closed loop and no MIL lights are present

PSI 1.6L PFI
FUEL SYSTEM DIAGNOSIS SECTION

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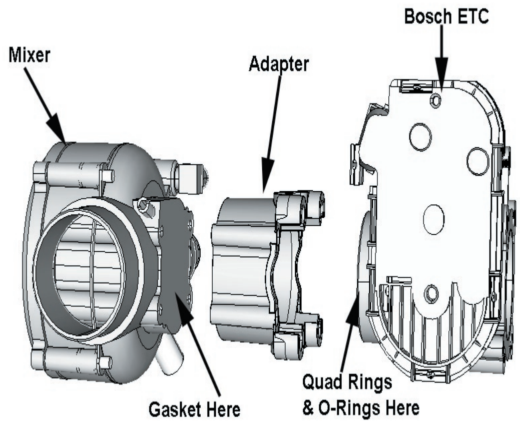
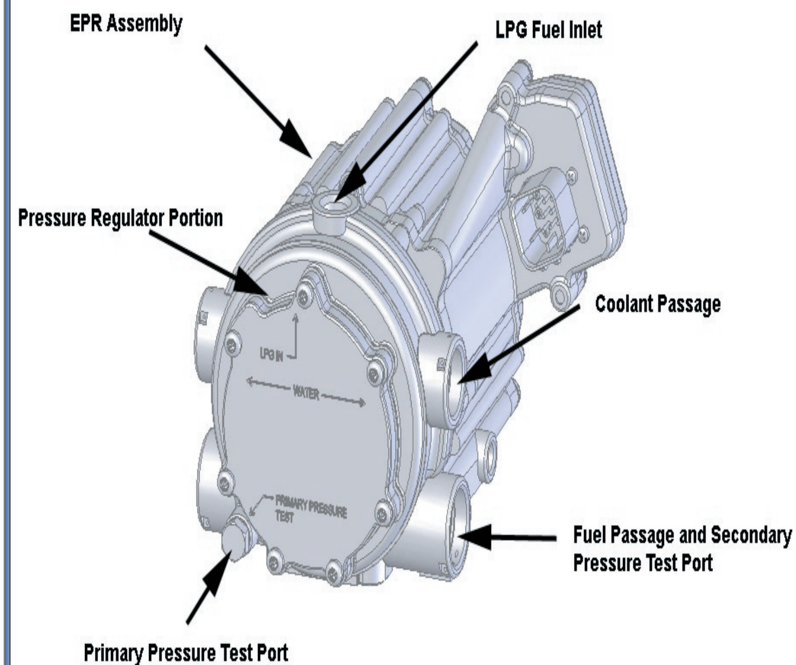
LPG Fuel System Diagnosis





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
- PSI Test Kit 101542
- 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

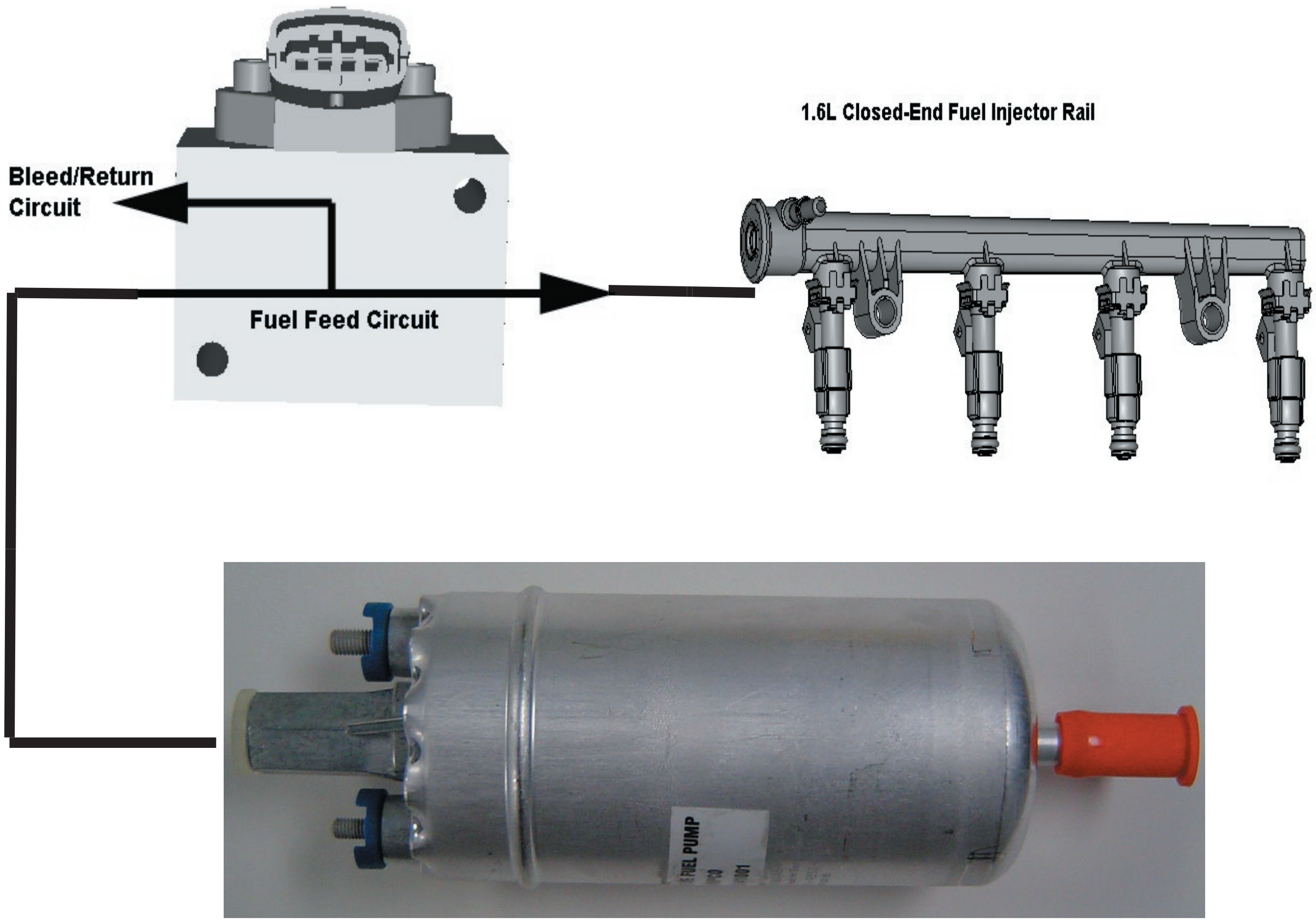
Step	Action	Value(s)	Yes	No
1	Were you referred to this procedure by a DTC diagnostic chart?	—	Go to *Step 3*	Go to *Step 2*
2	Perform the On Board Diagnostic (OBD) System Check. Are any DTCs present in the ECM?	—	Go to the applicable DTC Table	Go to *Step 3*
3	Verify that the LPG fuel tank has a minimum 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	—

Gasoline Fuel System Diagnosis



Gasoline Fuel System Description

This engine is equipped with a fuel injector rail that does not have a pressure regulator. Fuel pressure for this engine is regulated by the engine's ECM controlling the fuel pump via pulse width modulation. 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 is comprised of a .020" orifice and a 6 psi check valve 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 inline 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 circuit 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 System Diagnosis

Step	Action	Value(s)	Yes	No
1	Were you referred to this procedure by a DTC diagnostic chart?	—	Go to *Step 3*	Go to *Step 2*
2	Perform the On Board Diagnostic (OBD) System Check. Are any DTCs present in the ECM?	—	Go to the applicable DTC Table	Go to *Step 3*
3	Verify that the Gasoline fuel tank has a minimum of 1/4 tank of fuel, Does the vehicle have fuel?	—	Go to *Step 4*	—
4	1. Connect the Diagnostic Display tool to view gasoline fuel pressure feedback or connect a fuel pressure gauge into the fuel system. 2. Ignition “ON” fuel pump will run. Crank engine for several seconds. 3. Note the pressure 4. Turn ignition off pressure may vary slightly then hold steady Is pressure within specified values	55 +/- 5 psi	Go to *Step ??*	Go to *Step 5*
5	Is the pressure less than the specified value	55 +/- 5 psi	*Go to Step 6*	*Go to Step 9*
6	1. Check for restricted fuel filter. Replace if necessary. 2. Check for fuel line leak somewhere in system 3. Check for restricted fuel supply line from pump Was a problem found?		Go to Step ?	*Go to Step 7*
7	Replace the fuel pump. Was a problem found?		*Go to Step*	*Go to Step 8*
8	Replace the Fuel Pressure and Temperature Manifold Assembly Was a problem found?		*Go to Step*	*Consult with the Equipment Mfg. for fuel tank and line diagnosis*

10	Is pressure higher than the specified value?	55 +/-5 psi	Go to *Step 11*	Go to *Step ?*
11	Check for a restriction in the fuel return line between the Fuel Pressure and Temperature Sensor Manifold Assembly and the equipment fuel tank Was a problem found?		Go to *Step ?*	Go to *Step 8*
12	1. Check for restricted fuel filter 2. Check for restricted fuel supply line from pump Was a problem found?		Go to *Step 13*	Go to *Step 13*
13	1. Disconnect all test equipment 2. Start the engine. 3. Verify engine is in closed loop and no MIL is on. 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 (PSI 93206675)
	• 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 (PSI 93206675) • 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 (PSI 93206675)
	• 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 (PSI 93206675) • 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 (PSI 93206675) • 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 (PSI 93206675) • 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 (PSI 93206675) • 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 (PSI 93206675) • 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 1.6L PFI ELECTRICAL SECTION Table Of Contents

Description **Page**

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.

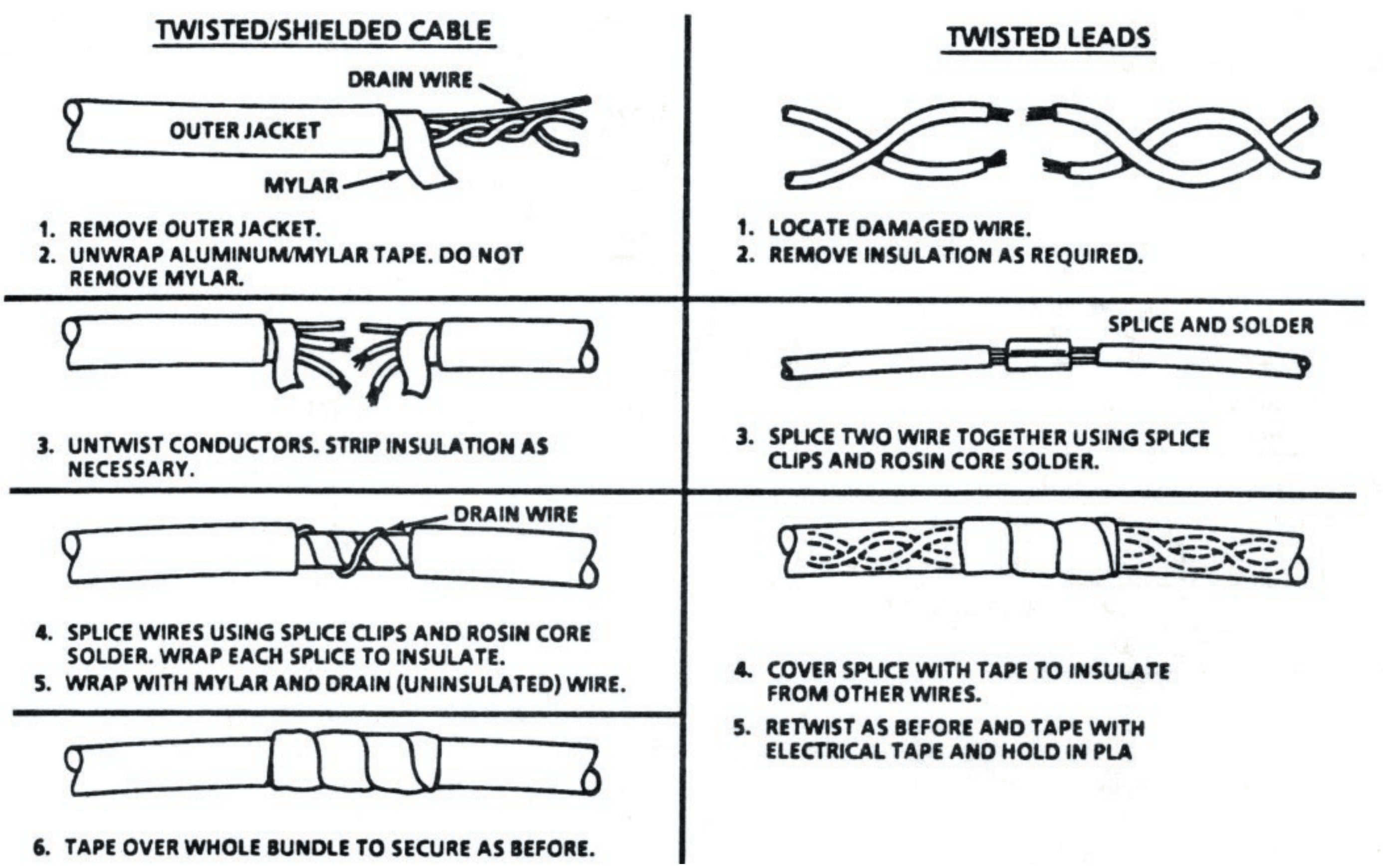
CONNECTORS AND TERMINALS

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 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.

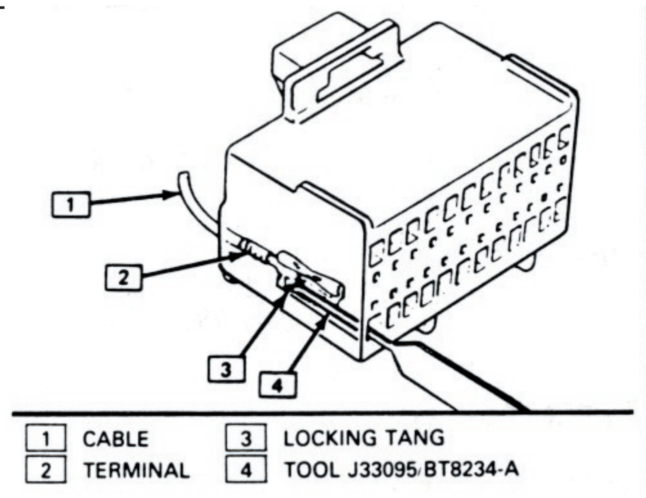


FIGURE 2 MICRO_PACK CONNECTOR

Metri-Pack

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

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

To remove a terminal:

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

If reusing the terminal, reshape the locking tang (2).

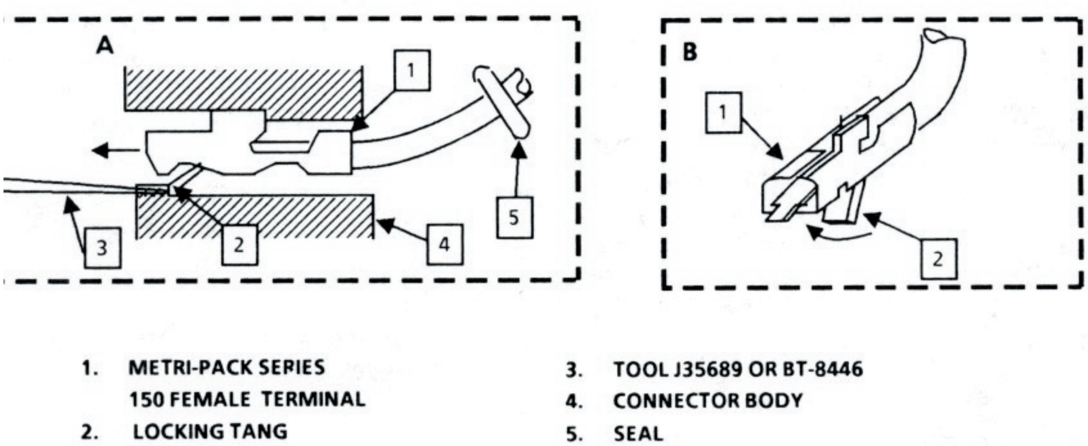


FIGURE 2 METR-PACK SERIES 150 TERMINAL REMOVAL

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.

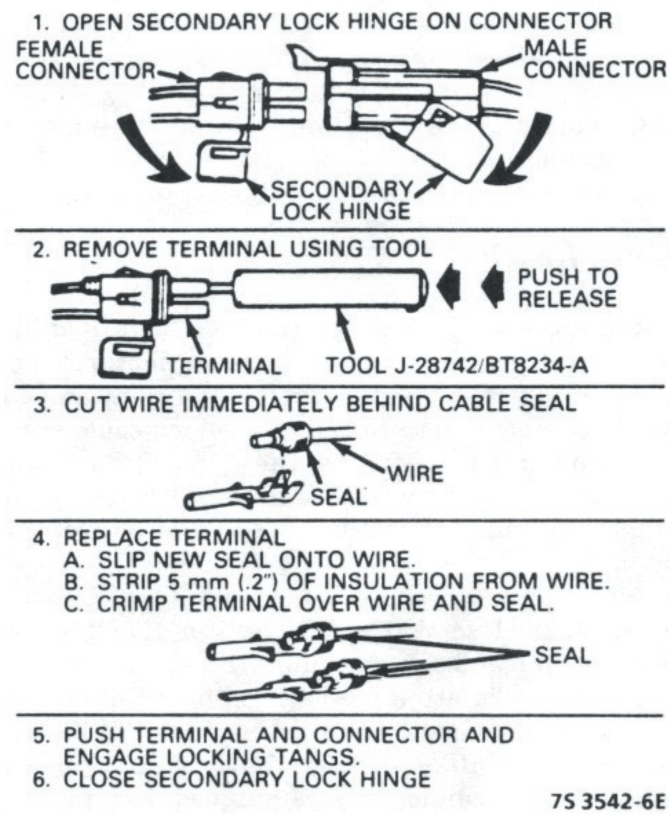
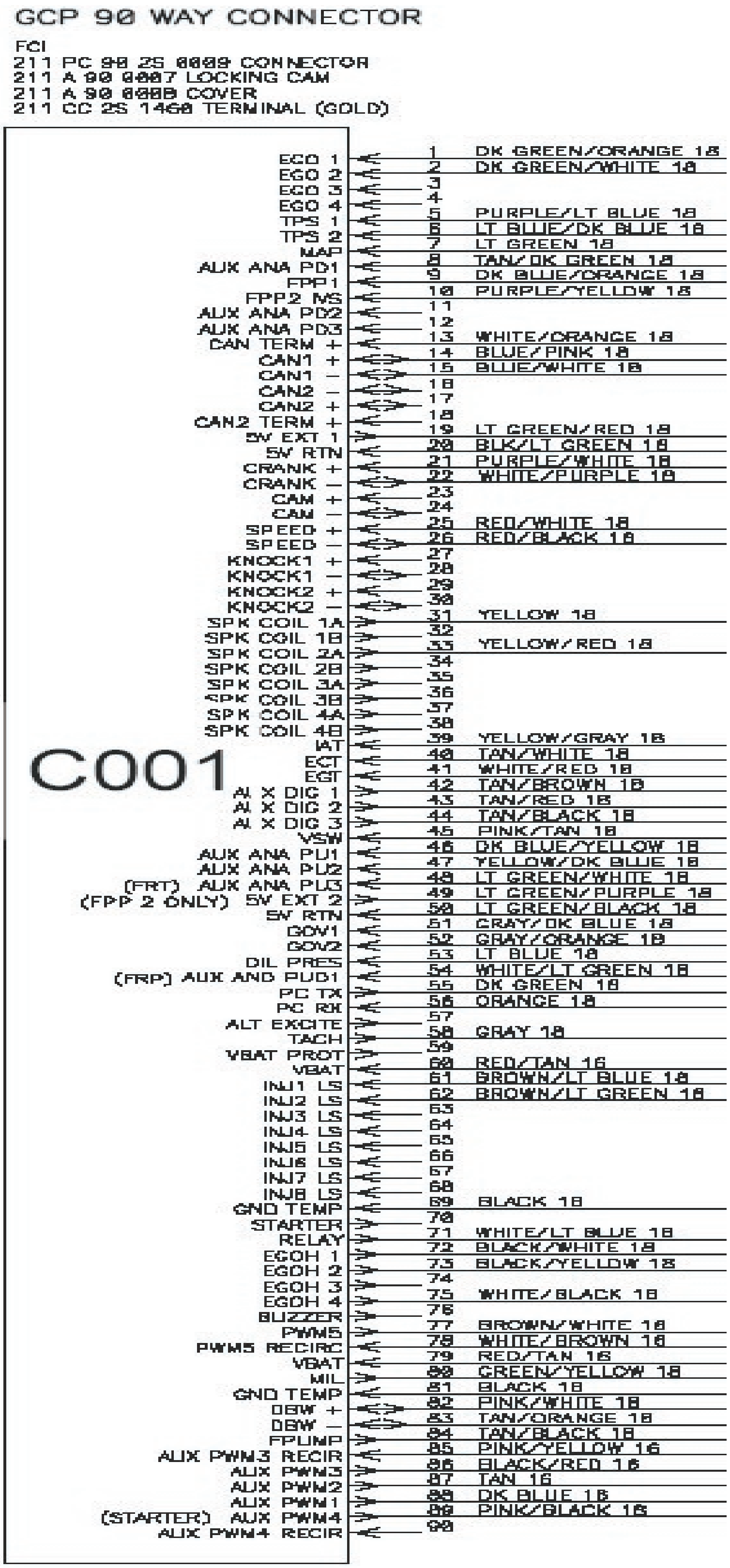
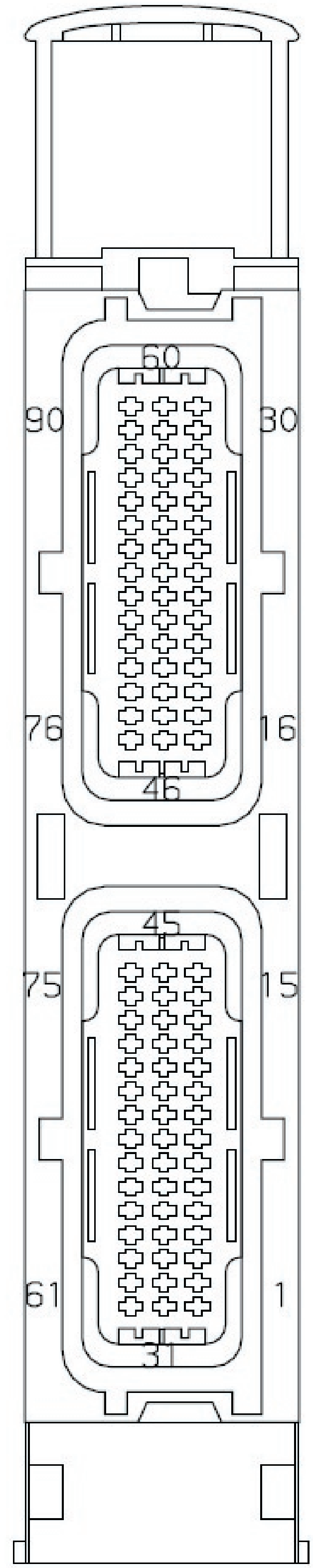


FIGURE 4 WEATHER PACK TERMINAL REPAIR

ECM Header Connector Pin-Out



ECM Header Connector Terminal 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

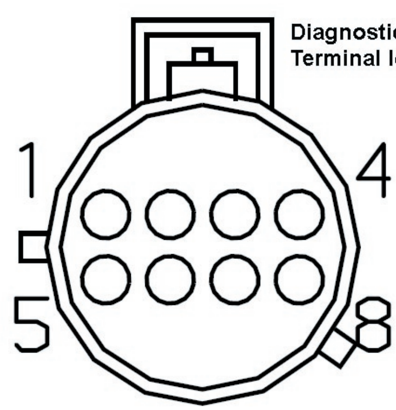
DIAGNOSTIC CONNECTOR

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 -

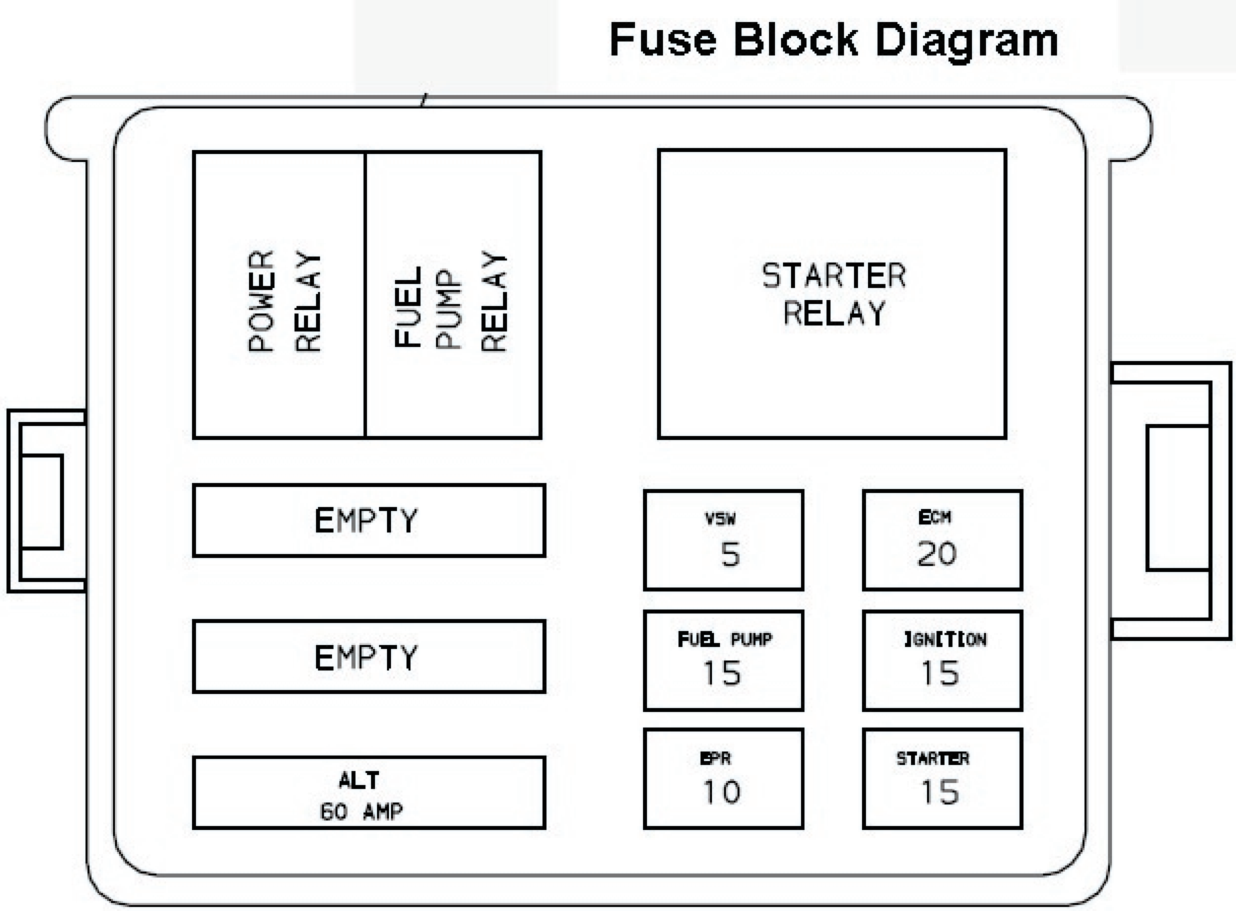
Diagnostic Connector Terminal Identification



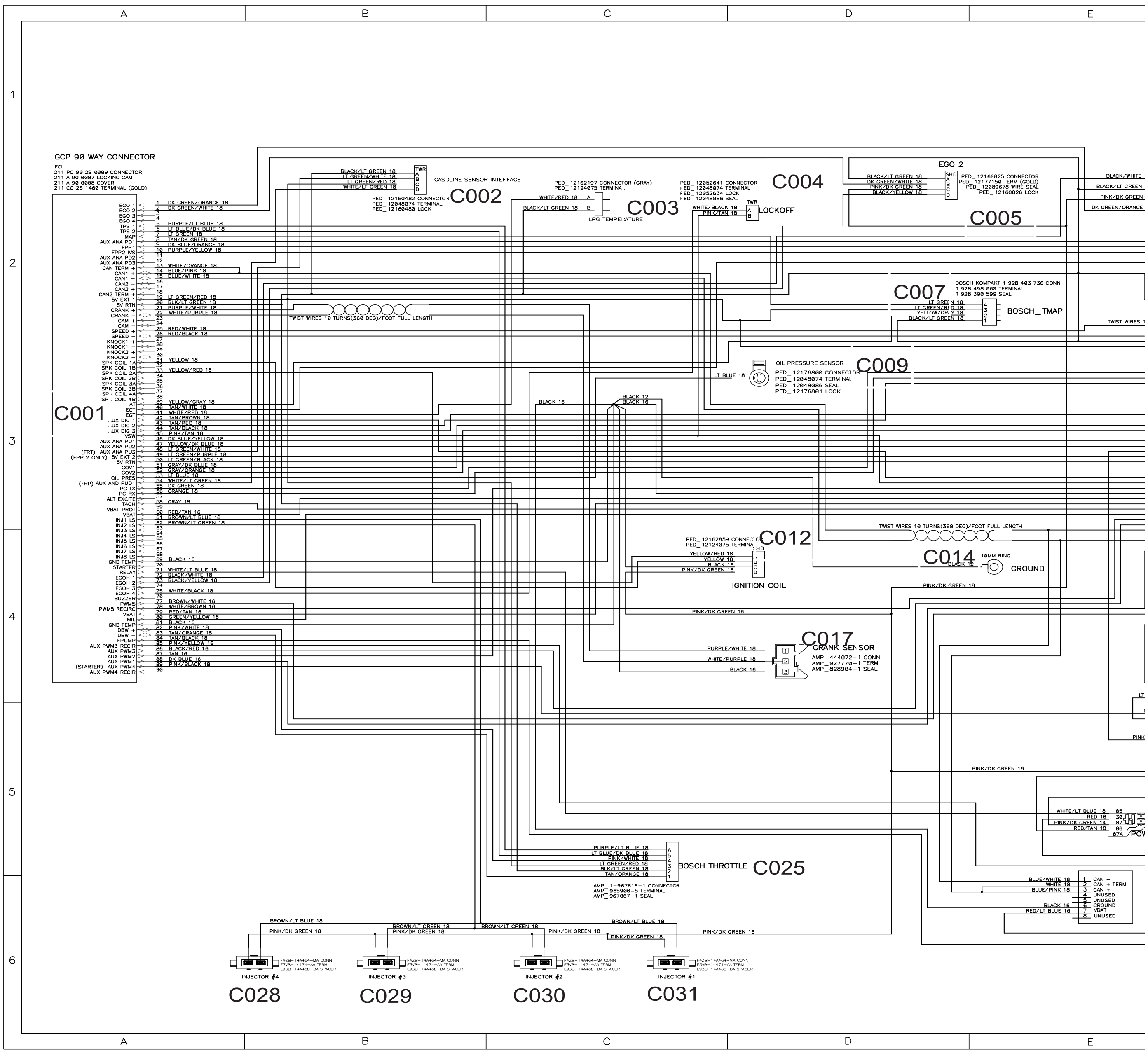
POWER SOLUTIONS, INC.

SPECTRUM by IMPCO

Engine Wire Harness Fuse and Relay Center Layout



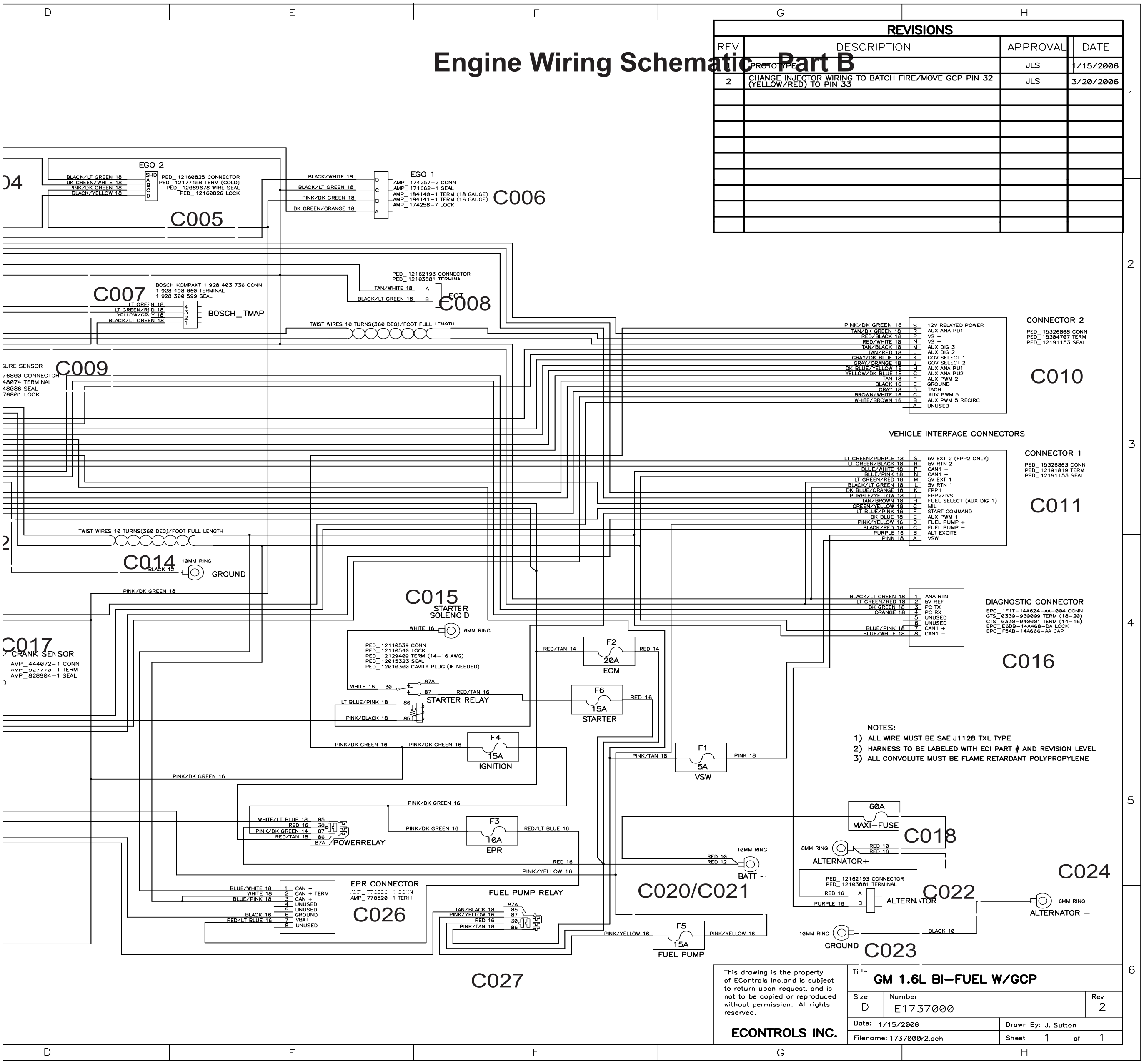
Engine Wiring Schematic - Part A



Power Solutions, Inc.

SPECTRUM by IMPCO

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:

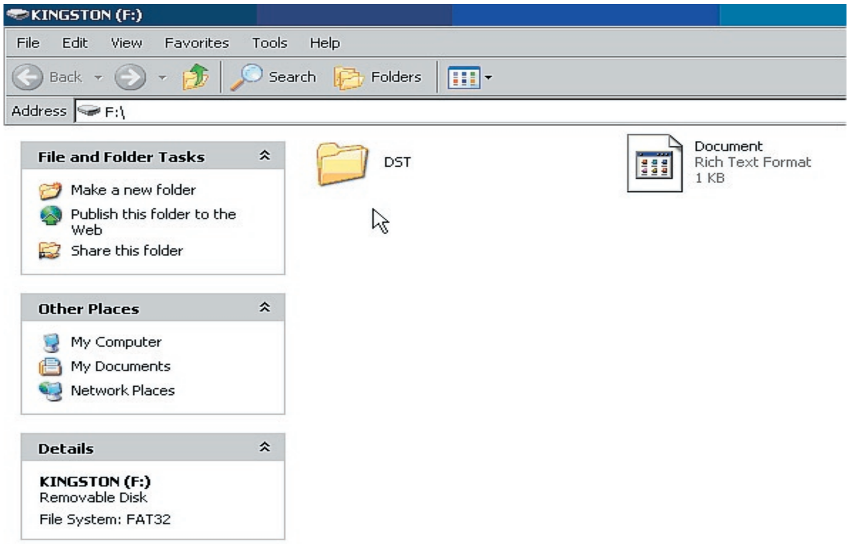
Windows XP
Windows 2000
Windows 98SE (Second Edition)

Minimum processor speed:
Pentium II 450 MHz

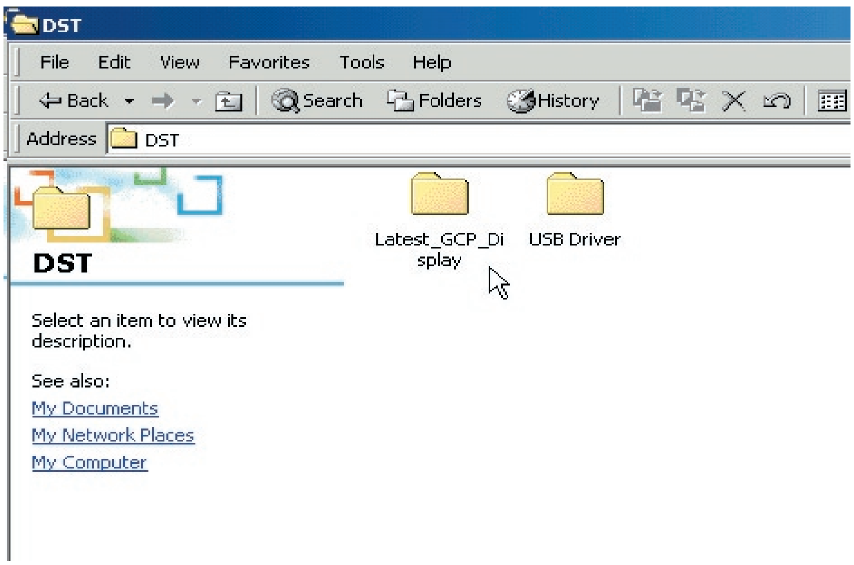
Minimum RAM requirement:

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

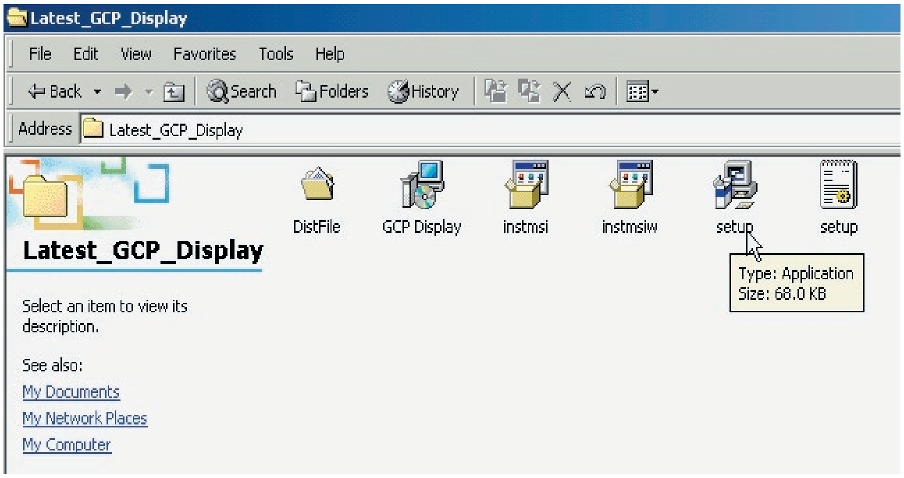
* At least one available RS232 serial or USB port.
* USB Driver does not support Windows 98SE (Second Edition)



- Open the DST folder

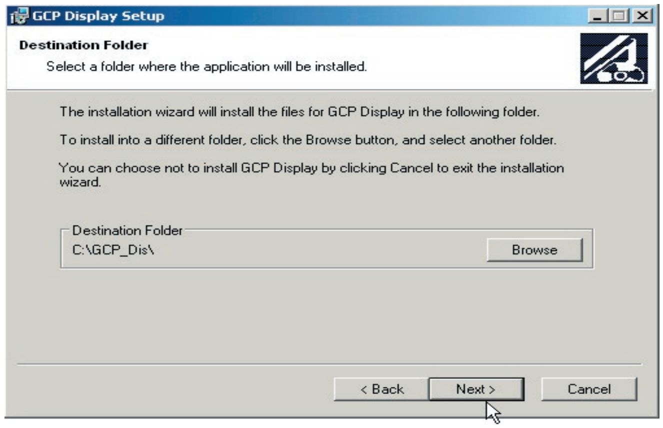


- Open the Latest_GCP_Display folder

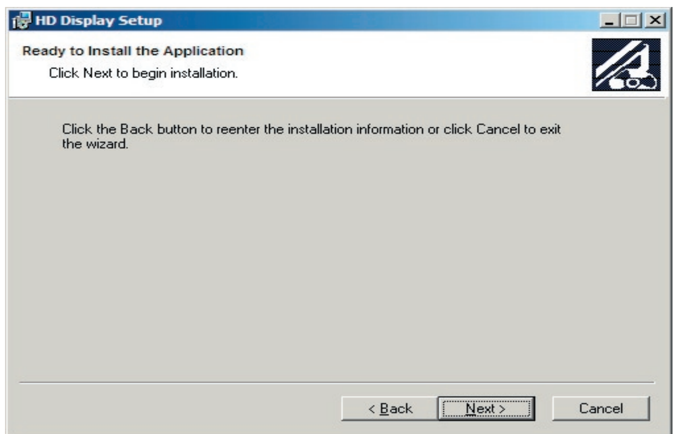


- Double click on “setup.exe” (application file) to start the windows installer. If a previous version of the GCP software is installed, the uninstaller will remove the previous version and exit. You will be required to start the installer again to install the new version.

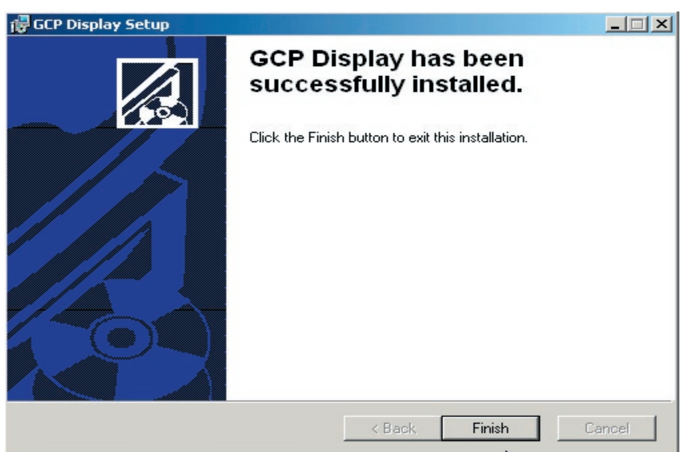
- Click next to continue



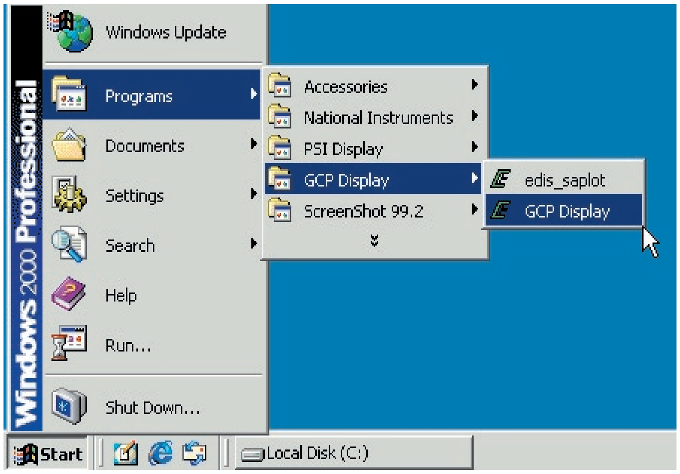
- Click next to continue



- Click next to continue



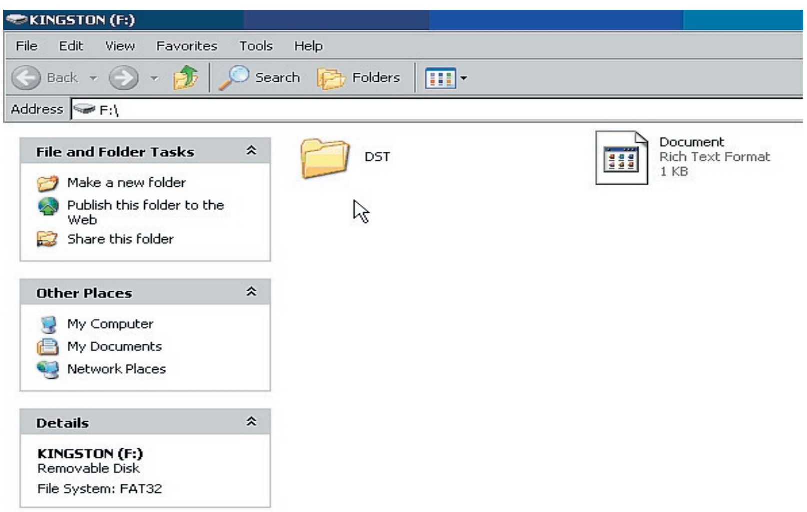
- Click the “finish” box to complete the installation.



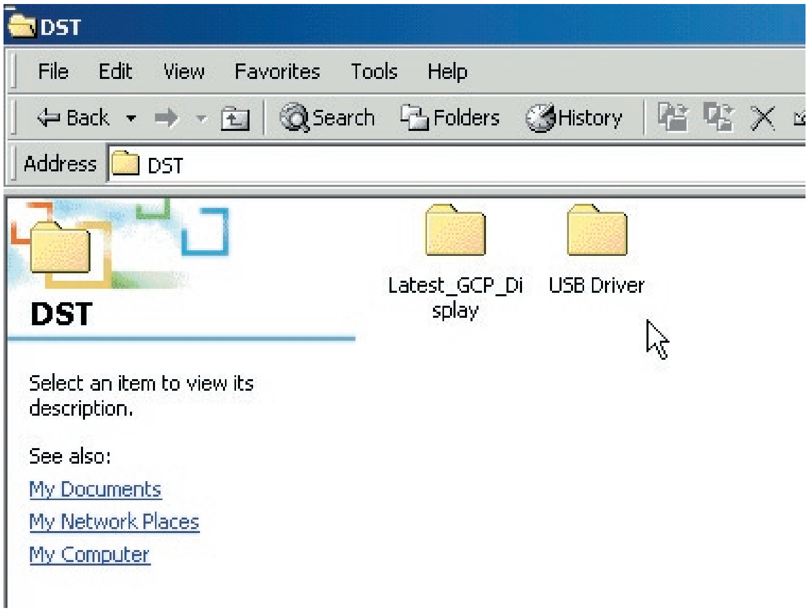
Once installed, the software can be accessed from
Start Menu → Programs → GCP Display → GCP Display

Installing the USB Adapter Driver

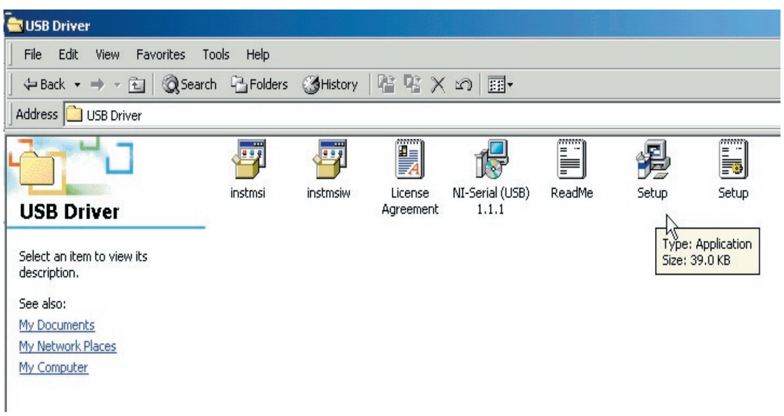
If your computer does not have an RS232 serial port, you will need to install the USB adapter driver. The installation of this driver is similar to the GCP display.



- 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.

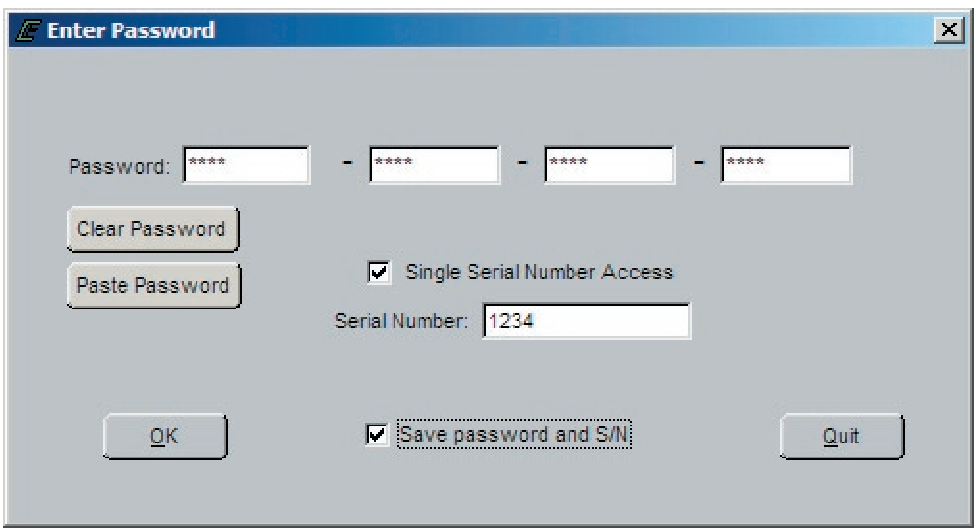


Figure 1: Populated Password Dialog Box

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

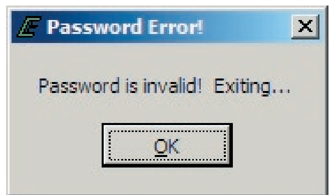


Figure 2: Password Error Prompt

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.

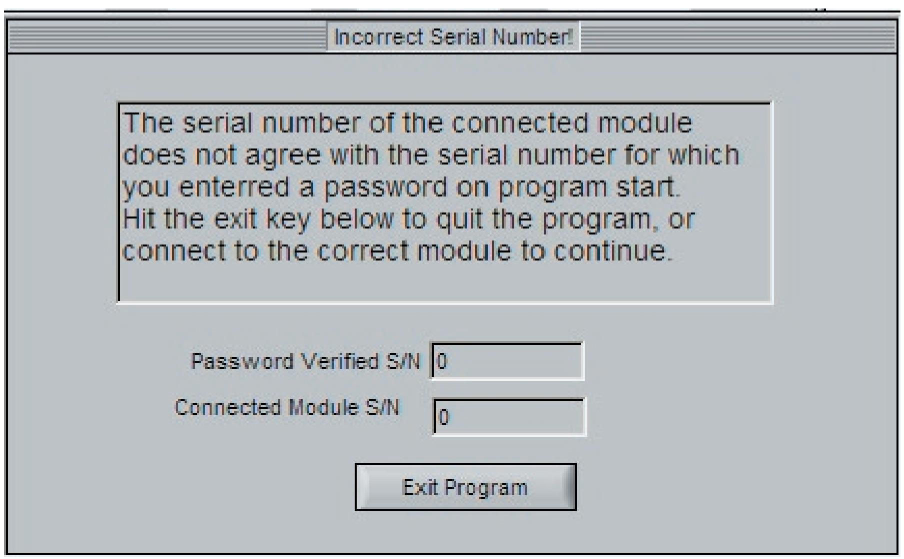


Figure 3: Incorrect Serial Number Message

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.

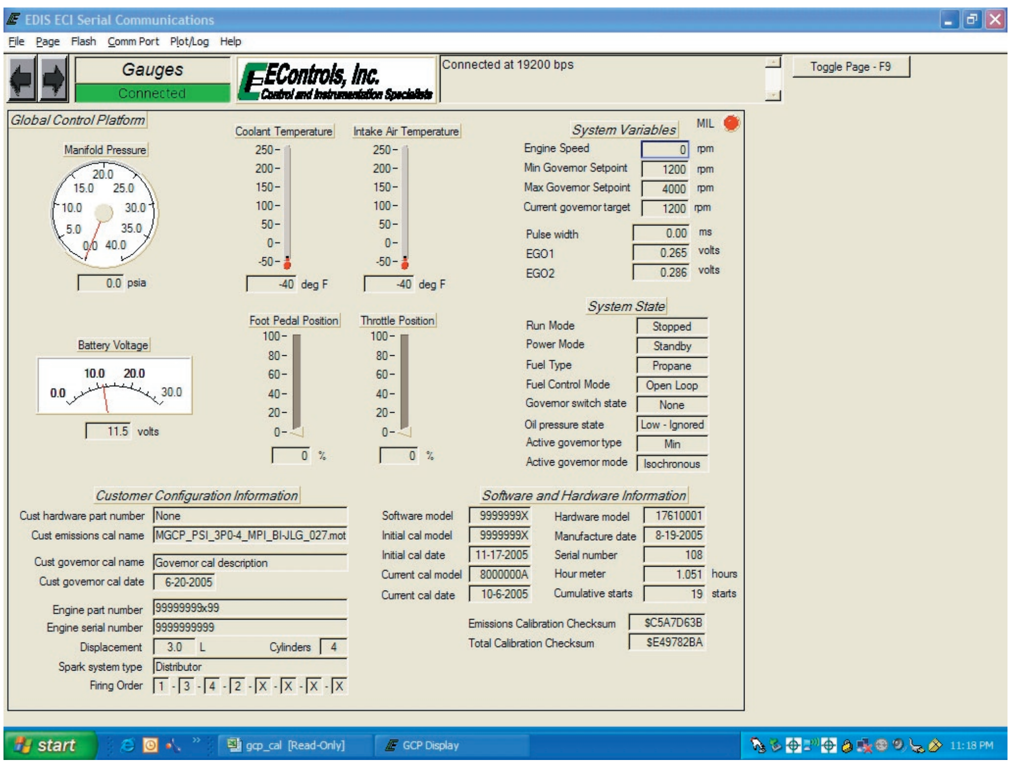
- Connect the system diagnostic cable to the RS232 port on the back of the computer. If you do not have a RS232 port, use the USB to RS232 adapter supplied in the IMPCO ITK test kit. Be sure to install the USB driver to enable the USB adapter for use with your computer.
- Connect the diagnostic cable 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

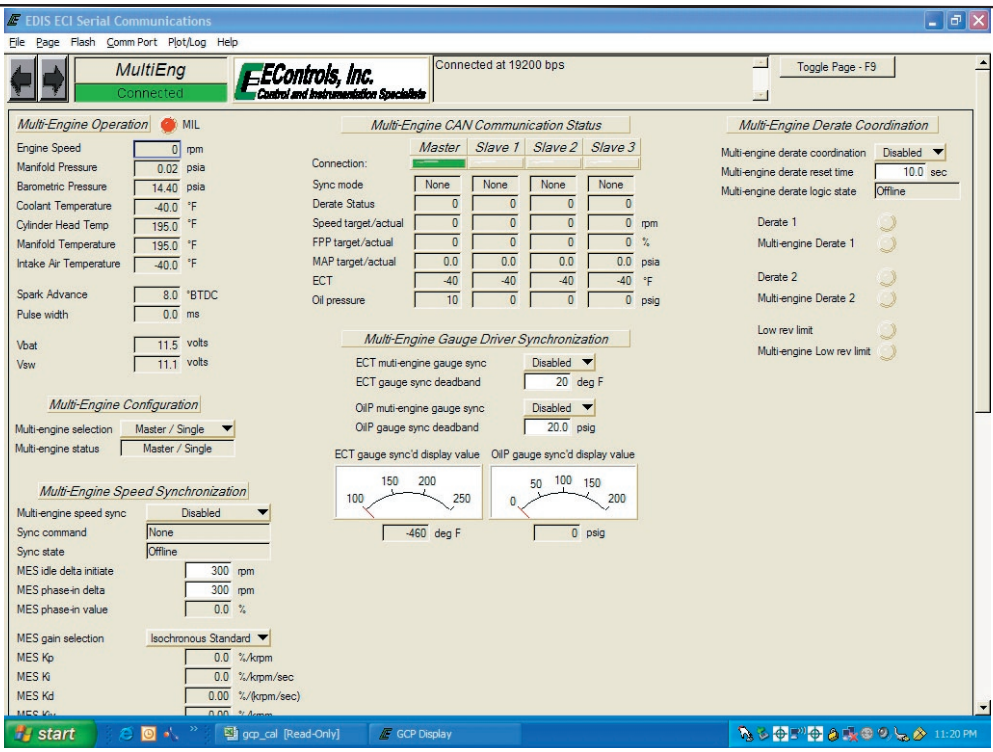
Gauge Screen

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



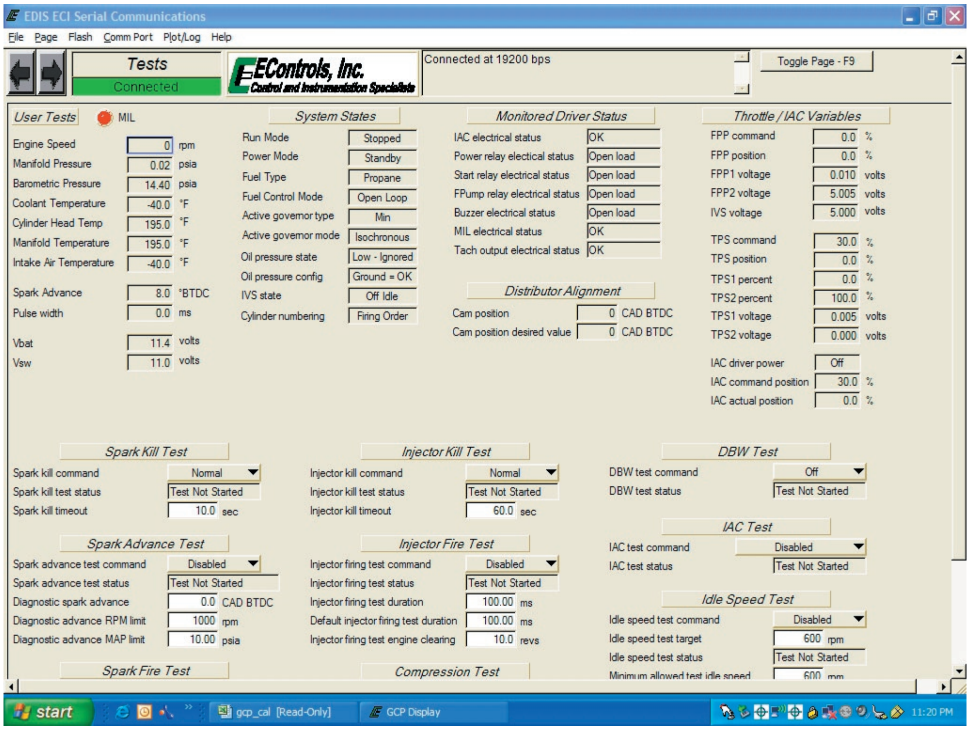
Multi Engine Page

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

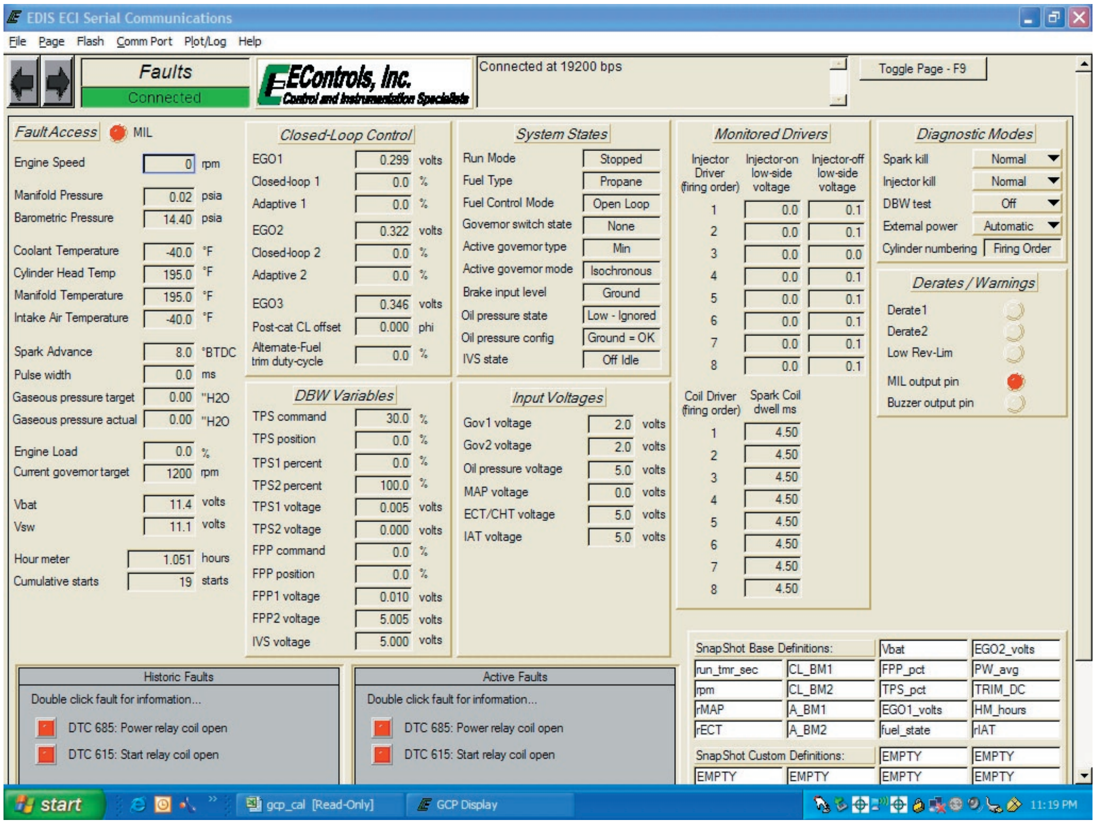
The Injector Kill mode is used to disable individual fuel injectors. If the Injector Kill mode is selected with the engine running below 1000 RPM, the minimum throttle command will lock into the position it was in when the test mode was entered. If the Injector Kill mode is selected with the engine running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

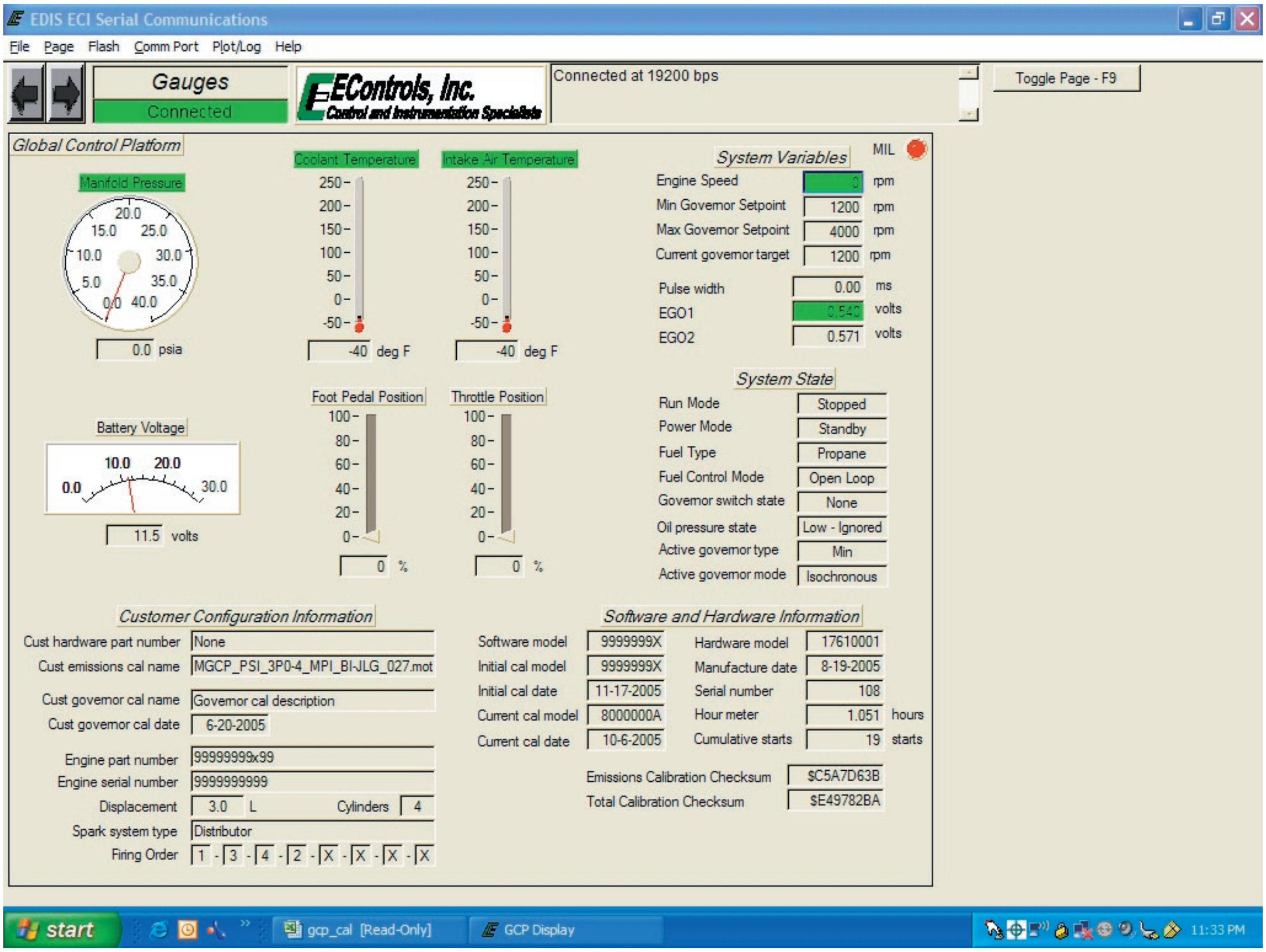


Figure 5: Tagged Variables for Plot/Log

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.

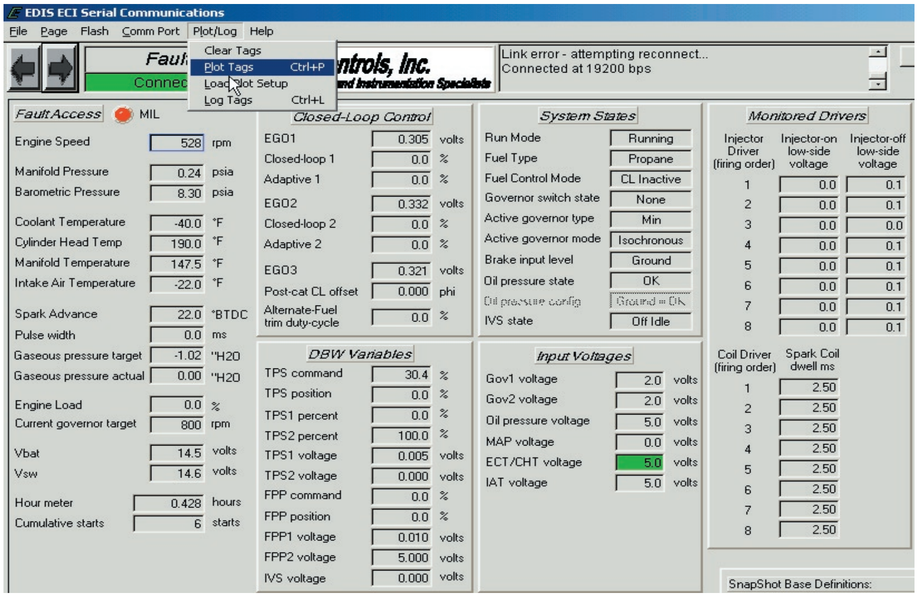


Figure 6

- 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

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

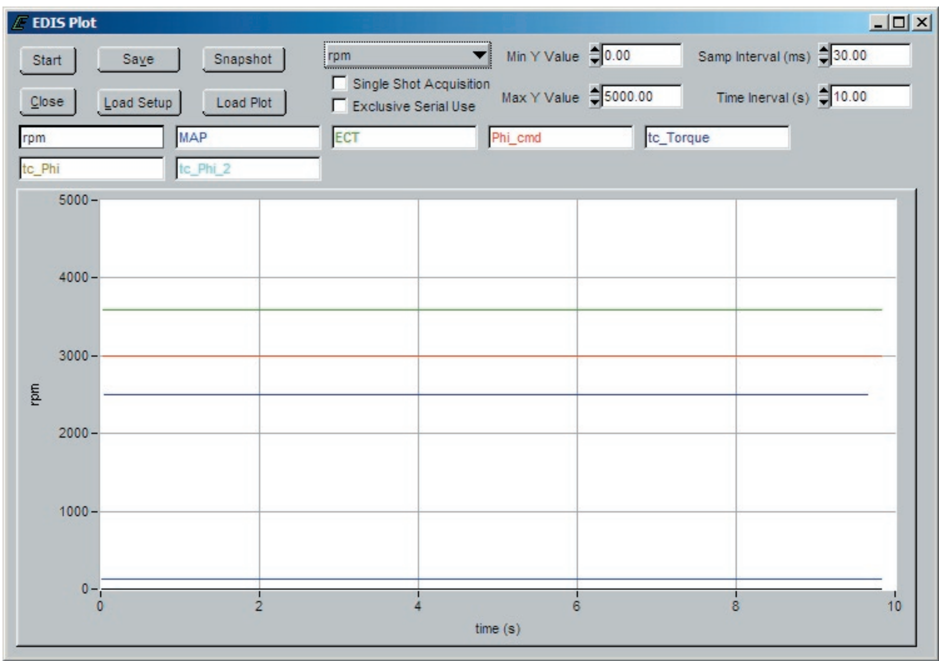


Figure 7 DST Plot

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

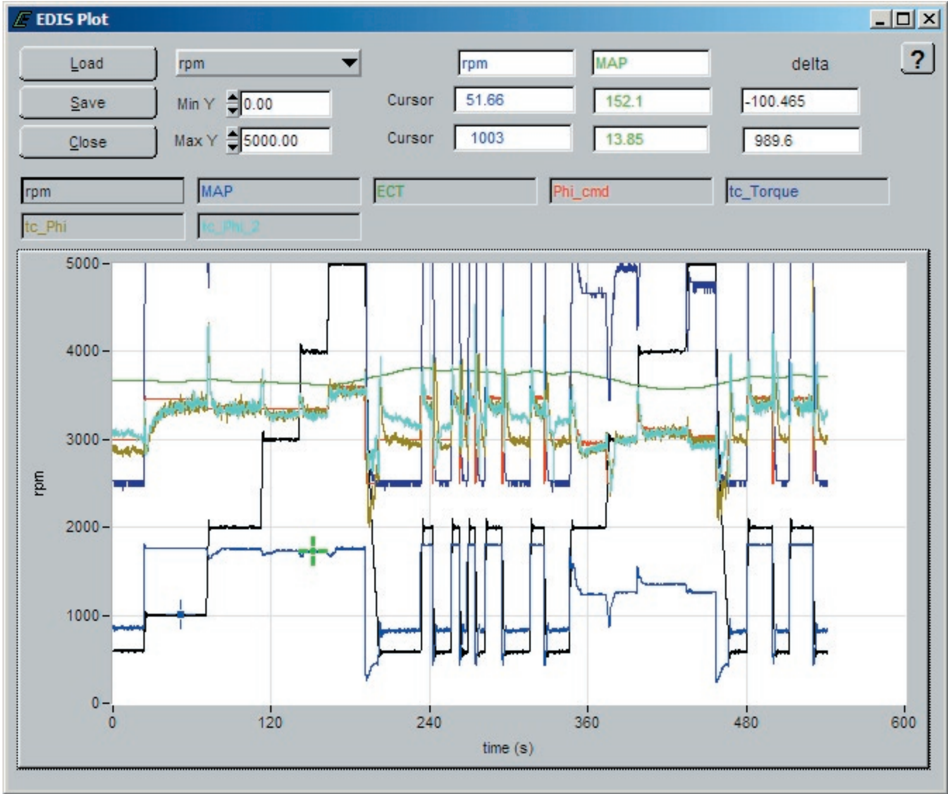
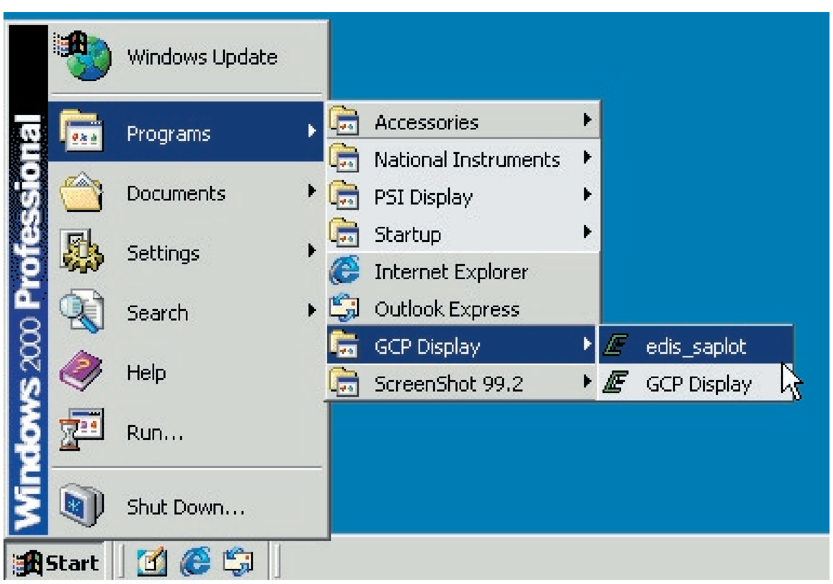


Figure 8: DST Plot Snapshot

- 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.

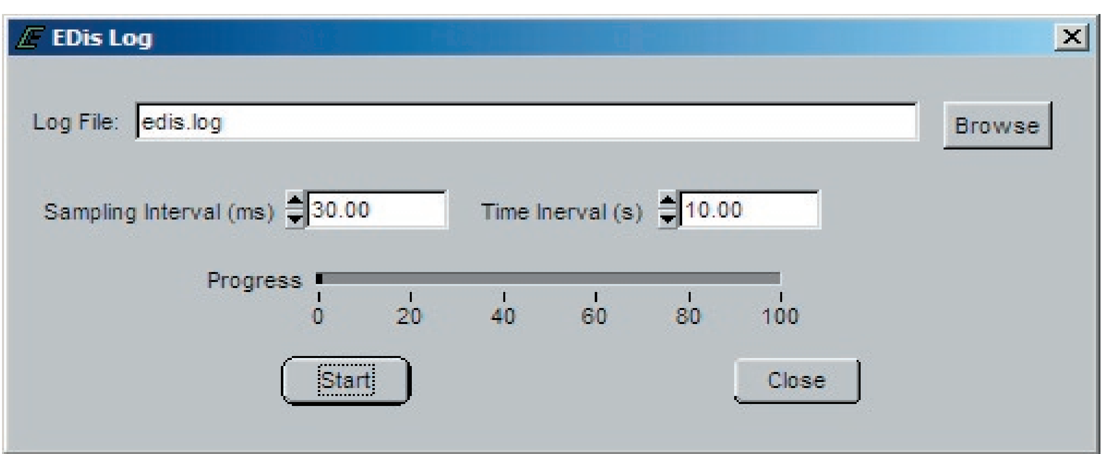


Figure 9: DST Log Interface

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.

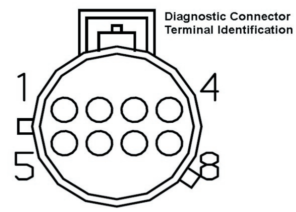
Check the ECM system power and ground circuits. Refer to DTC 562 for the power schematic. Also check for +12 volts switched power at ECM pin 45 with the ignition key on.

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:



- Jumper 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.

PSI 1.6L PFI
DIAGNOSTIC TROUBLE CODE SECTION
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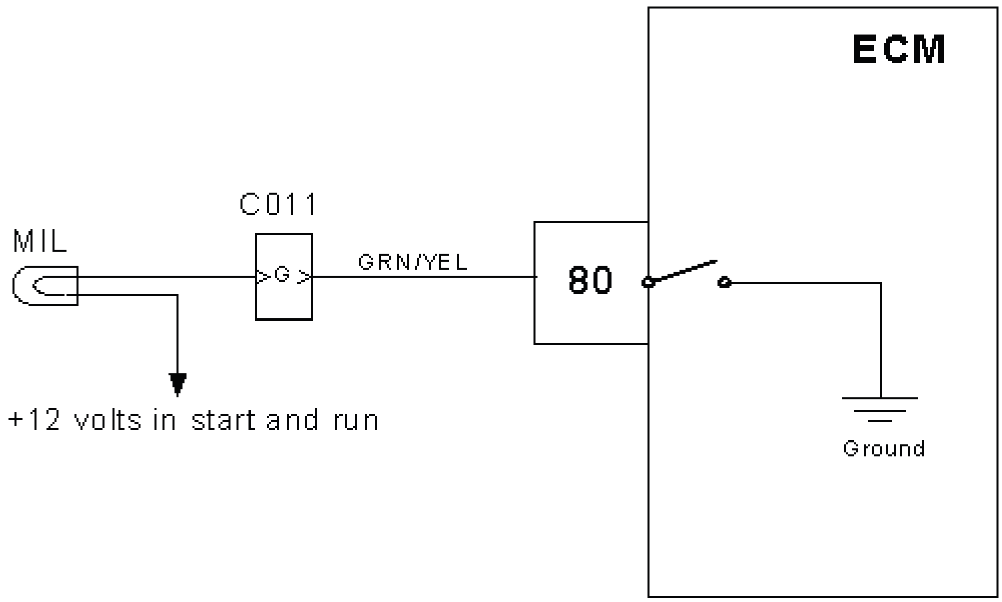
1.6L DTC Code to SPN:FMI Code Cross Reference

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
336	Crank Sync Noise	636	2
337	Crank Loss	636	4
420	Gasoline Cat Monitor	520211	10
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
1626	CAN Tx Failure	639	12
1627	CAN Rx Failure	639	12
1628	CAN Address Conflict Failure	639	13
2111	Unable to Reach Lower TPS	51	7
2112	Unable to Reach Higher TPS	51	7
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.

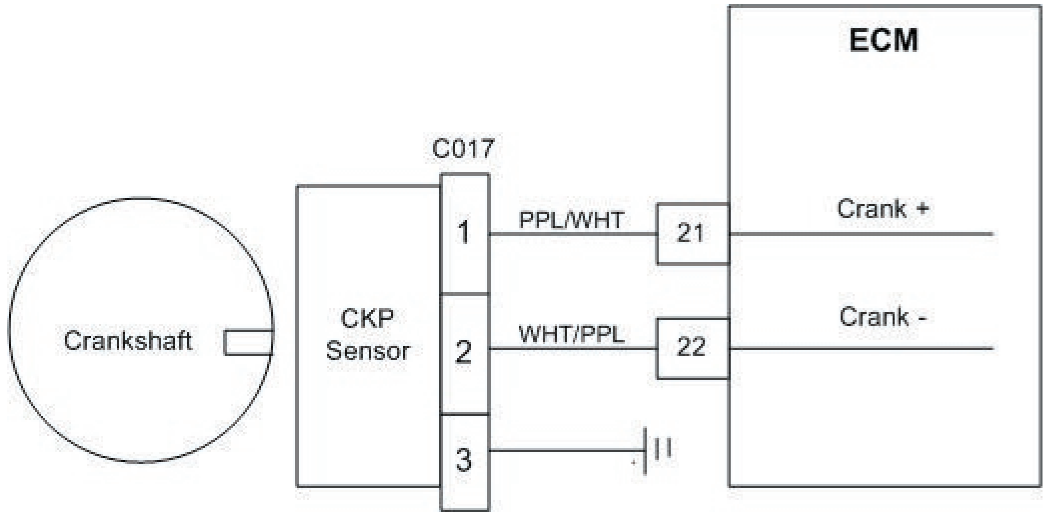
The MIL serves as notification of an emissions related problem. The MIL also has the ability to flash DTC codes in what is referred to the blink code mode. It will display DTC's that have been stored due to a system malfunction. The following DTC charts in this manual will instruct the technician to 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

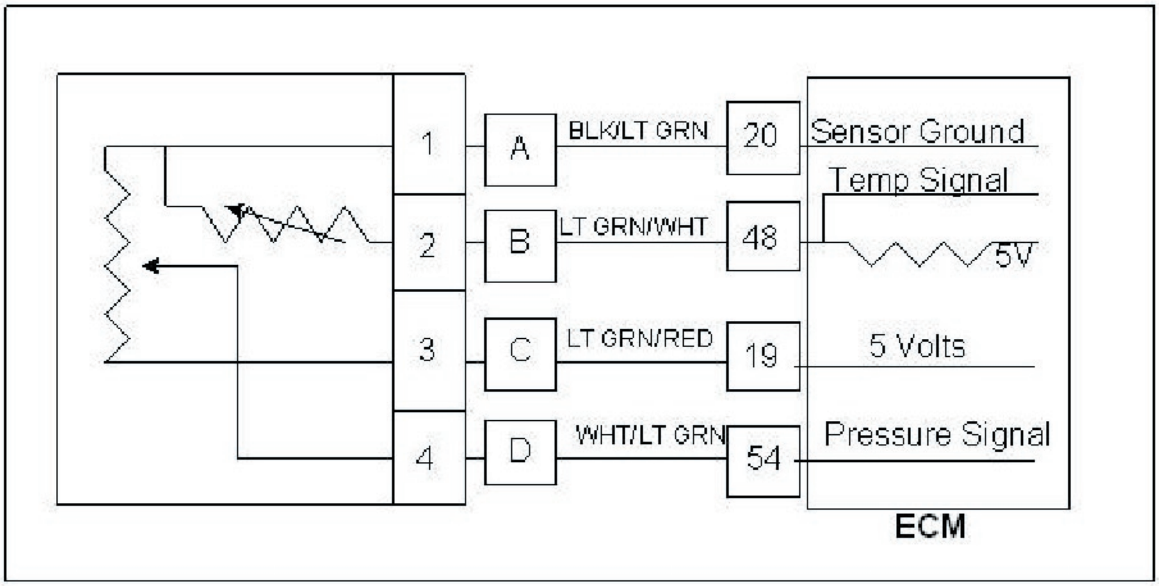
The CKP (crankshaft position sensor) is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize 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 pins 1 & 2 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 1 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 2 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-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

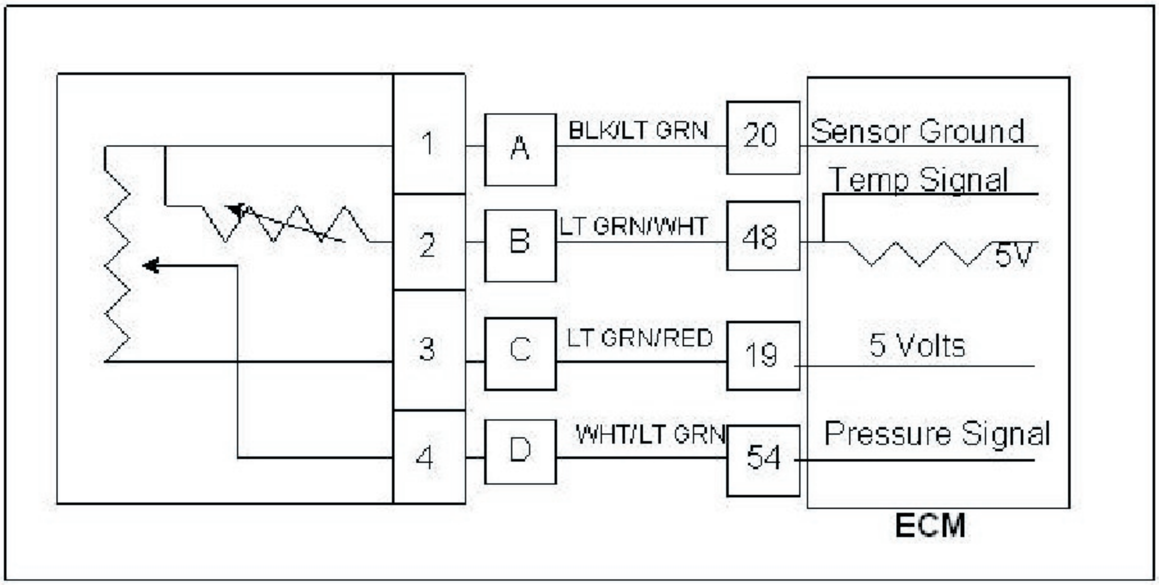
Note: The fuel pressure and temperature sensor is wired via Equipment Manufacturer supplied harness jumper. The terminals A, B, C, D & 19, 20, 48, 54 are engine wiring harness terminals at the fuel sensor interface connector C002 and the ECM header connector C001. You may need to consult additional wiring 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

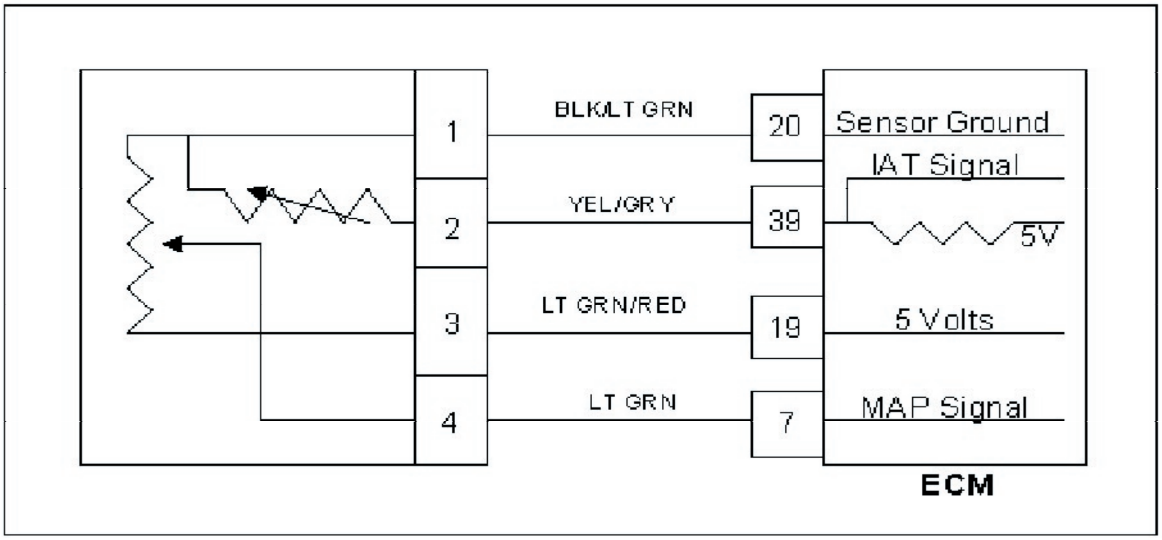
Note: The fuel pressure and temperature sensor is wired via Equipment Manufacturer supplied harness jumper. The terminals A, B, C, D & 19, 20, 48, 54 are engine wiring harness terminals at the fuel sensor interface connector C002 and the ECM header connector C001. You may need to consult additional wiring 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.

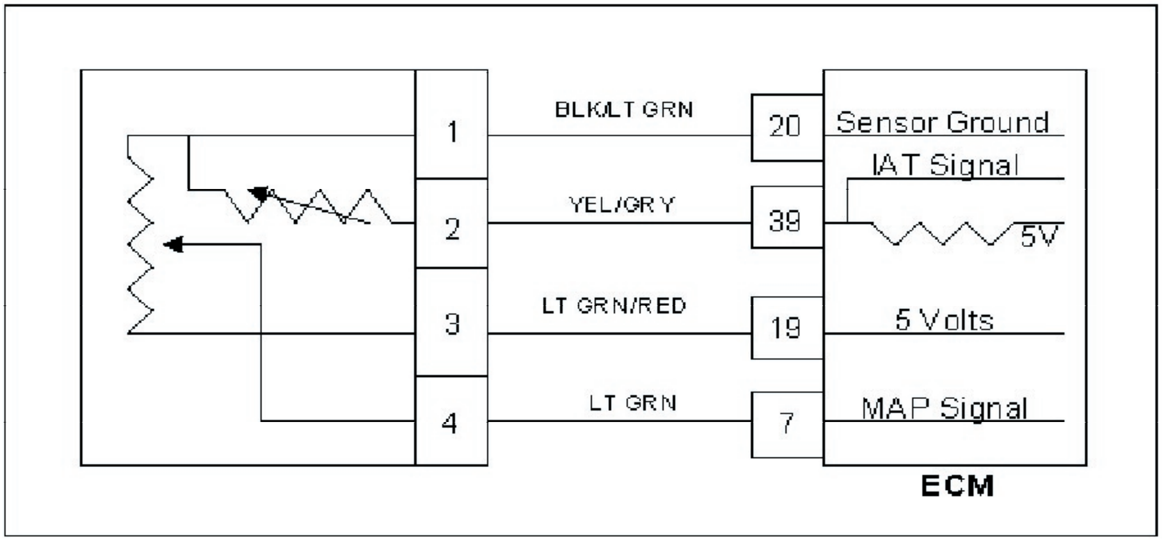
DTC 107- MAP Low Voltage SPN/FMI 106:4

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 16 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

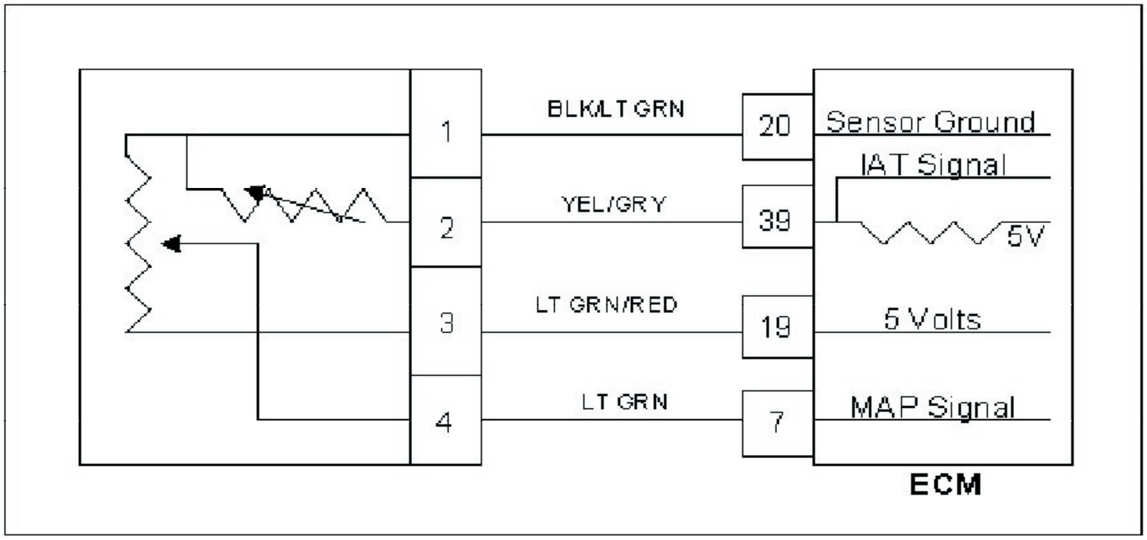
Circuit Description

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 16 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 1000 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 1000 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.

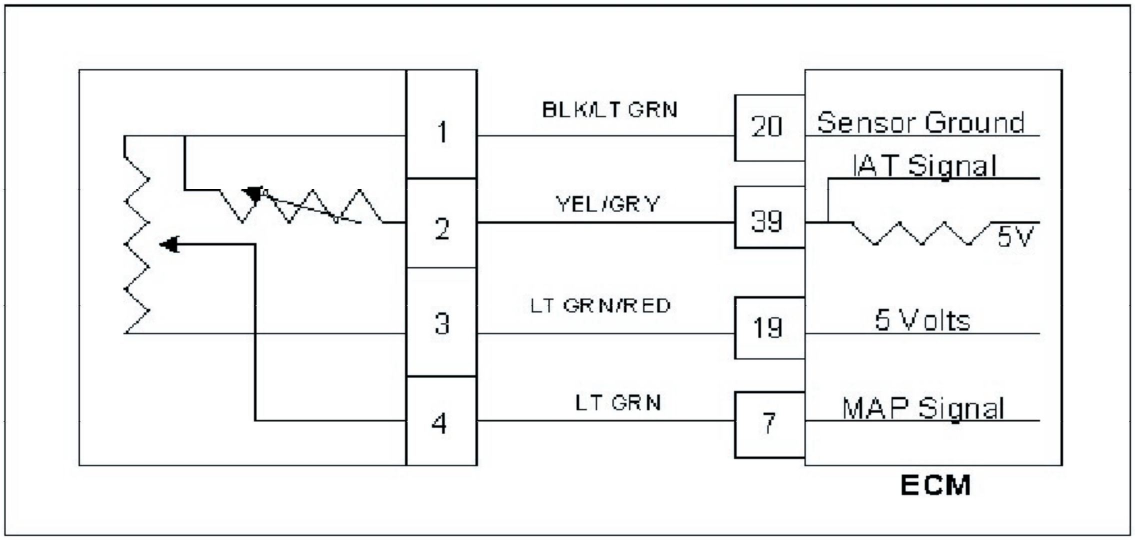
DTC 111-IAT Higher Than Expected 1 SPN/FMI 105:15

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
- Use the chart below to check resistance accross pins 1 and 2 at TMAP sensor and compare resistance to air temperature.
- If none of the above can be found, Follow the diagnostic steps for DTC 112-IAT Low Voltage

Temp (° F)	Ohms
248	110
239	125
221	162
203	214
185	284
167	383
149	522
131	721
104	1,200
77	2,063
50	3,791
23	7,419
-4	15,614
-22	26,854
-31	35,763
-40	48,153

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.

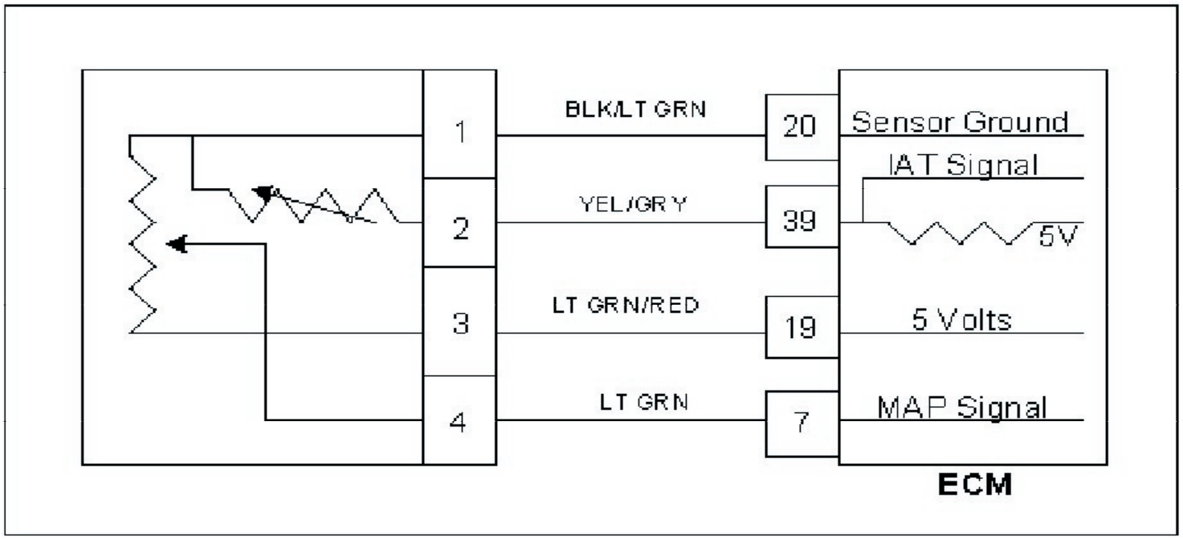
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow. This fault will set if the signal voltage is less than 0.05 volts for 1 second anytime the engine is cranking or running. The ECM will use the default 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.

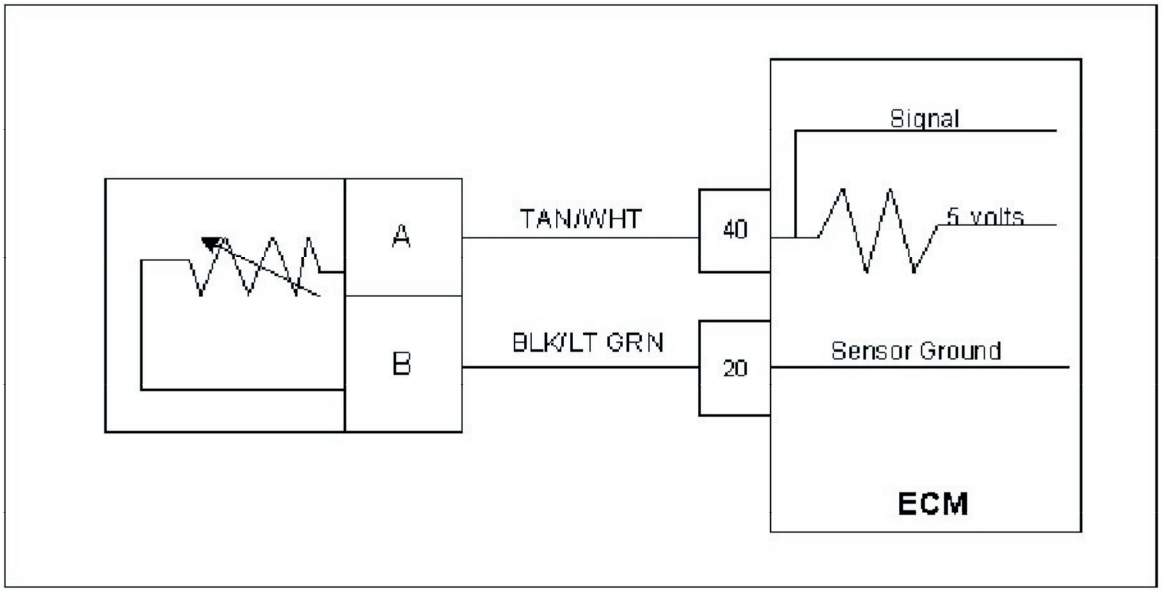
The IAT is a calculated value based mainly on the IAT sensor at high airflow, and influenced more by the ECT (Engine Coolant Temperature) at low airflow. This fault will set if the signal voltage is greater than 4.95 volts for more than 1 second anytime the engine is running. The ECM will use a default 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 215 degrees F. for greater than 5 seconds
- MIL-On
- Power derate (level 1)
- Adaptive-Disabled during active fault

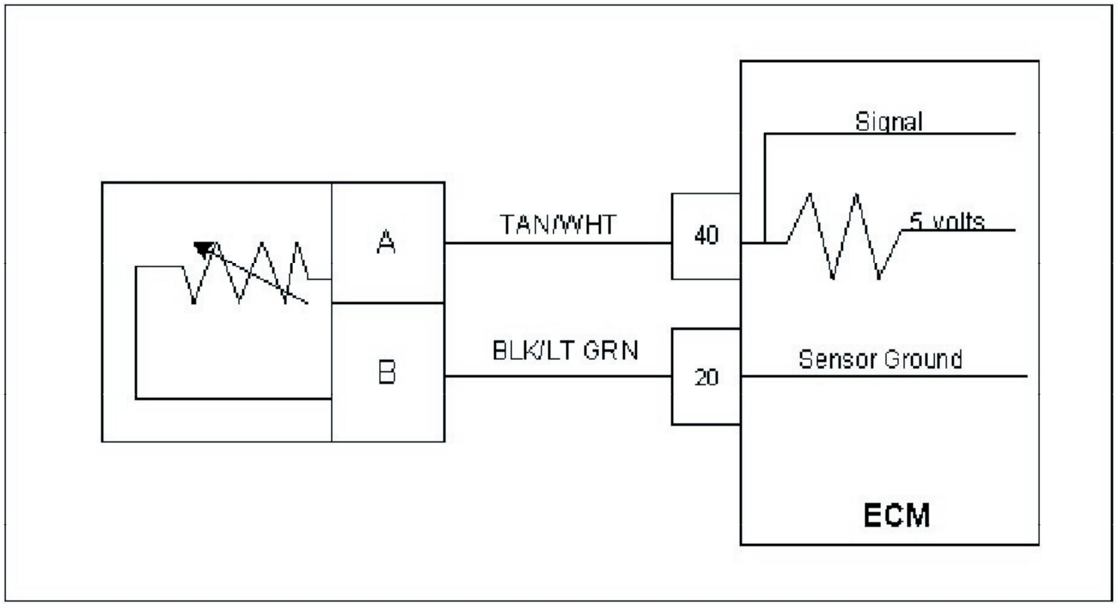
Circuit Description

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 5 seconds with the engine speed over 600 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

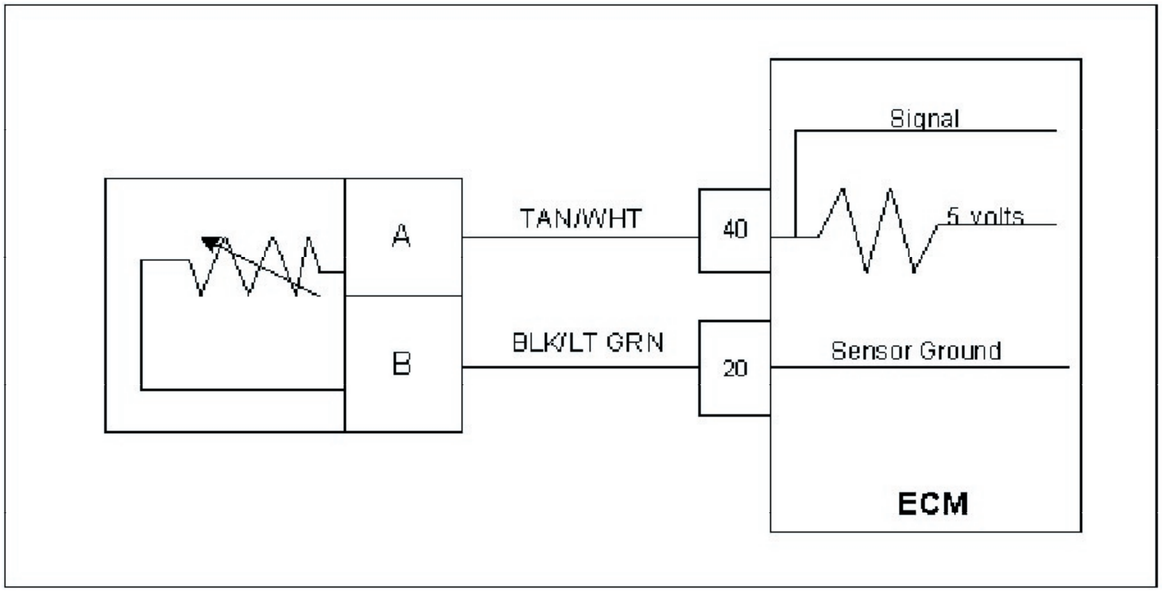
The ECT (Engine Coolant Temperature) sensor is a temperature sensitive resistor located in the engine coolant passage. It is used for the engine airflow calculation, gasoline cold enrichment and to enable other temperature dependant features. The ECM provides a voltage divider circuit so that when the 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 (°F)	Ohms
242	101
231.9	121
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-5.7	28,770
-21.7	49,715
-30.8	71,589
-40	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.

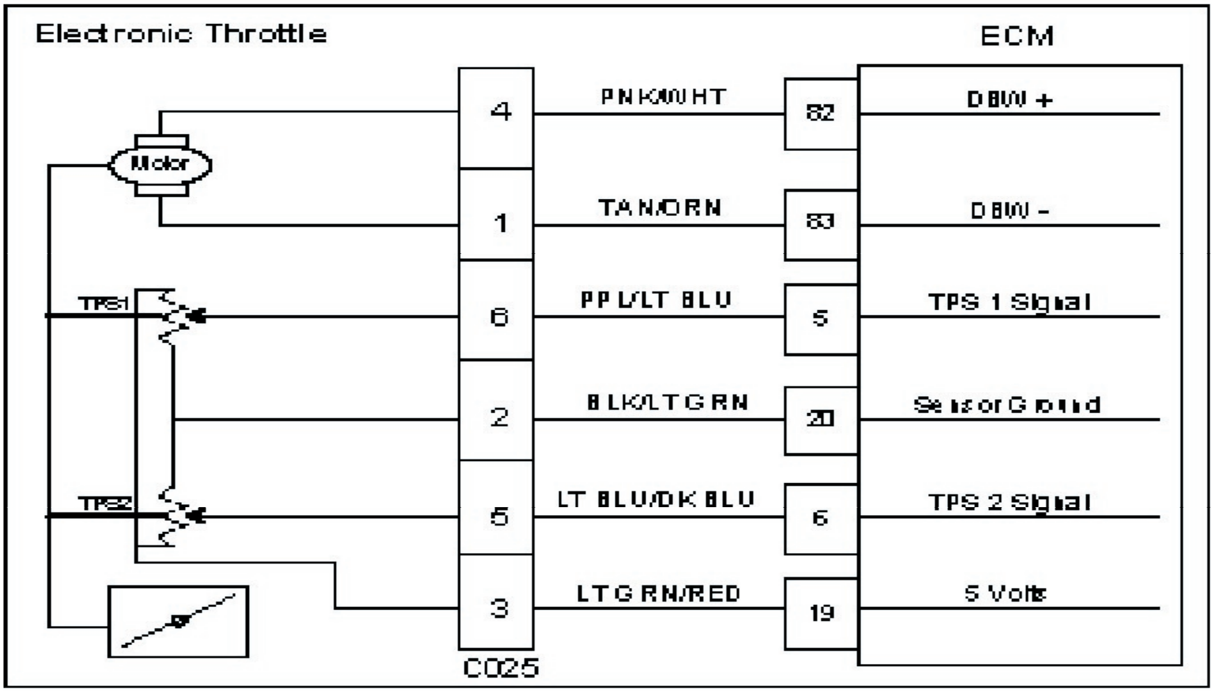
Temp (° F)	Ohms
242.4	101
231.9	131
211.6	175
201.4	209
181.9	302
163.1	434
144.9	625
127.4	901
102.4	1,556
78.9	2,689
49.9	5,576
23.5	11,562
-5.7	28,770
-21.2	49,715
-30.8	71,589
-40.0	99,301

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

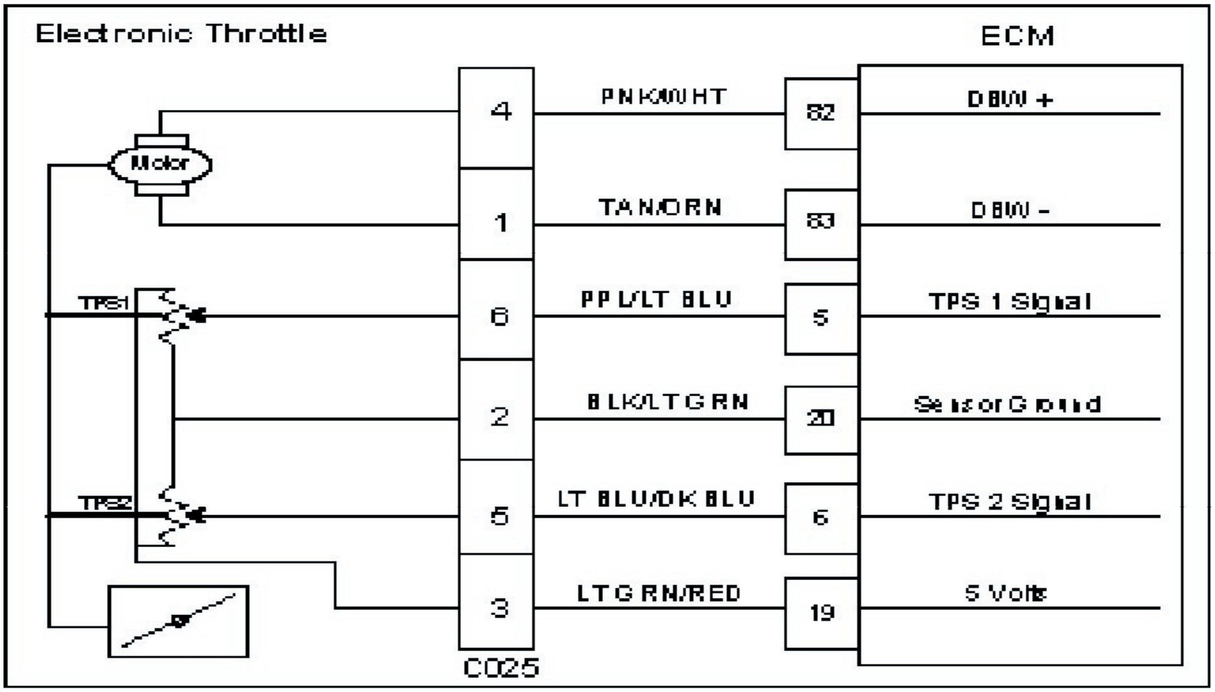
There are two Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS 1 will read low voltage when closed and TPS 2 will read high voltage when closed. The TPS 1 and TPS 2 percentages are calculated from these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

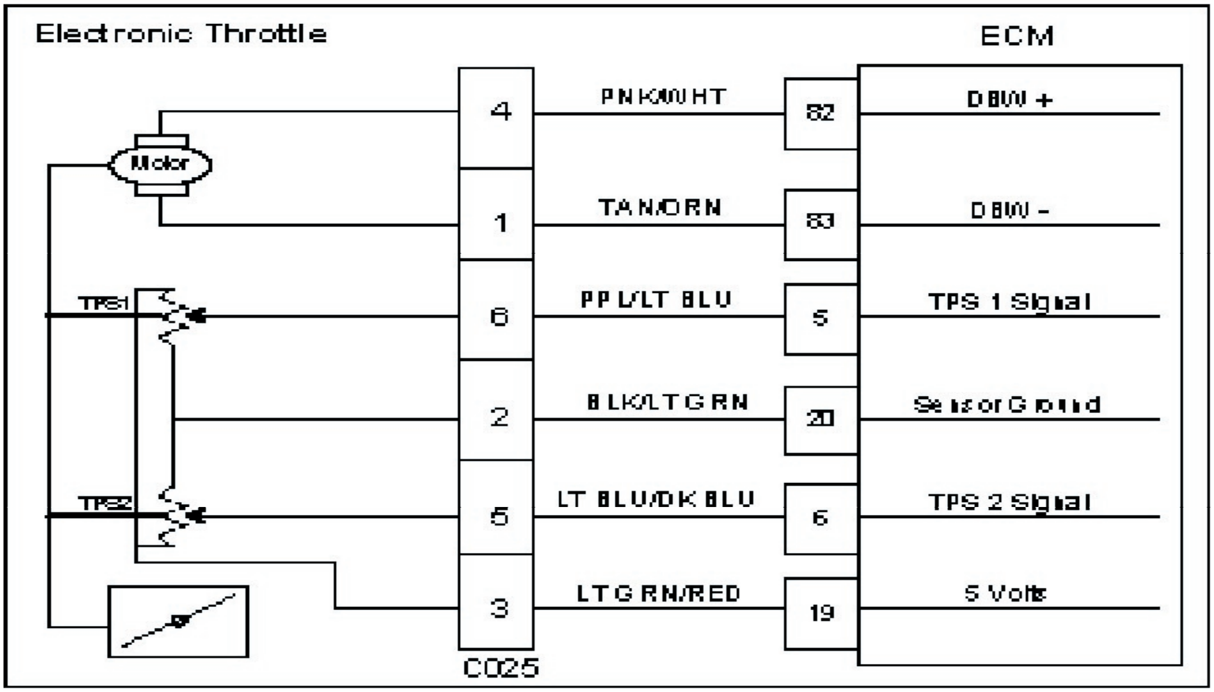
This fault will set if the TPS 1 voltage is less than 0.20 volts for more than .50 seconds. The MIL command in ON and power derate level 1 will be enforced limiting maximum throttle to 50%.

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

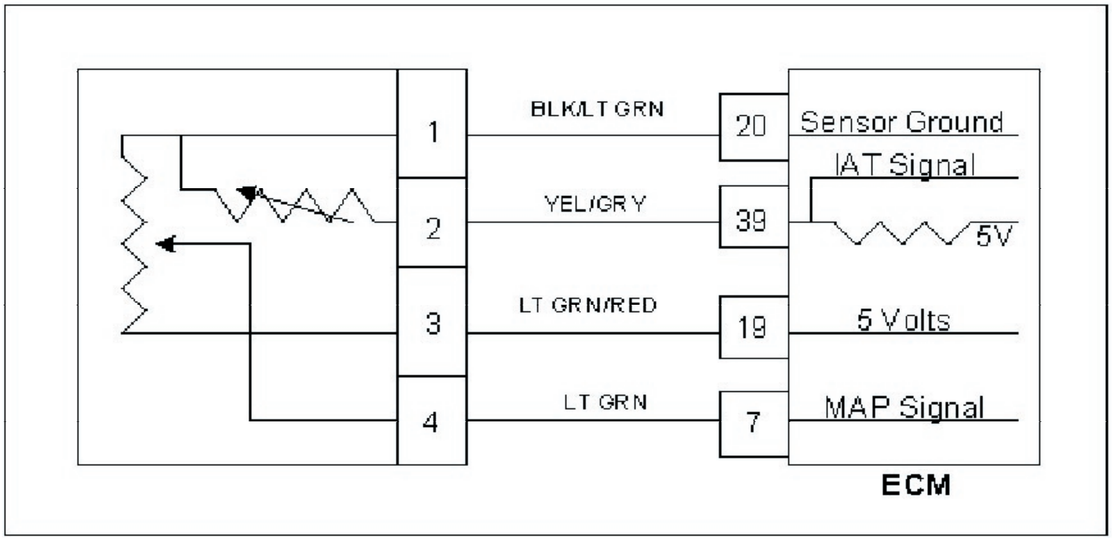
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read lower voltage when closed and TPS2 will read higher voltage when closed. The TPS1 and TPS2 percentages are calculated from these 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 210 degrees F. for more than 120 seconds with engine speed greater than 1000 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 1000. 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

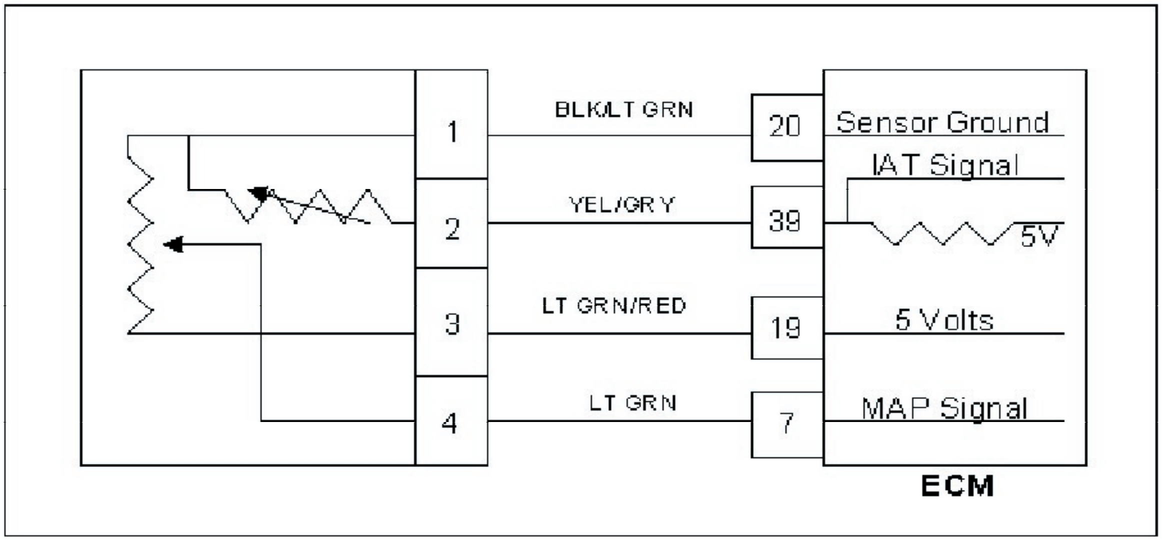
Diagnostic Aid

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
- Use the chart below to check resistance accross pins 1 and 2 at TMAP sensor and compare resistance to air temperature.
- If none of the above can be found, follow the diagnostic steps for **DTC 112-IAT Low Voltage.**

Temp (° F)	Ohms
248	110
239	125
221	162
203	214
185	284
167	383
149	522
131	721
104	1,200
77	2,063
50	3,791
23	7,419
-4	15,614
-22	26,854
-31	35,763
-40	48,153

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

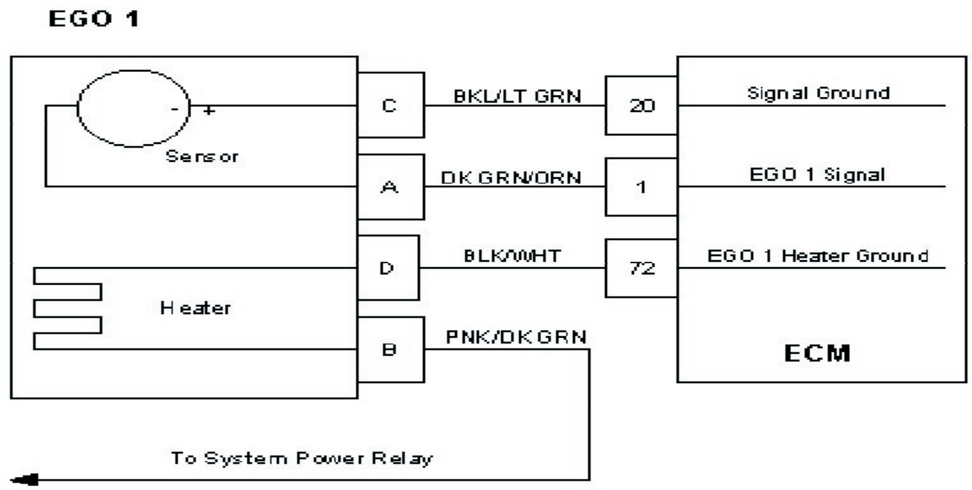
Circuit Description

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.

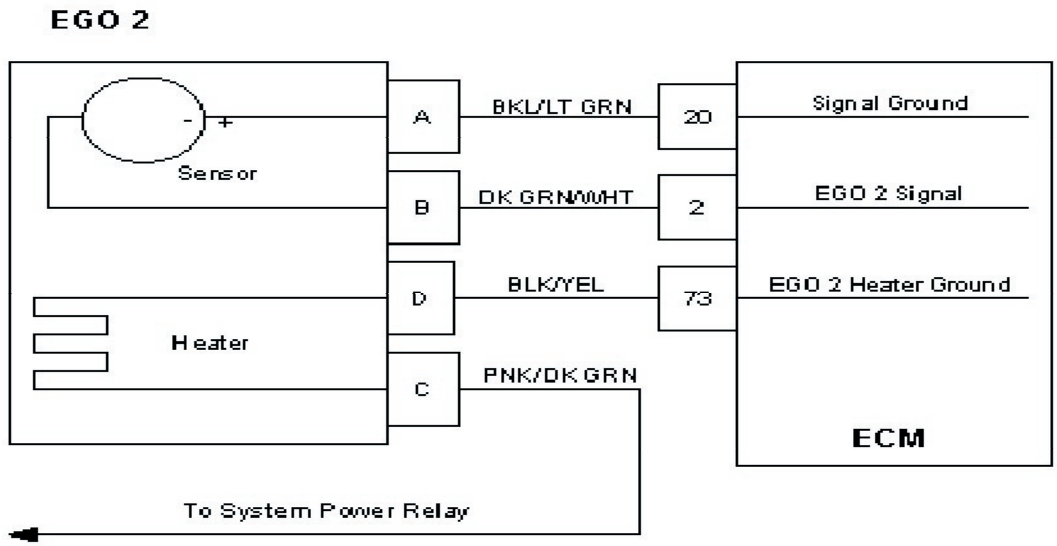
This fault will set if EGO 1 is cold, non-responsive, or inactive for more than 120 seconds.

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 2 second after active fault
- Adaptive- Disabled during active fault
- Closed Loop- Disabled during active fault

Circuit Description

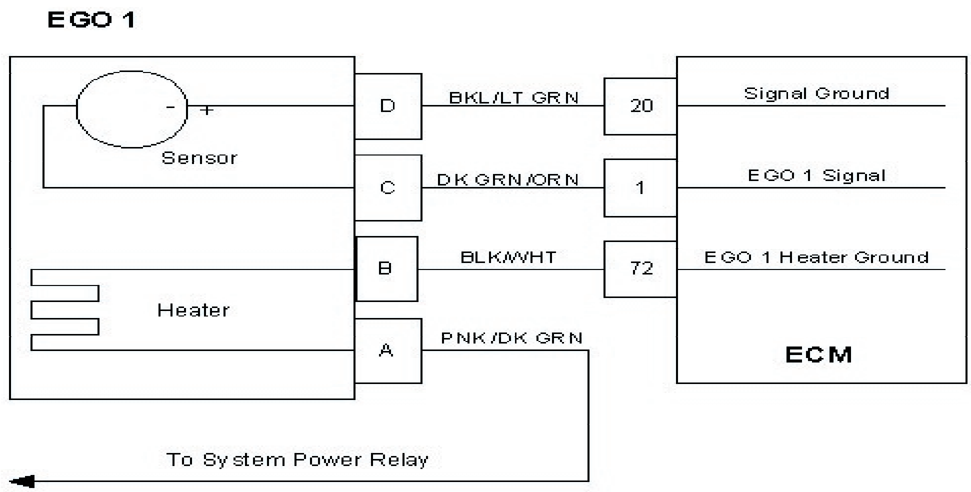
The EGO 2 sensor is used to monitor the efficiency of the catalytic converter. The ECM compares the EGO 1 and EGO 2 voltage signals to determine this. This fault will set if EGO 2 is cold, non-responsive, or inactive for more than 120 seconds.

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

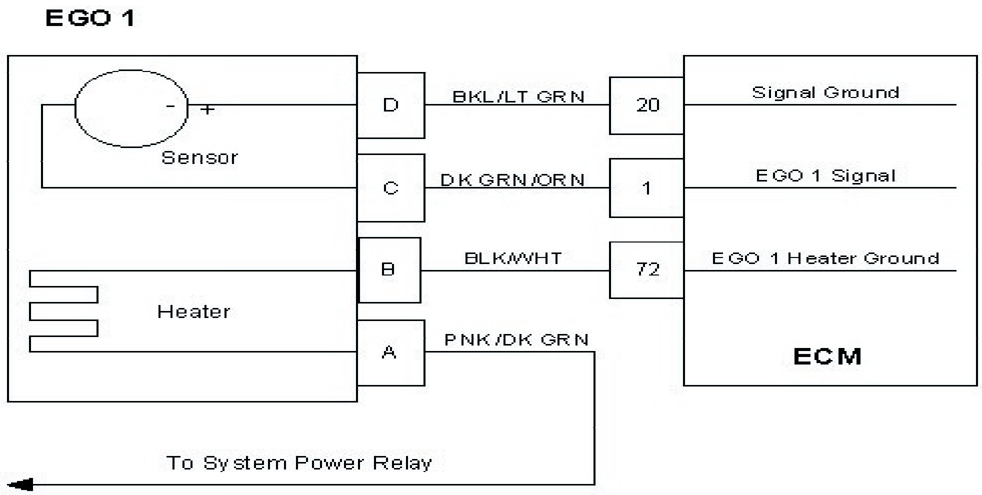
Check for other DTC codes that may be set. Correct those starting with the lowest code set number before proceeding with the diagnostic chart.
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause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

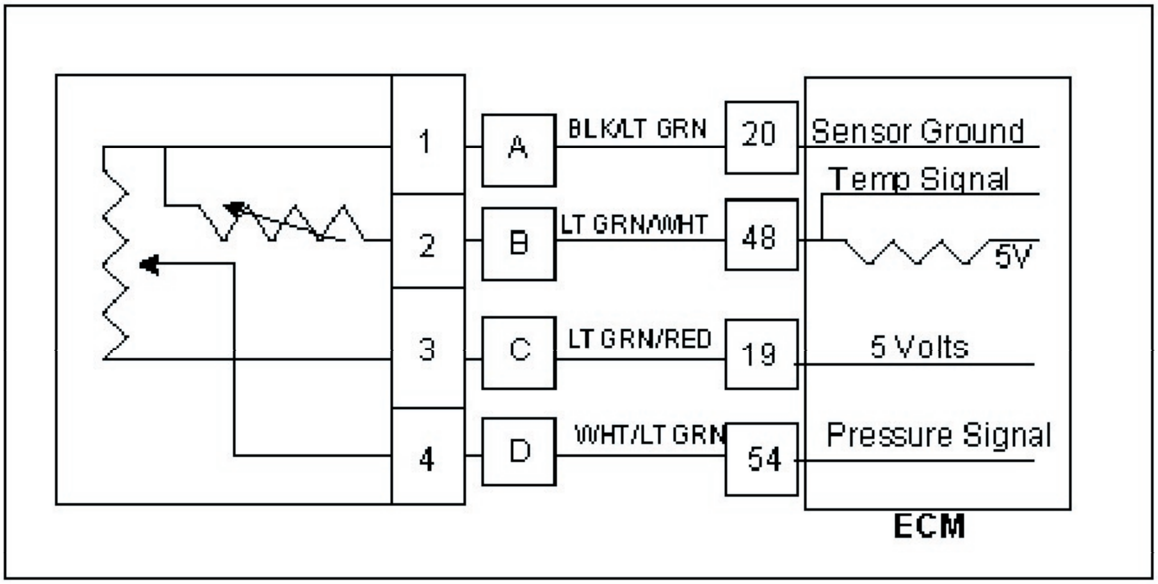
Diagnostic Aid

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

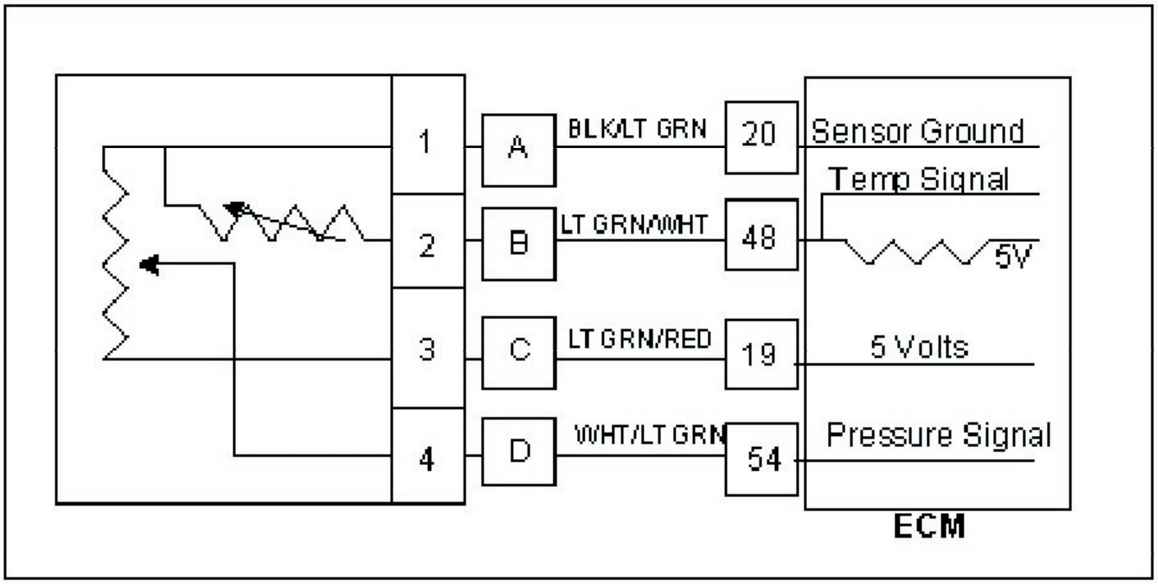
Note: The fuel pressure and temperature sensor is wired via Equipment Manufacturer supplied harness jumper. The terminals A, B, C, D & 19, 20, 48, 54 are engine wiring harness terminals at the fuel sensor interface connector C002 and the ECM header connector C001. You may need to consult additional wiring 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

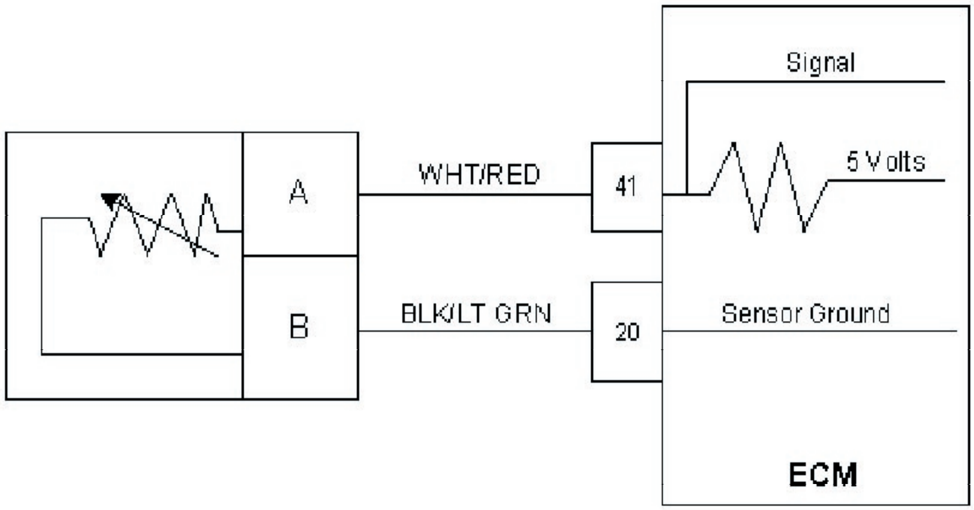
Note: The fuel pressure and temperature sensor is wired via Equipment Manufacturer supplied harness jumper. The terminals A, B, C, D & 19, 20, 48, 54 are engine wiring harness terminals at the fuel sensor interface connector C002 and the ECM header connector C001. You may need to consult additional wiring 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 Sensor Voltage Low SPN/FMI 520240:4



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

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

Circuit Description

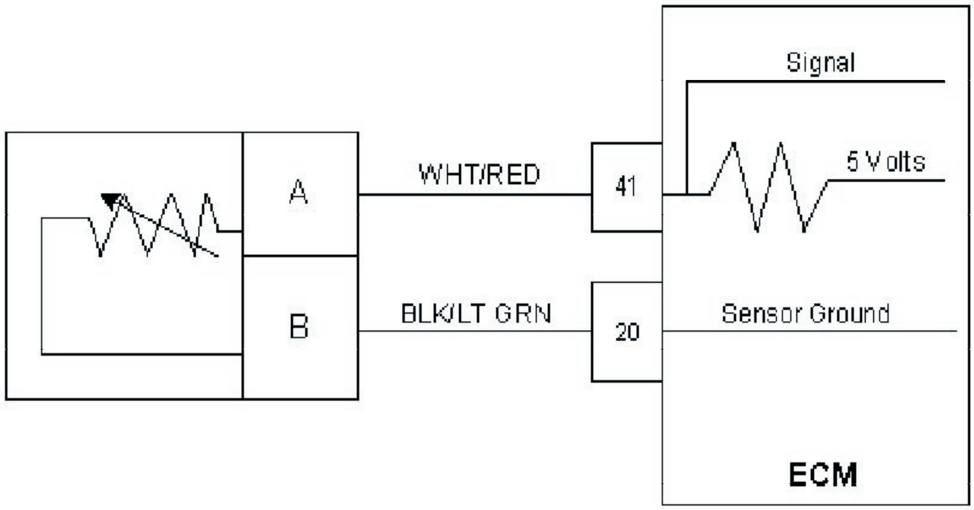
The FT (Fuel Temperature) sensor is a temperature sensitive resistor located near the fuel outlet of the electronic pressure regulator. It is used to help determine fuel charge density for accurate fuel mixture control. The ECM provides a voltage divider circuit so that when the sensor is cool the signal 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

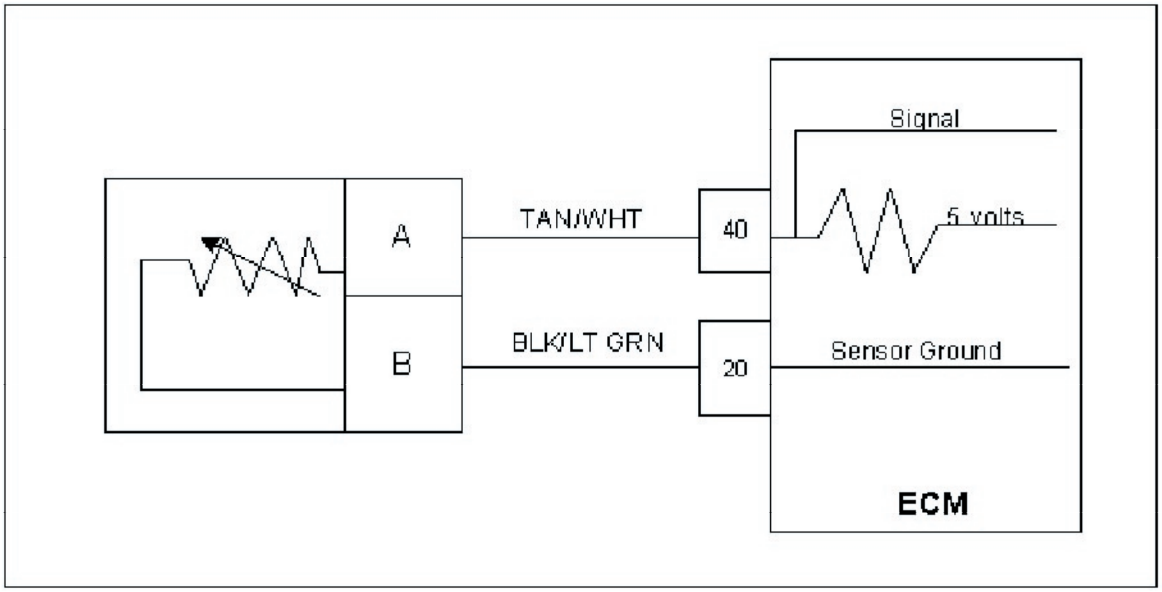
The FT (Fuel Temperature) sensor is a temperature sensitive resistor located near the fuel outlet of the electronic pressure regulator. It is used to help determine fuel charge density for accurate fuel mixture control. The ECM provides a voltage divider circuit so that when the sensor is cool the signal 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 225 deg. F for more than 15 seconds with the engine speed greater than 600 rpm
- MIL-On
- Engine Shut Down

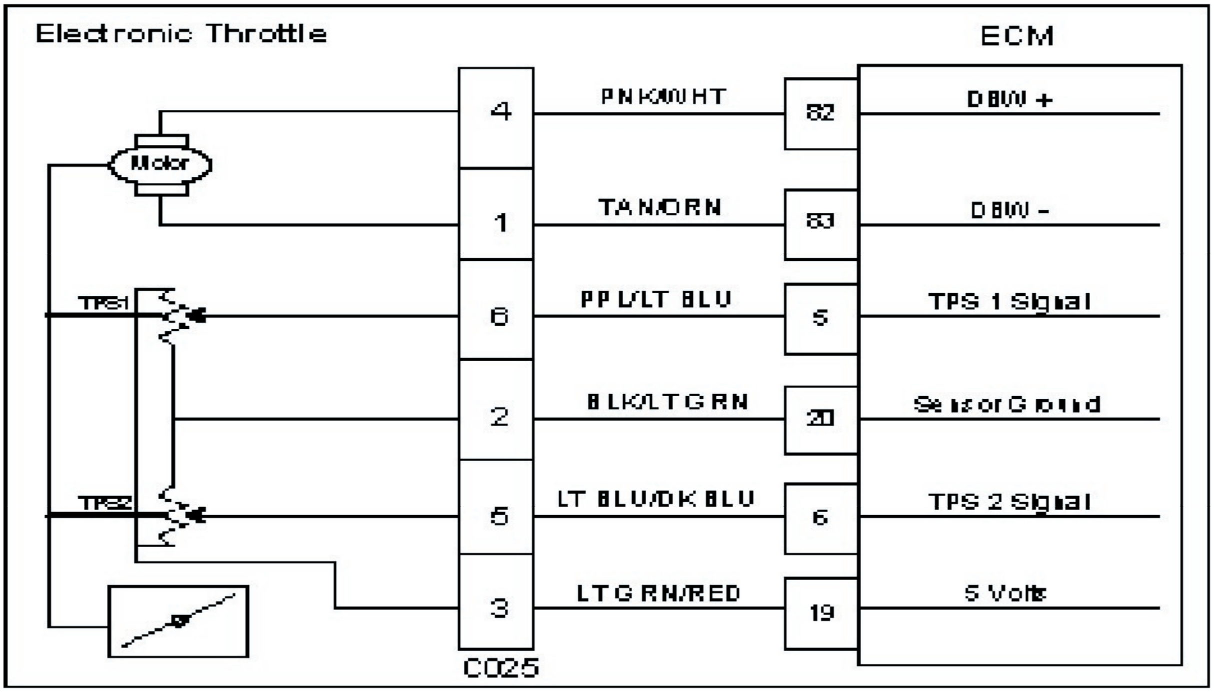
Circuit Description

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 225 degrees F. for more than 15 seconds with the engine speed over 600 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 3300 for 2 seconds continuously
- MIL- On during active fault

Circuit description

This fault will set anytime the engine RPM exceeds 3300 for 2 seconds or more continuously. The MIL command is ON during this active fault.

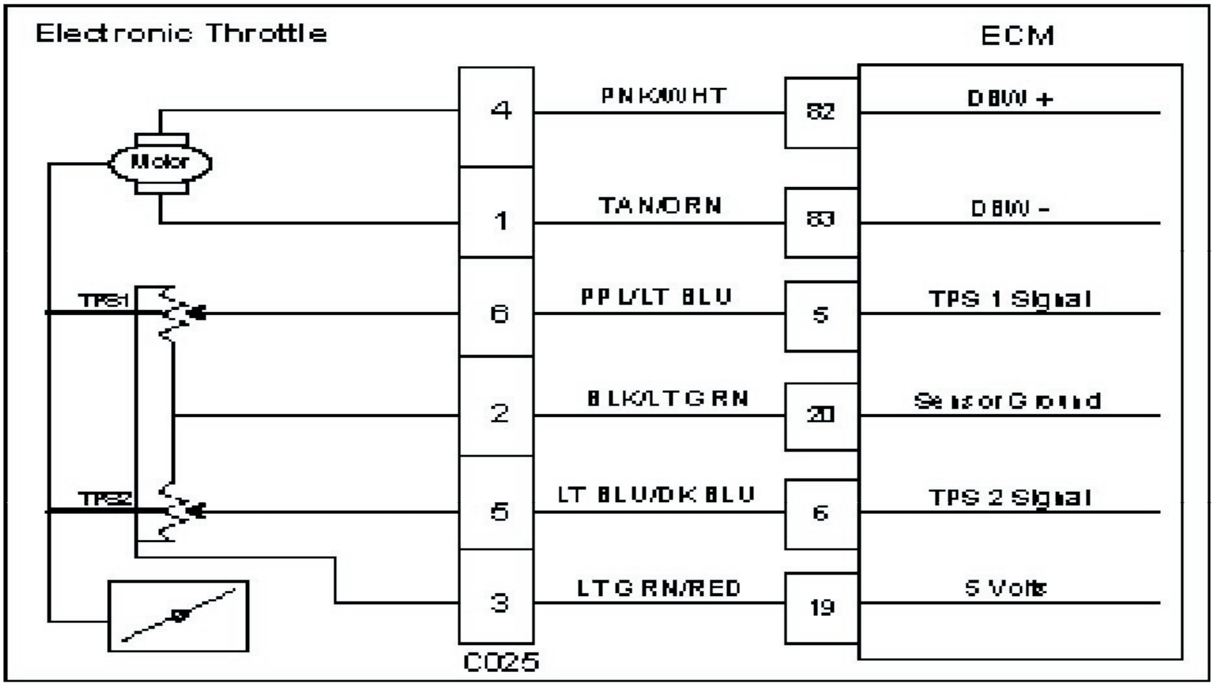
Diagnostic Aid

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

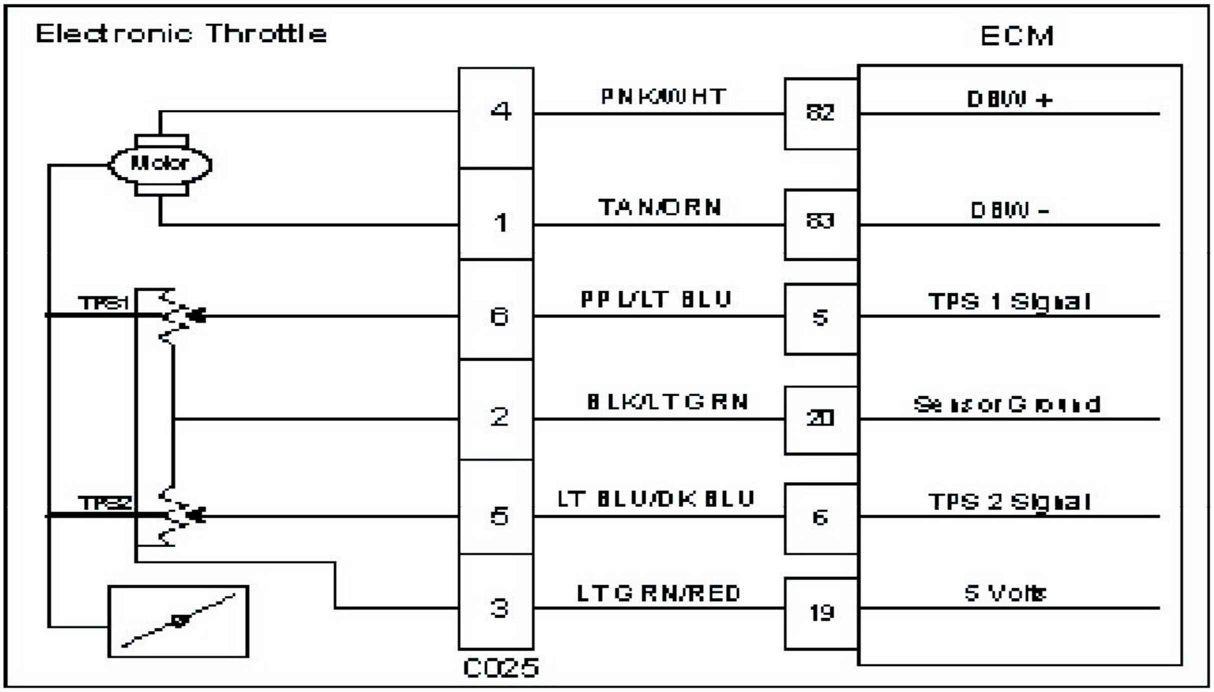
There are two Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS 1 will read lower voltage when closed and TPS 2 will read higher voltage when closed. The TPS 1 and TPS 2 percentages are calculated from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

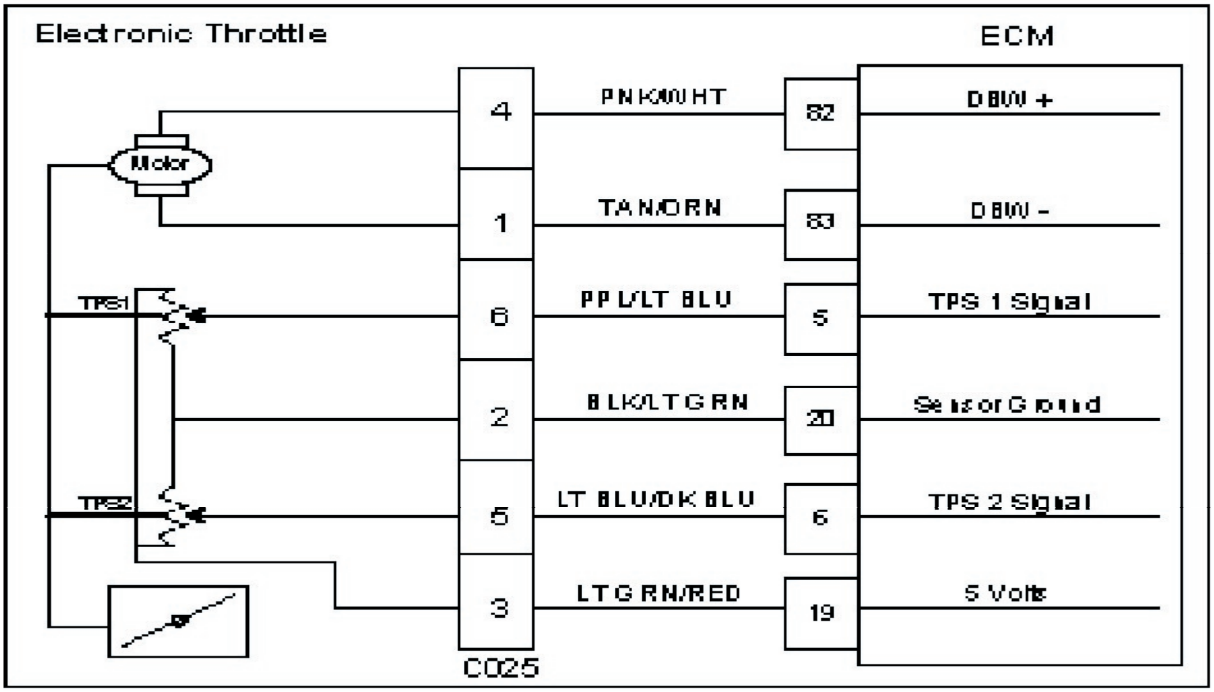
There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read lower voltage when closed and TPS2 will read higher voltage when closed. The TPS1 and TPS2 percentages are calculated from these 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 the engine will shutdown.

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.

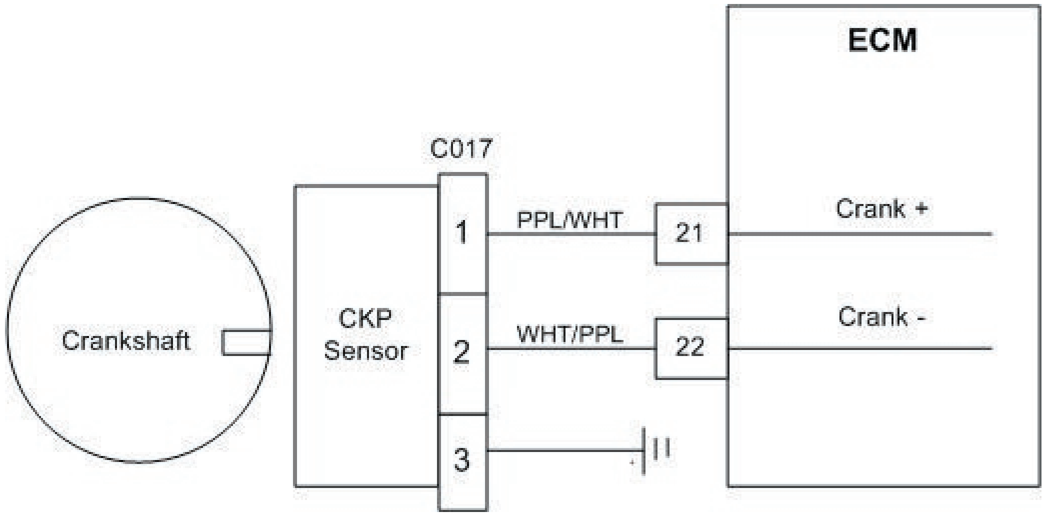
This fault will set if the TPS 2 voltage is greater than 4.80 volts for more than .50 seconds. The MIL command is ON and the engine will shutdown.

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 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

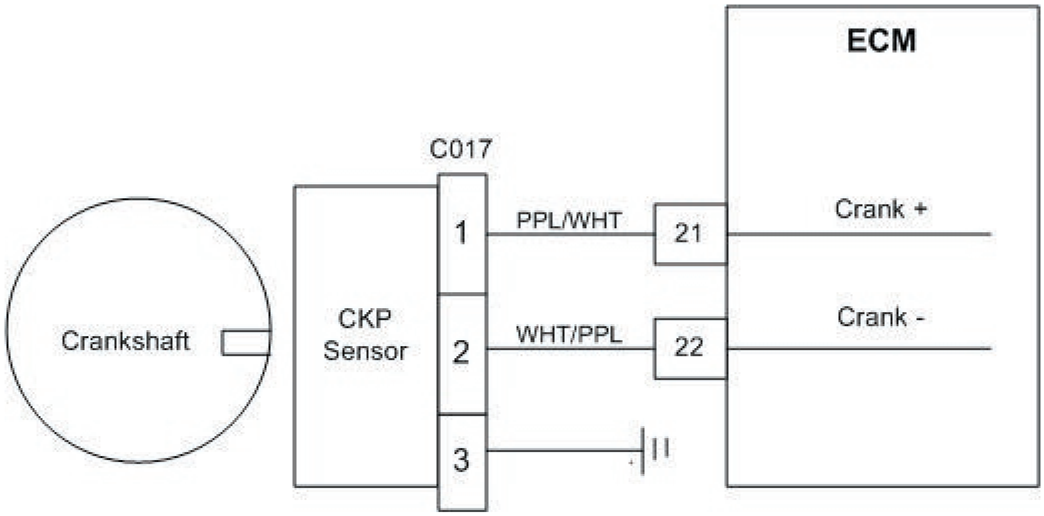
The CKP (crankshaft position sensor) is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize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

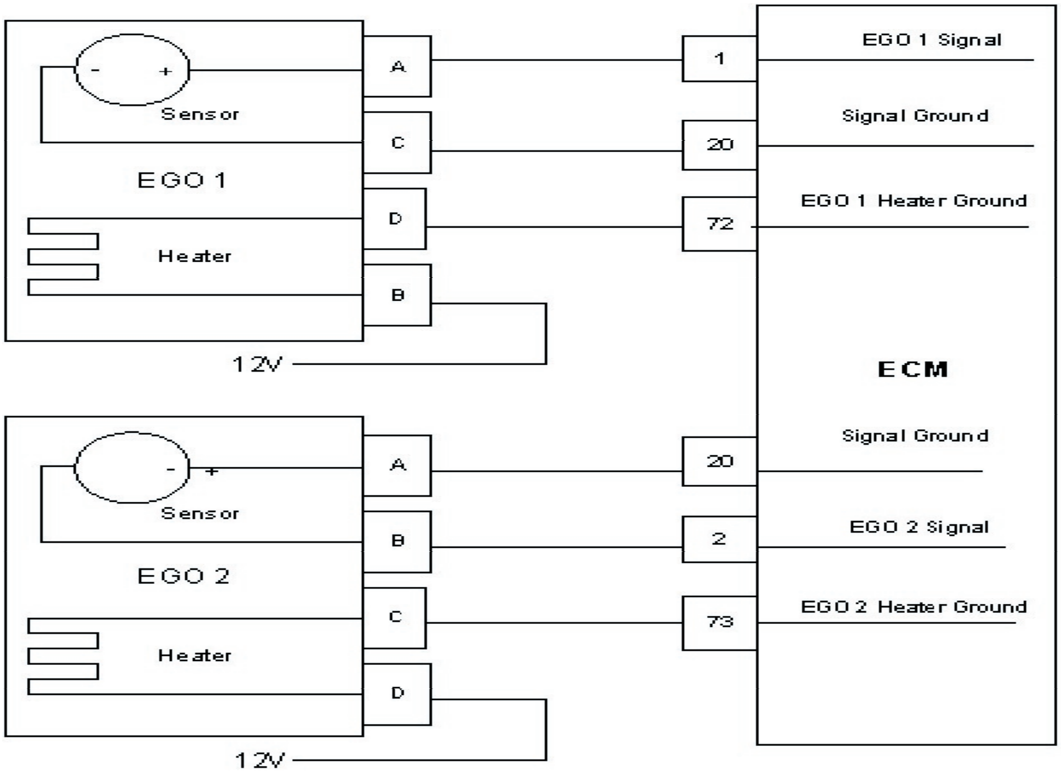
The CKP (crankshaft position sensor) is a magnetic transducer mounted on the engine block adjacent to a pulse wheel located on the crankshaft. It determines crankshaft position by monitoring the pulse wheel. The Crankshaft Position sensor is used to measure engine RPM and its signal is used to synchronize the ignition and fuel systems. This fault will set if three or more cam pulses 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 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

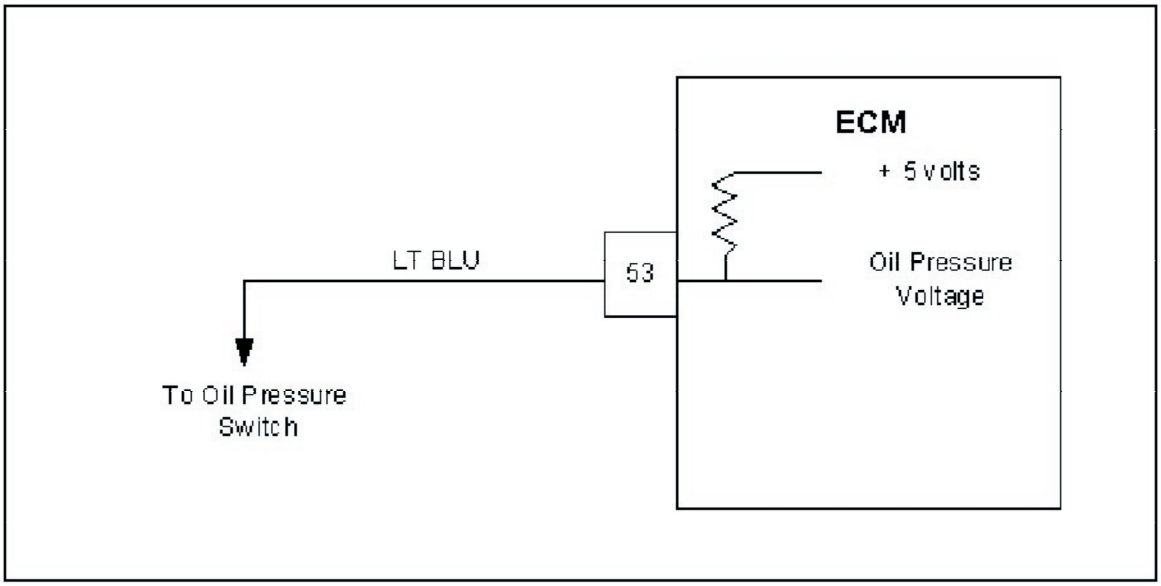
Circuit Description

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

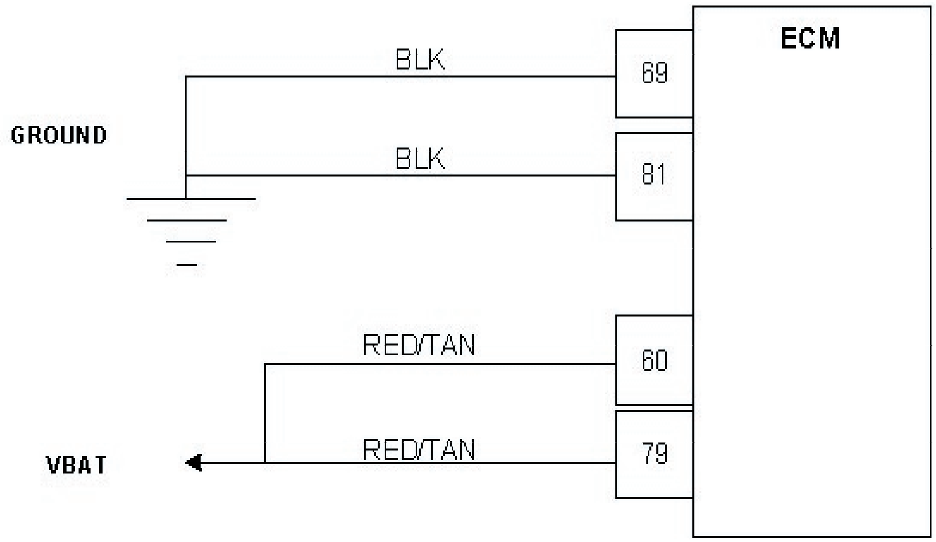
The Oil Pressure Switch is used to communicate a low oil pressure condition to the ECM. Engine damage can occur if the engine is operated with low oil pressure. The ECM uses an analog voltage input with an internal 5 volt reference. If the oil pressure circuit is grounded, the input voltage will be near 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

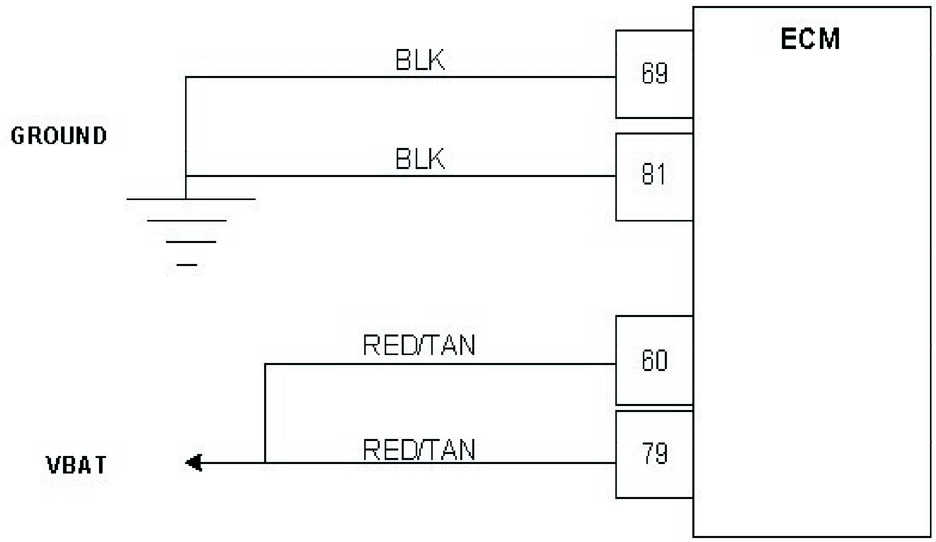
Circuit Description

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

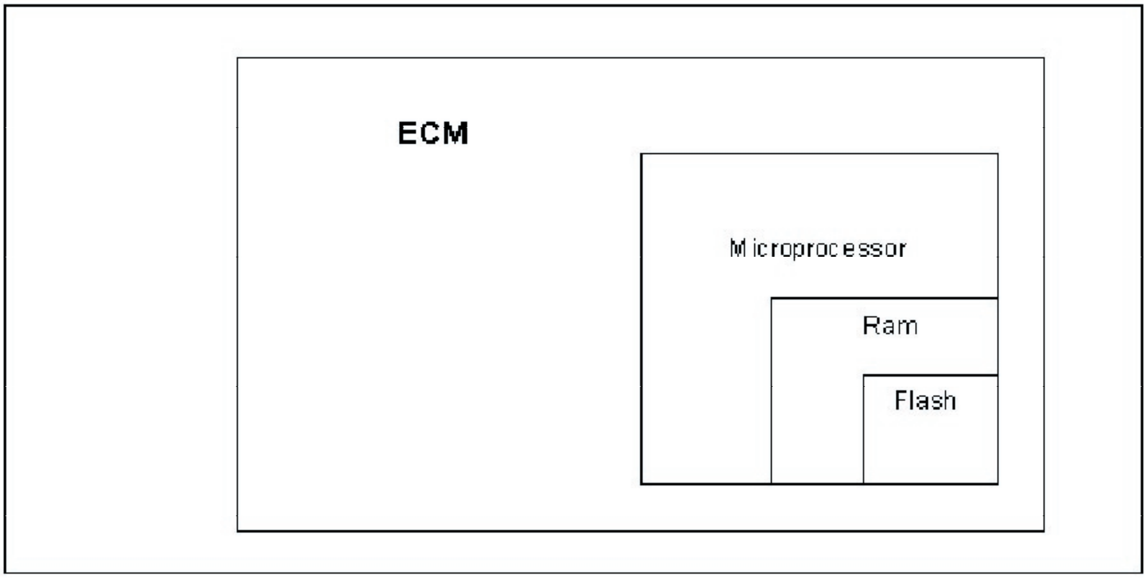
Circuit Description

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

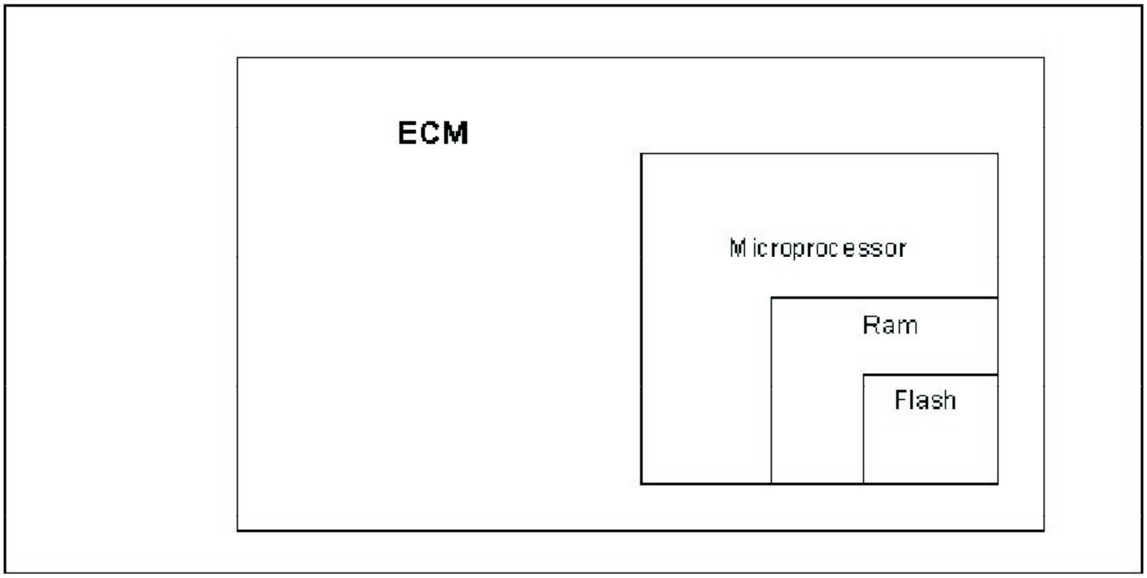
Circuit Description

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

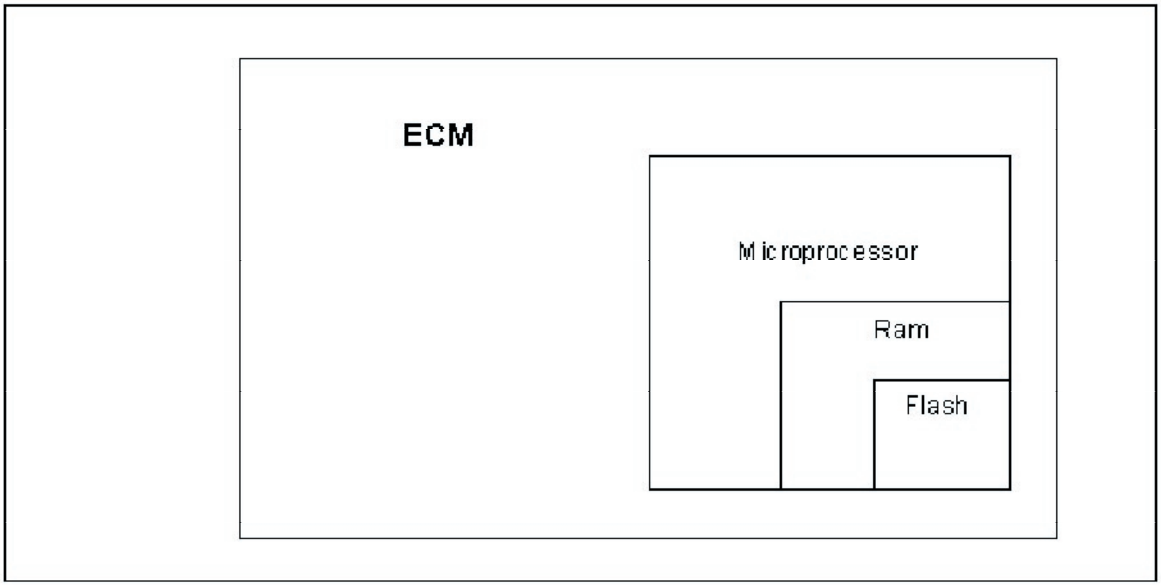
Circuit Description

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

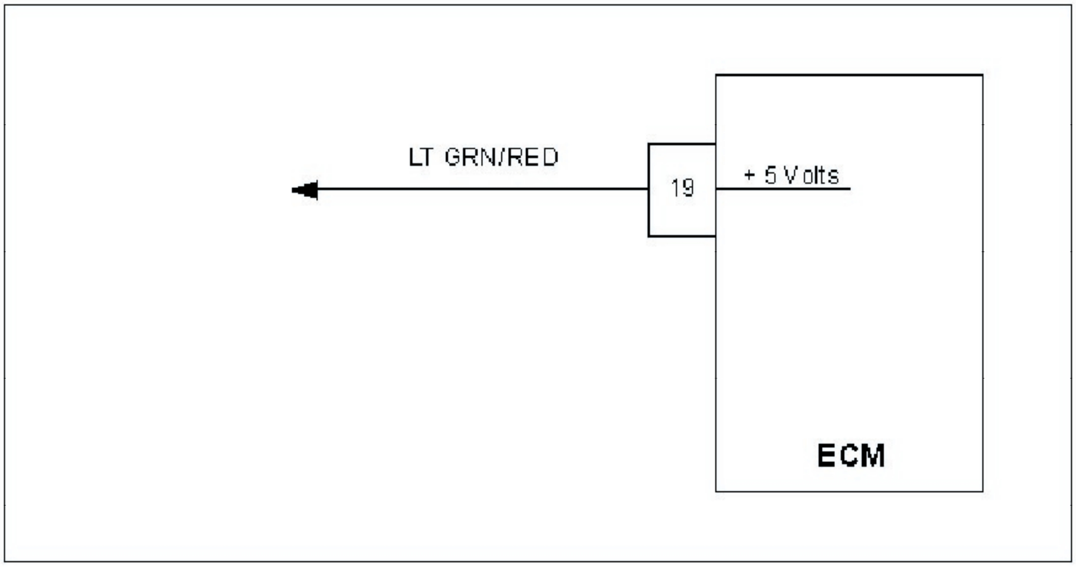
Circuit Description

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

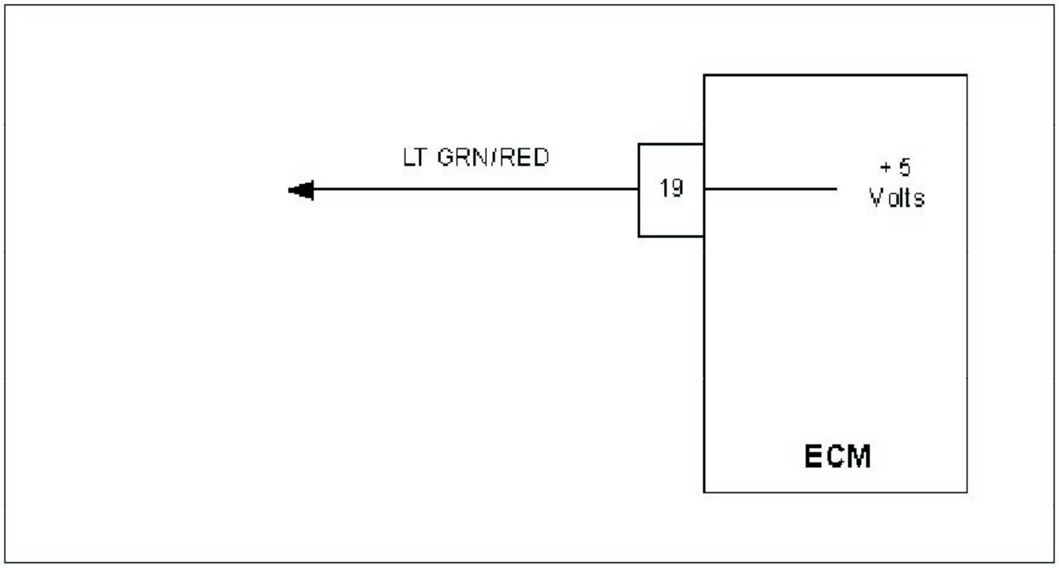
The External 5 volt supply powers many of the sensors and other components of the fuel system. The accuracy of the 5 volt supply is very important to the accuracy of the powered sensors and fuel control by the ECM. The ECM is able to determine if they are overloaded, shorted, or otherwise out of specification 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

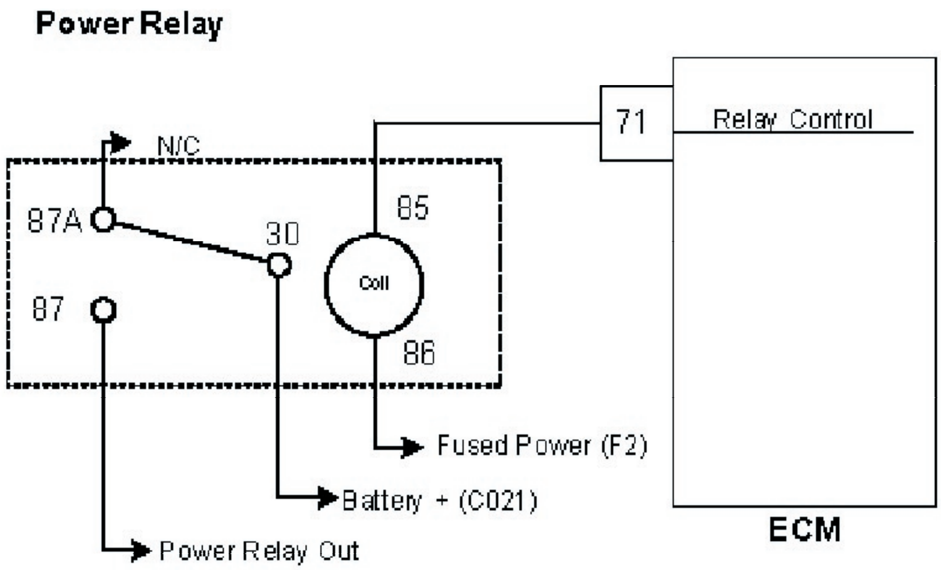
Circuit Description

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

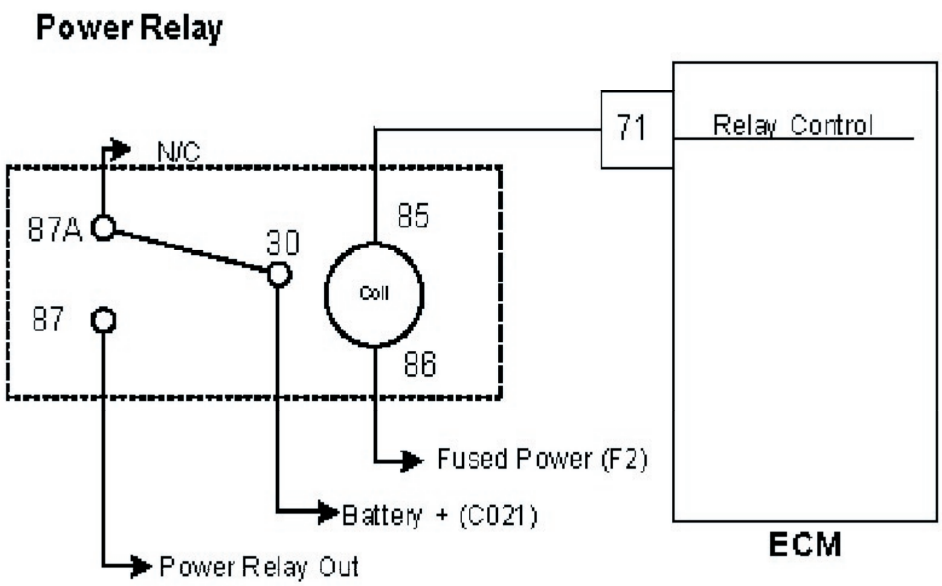
The power relay switches power out to various sensors, actuators and solenoids in the fuel system. This fault will set if the ECM detects an open circuit on the relay control output.

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

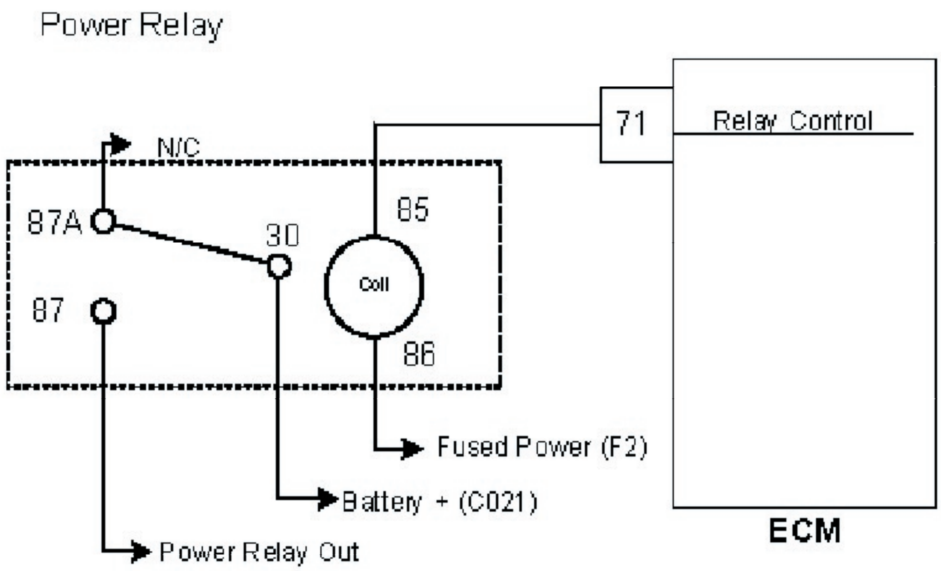
Circuit Description

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

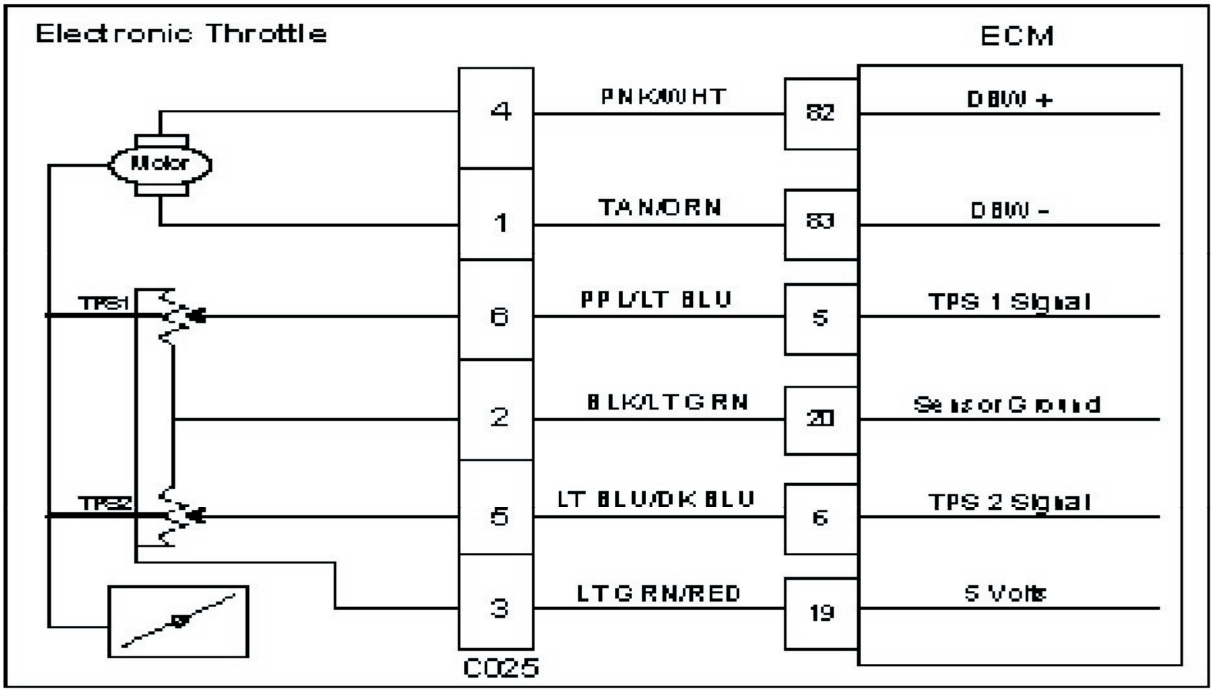
The power relay switches power out to various sensors, actuators and solenoids in the fuel system. This fault will set if the ECM detects a short circuit to power on the relay control output.

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 3500 for 2 seconds continuously
- MIL- On during active fault

Circuit Description

This fault will set anytime Engine RPM is greater than 3500 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.

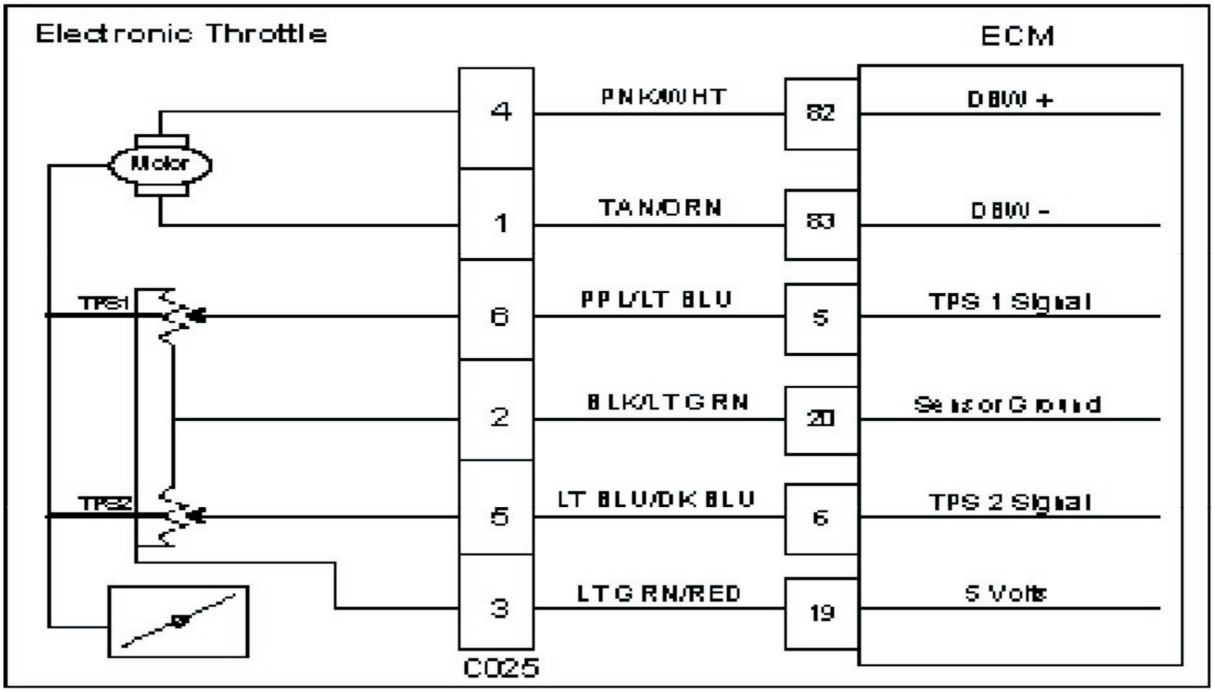
Diagnostic Aid

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 3700
- MIL- On during active fault
- Engine Shut Down

Circuit description

This fault will set anytime the engine RPM exceeds 3700. 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.

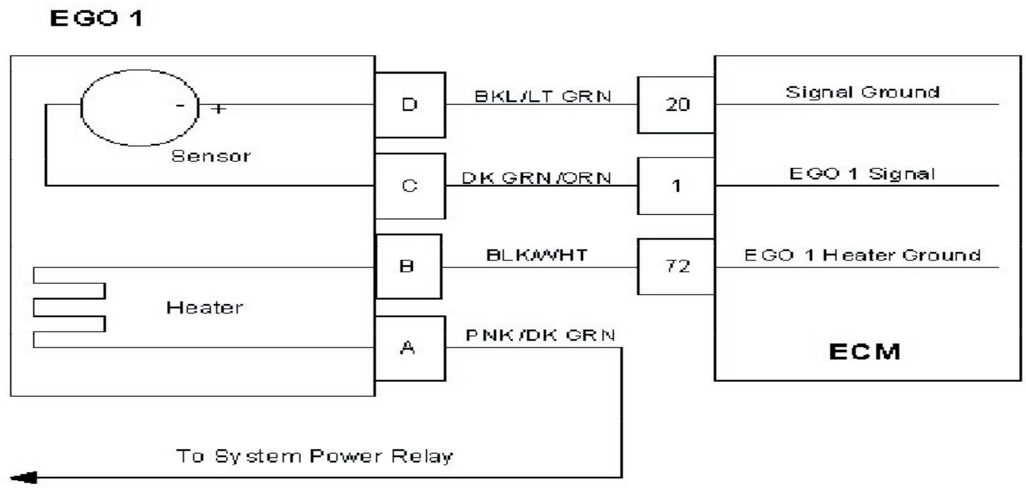
Diagnostic Aid

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

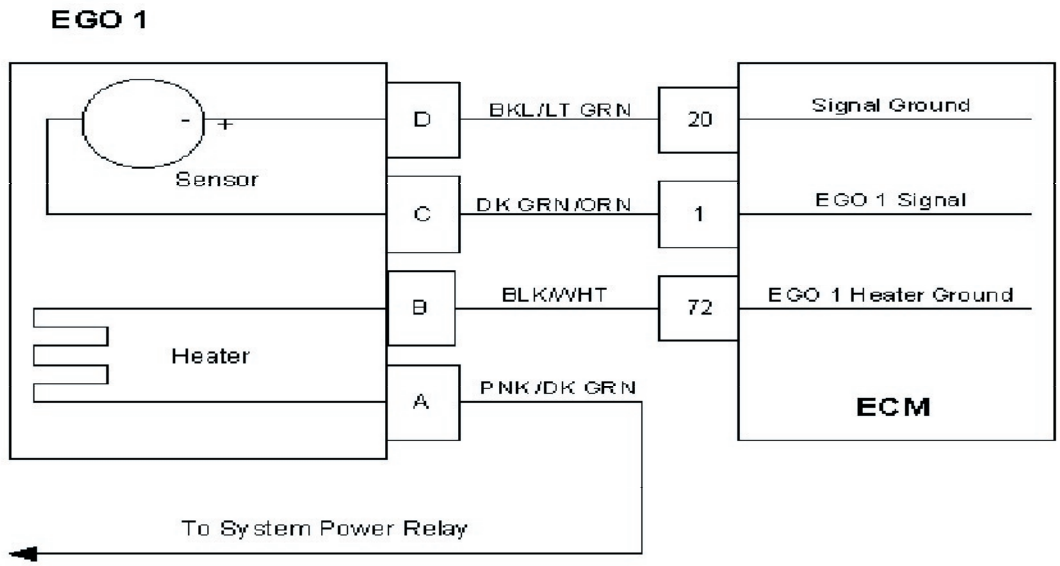
Diagnostic Aid

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 secondary fuel pressure, faulty EPR (Electronic Pressure Regulator) or contaminated fuel filter can cause fuel the system to run lean. Perform LPG Fuel System Diagnosis Diagnosis (Section 5).
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. Perform LPG Fuel System Diagnosis Diagnosis (Section 5).

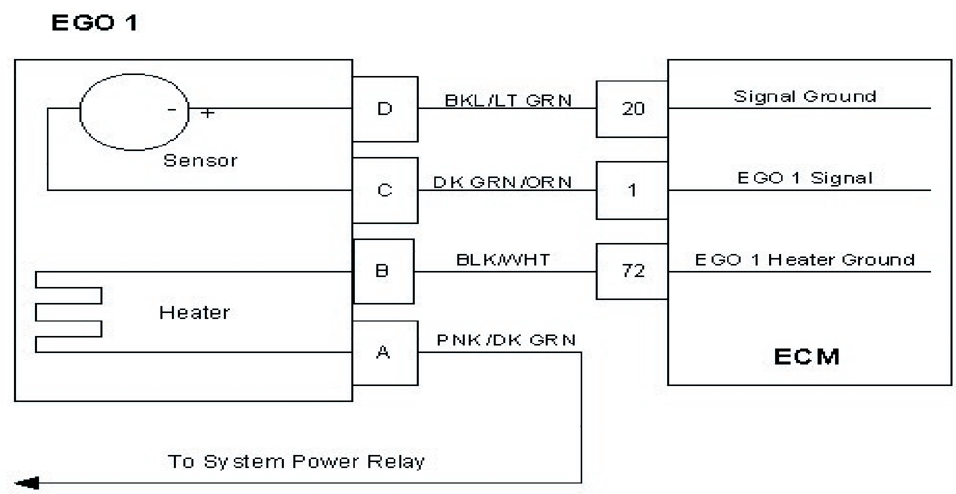
Fuel Quality A drastic variation in fuel quality (very high butane content) may cause the fuel system to run rich. Be sure that the specified HD-5 or HD-10 motor fuel grade propane is used

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

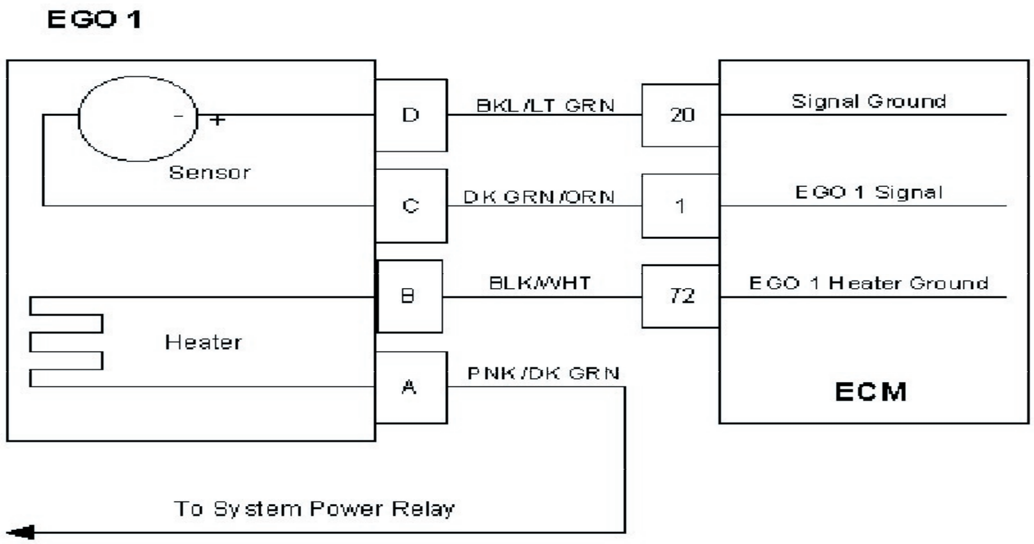
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at especially at light load.
Fuel Pressure Low fuel pressure, faulty fuel regulator or contaminated fuel filter can 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)	Refer to Diagnostic Aids for DTC 1155

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-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.

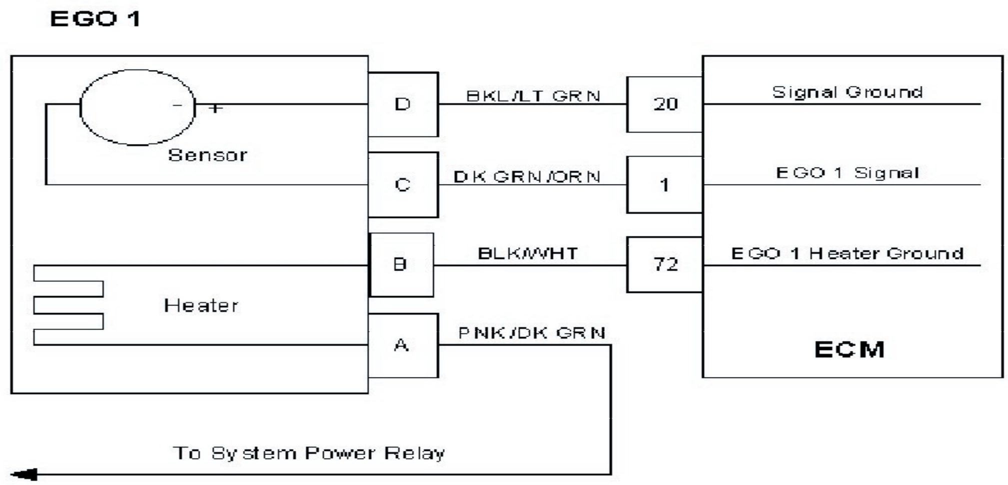
Diagnostic Aid

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

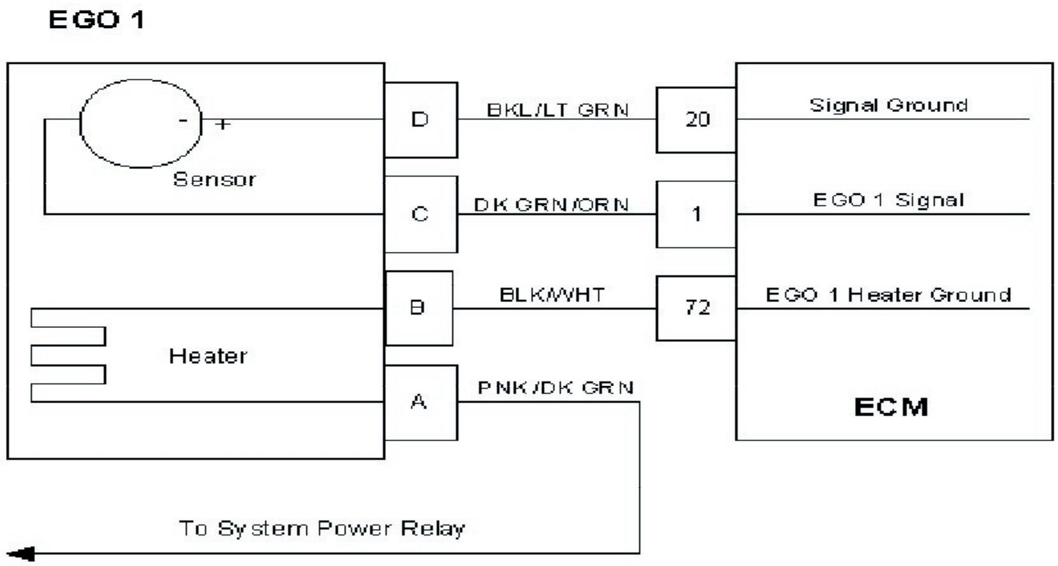
Oxygen Sensor Wire Heated Oxygen sensor wires may be mis-routed and contacting the exhaust manifold.
Vacuum Leaks Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at especially at light load.
Fuel Mixer System can be lean due to faulty EPR (Electronic Pressure Regulator) or faulty fuel mixer.
Fuel Pressure Low secondary fuel pressure, faulty low pressure regulator or contaminated fuel filter can cause fuel the system to run lean. Perform LPG Fuel System Diagnosis (Section 5).
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)

Step	Action	Value(s)	Yes	No
7	• Replace EGO 1 sensor Is the replacement complete?		Go to Step (8)	Refer to Diagnostic Aids for DTC 1161
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. Perform LPG Fuel System Diagnosis (Section 5).

Fuel Mixer System can be rich due to faulty EPR (Electronic Pressure Regulator) or a worn fuel mixer.

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.

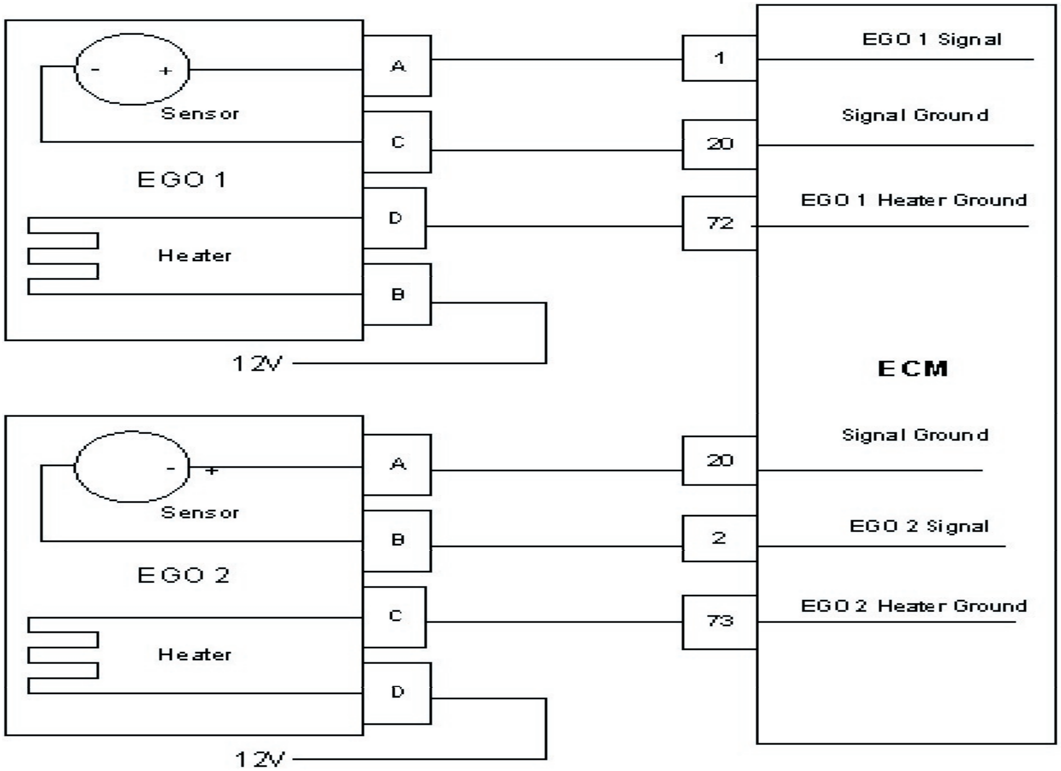
Air Filter A plugged, damaged or modified air filter may cause the system to run rich.

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)

Step	Action	Value(s)	Yes	No
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)	Refer to Diagnostic Aids for DTC 1162
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

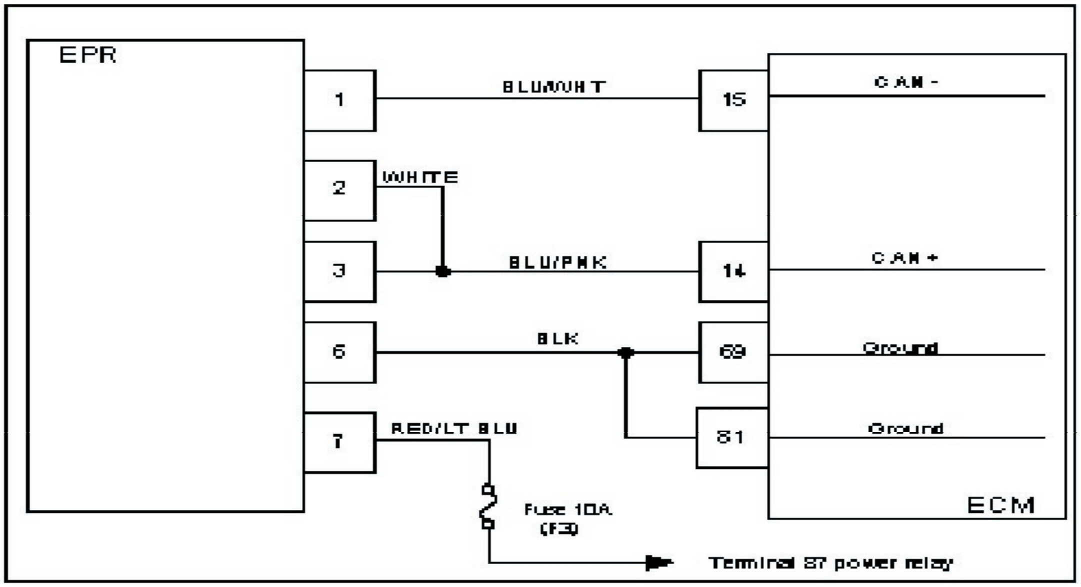
Circuit Description

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 H2O 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.

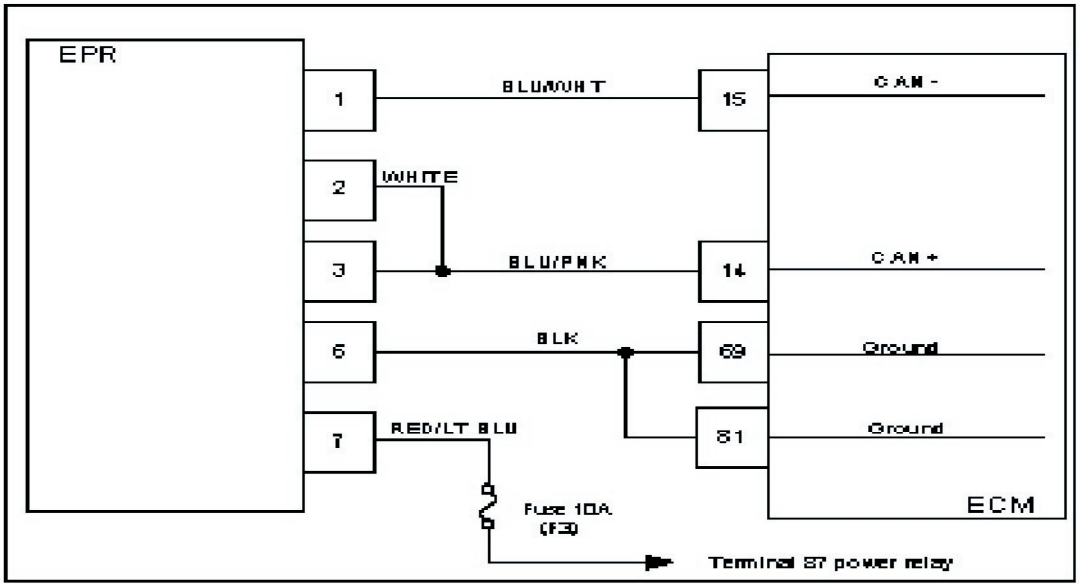
Diagnostic Aid

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 LPG Fuel System Diagnosis procedure (Section 5) 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 H_2O 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.

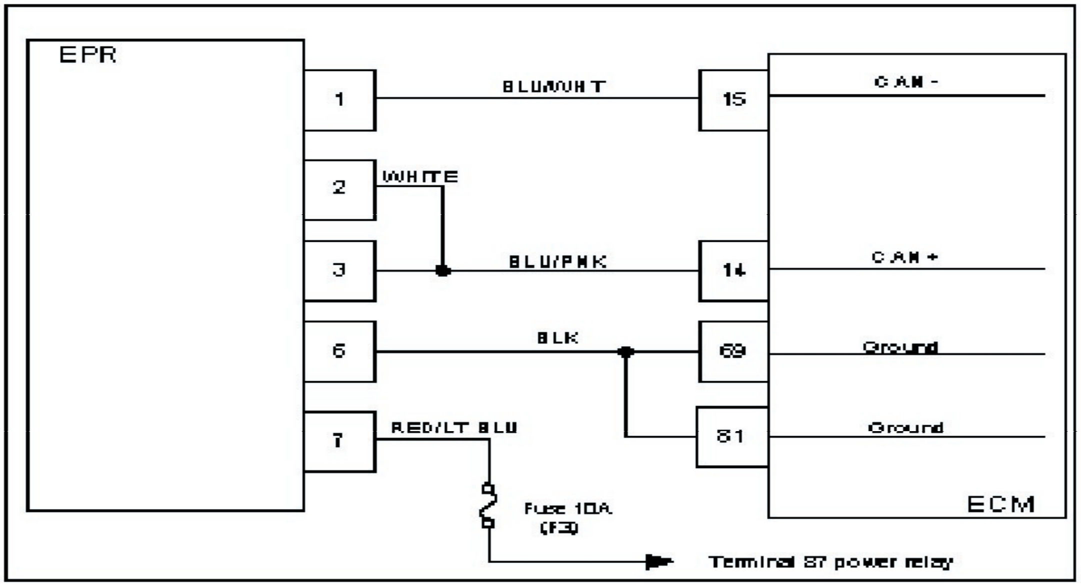
Diagnostic Aid

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 LPG Fuel System Diagnosis (Section 5). 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.

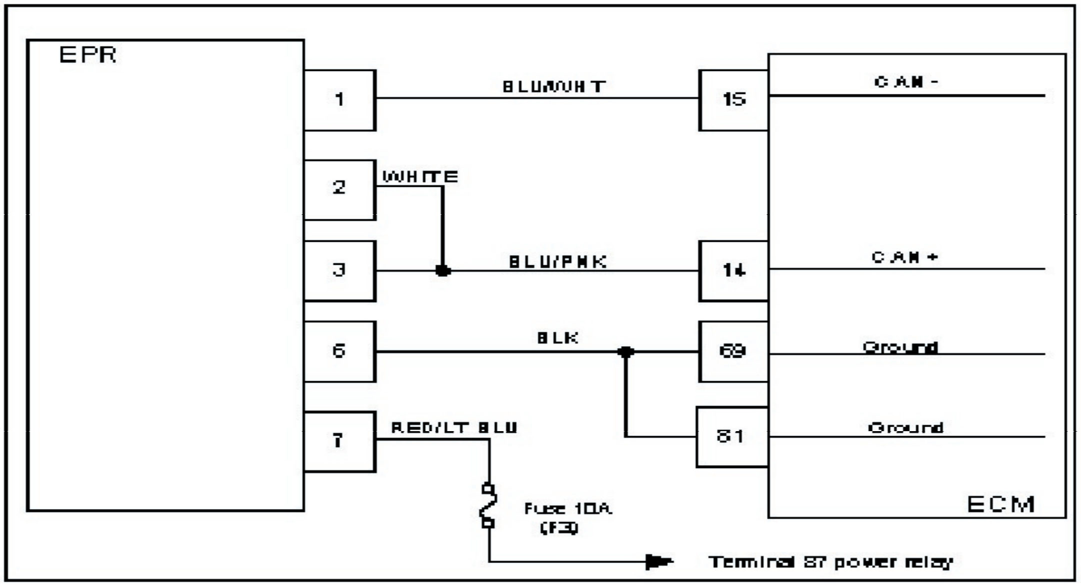
DTC 1173-EPR Communication Lost SPN/FMI 520260:31

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 (EPR) fuse Is the fuse open?		Go to step (5)	Go to step (6)
5	• Replace EPR 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
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

Step	Action	Value(s)	Yes	No
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
16	• Replace the ECM Is the replacement complete?		Go to step (17)	_

Step	Action	Value(s)	Yes	No
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.

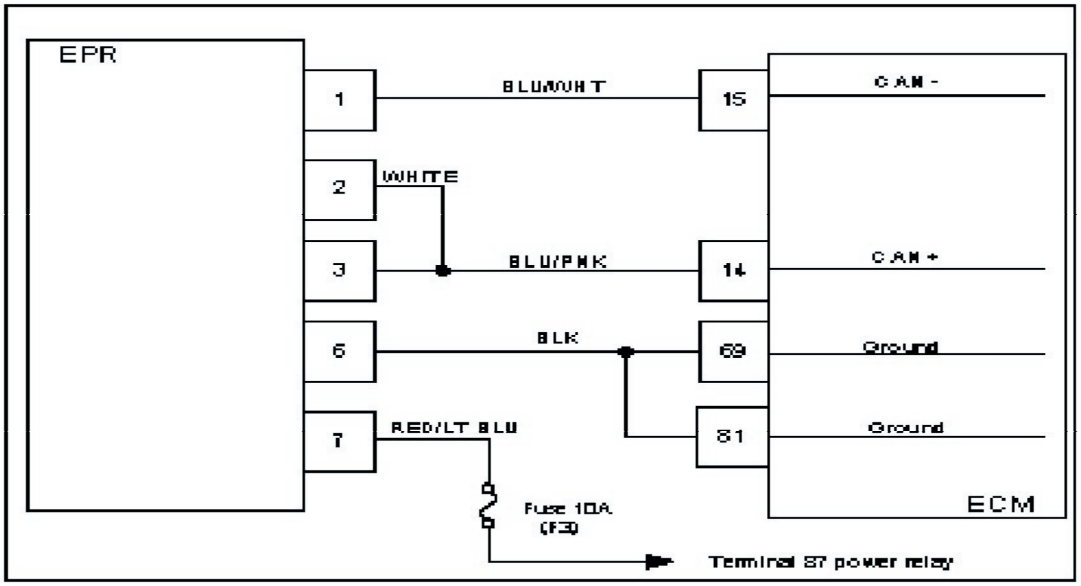
Diagnostic Aid

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

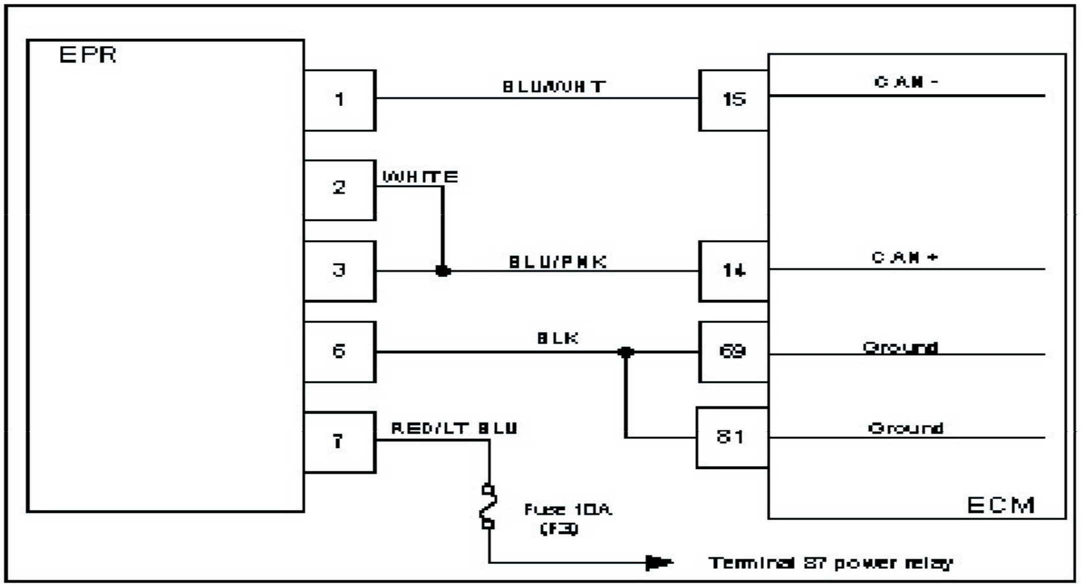
This DTC indicates abnormal EPR internal voltages that are not measurable externally. Check the system charging voltage to be sure this DTC and other low voltage DTC's are not present. Repair the charging system if it is found to be out of specification for low charge voltage. In the event of multiple 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 actuator
- Adaptive disabled
- Closed loop disabled

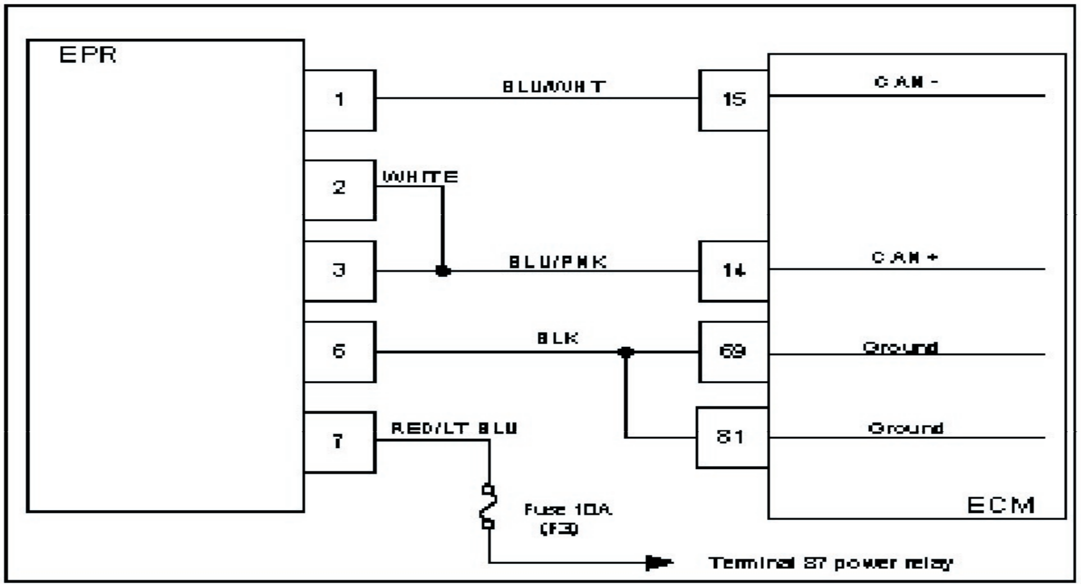
Circuit Description

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)	Repair Other DTC's
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

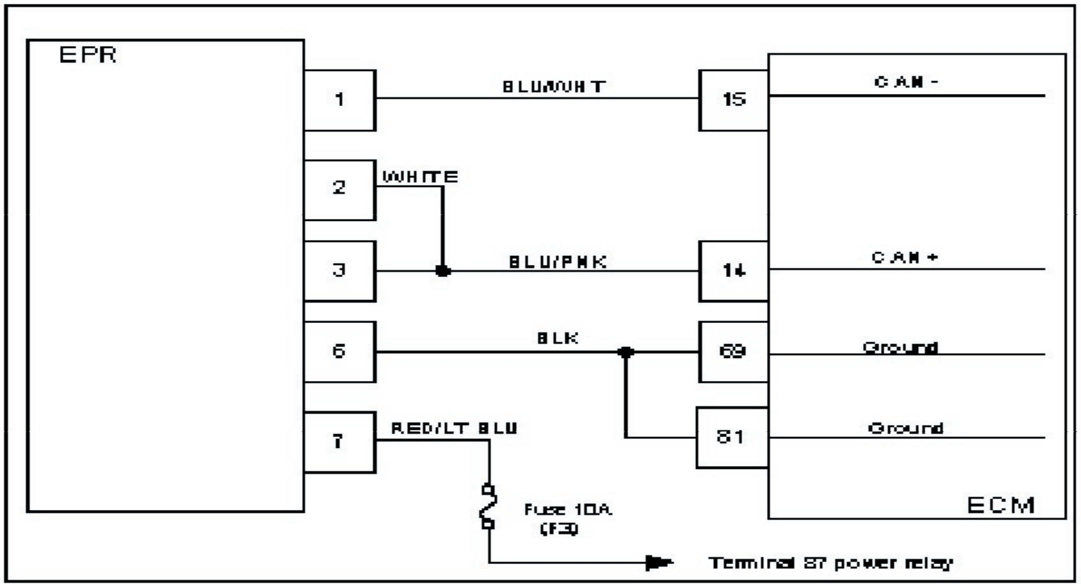
Circuit Description

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)	Repair Other DTC's
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

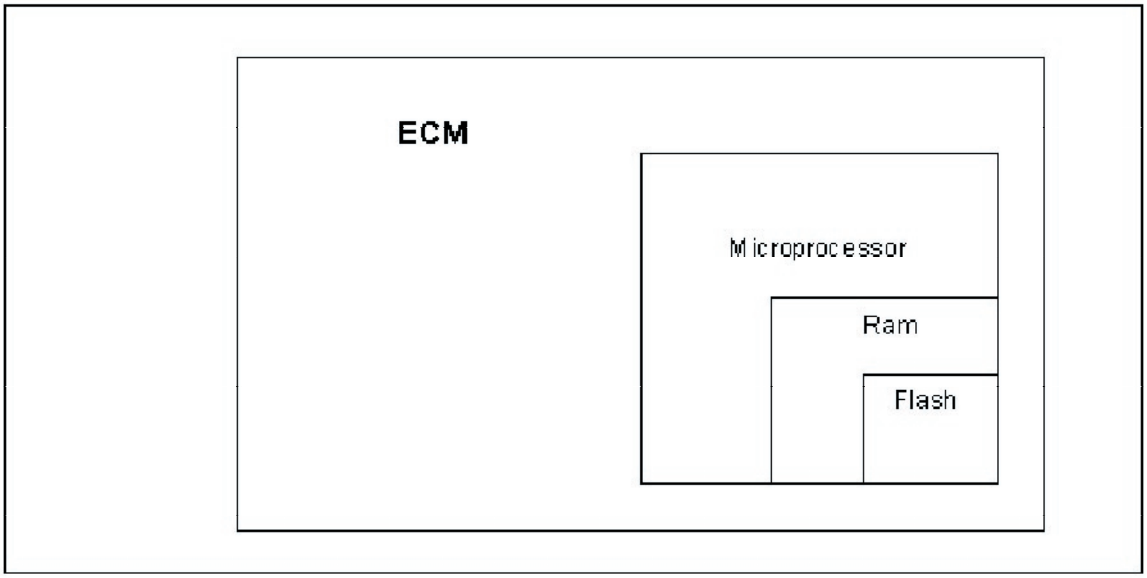
Circuit Description

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)	Repair Other DTC's
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

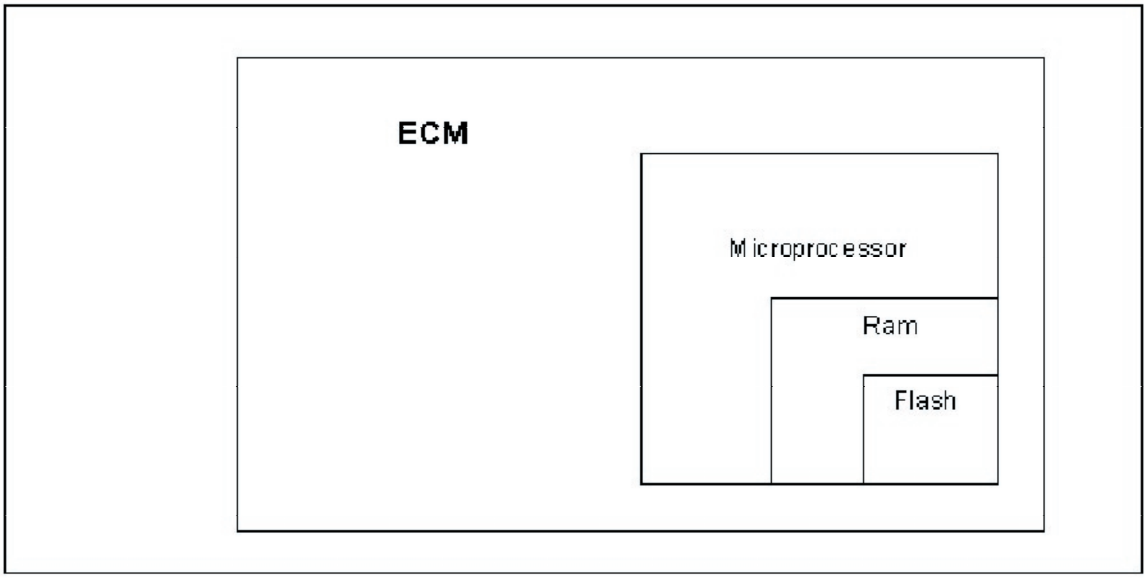
Circuit Description

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

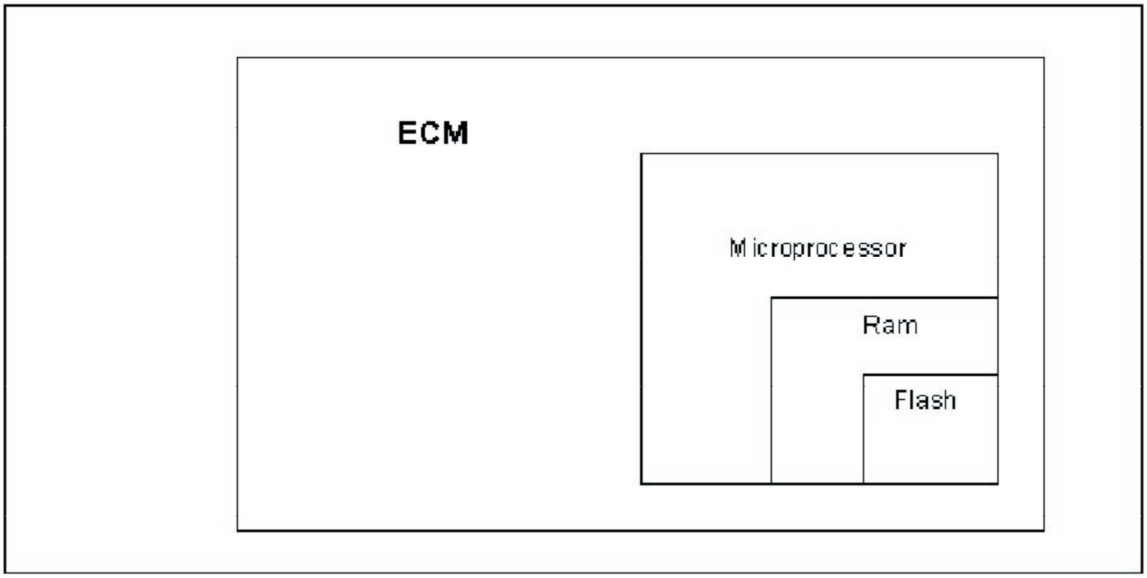
Circuit Description

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

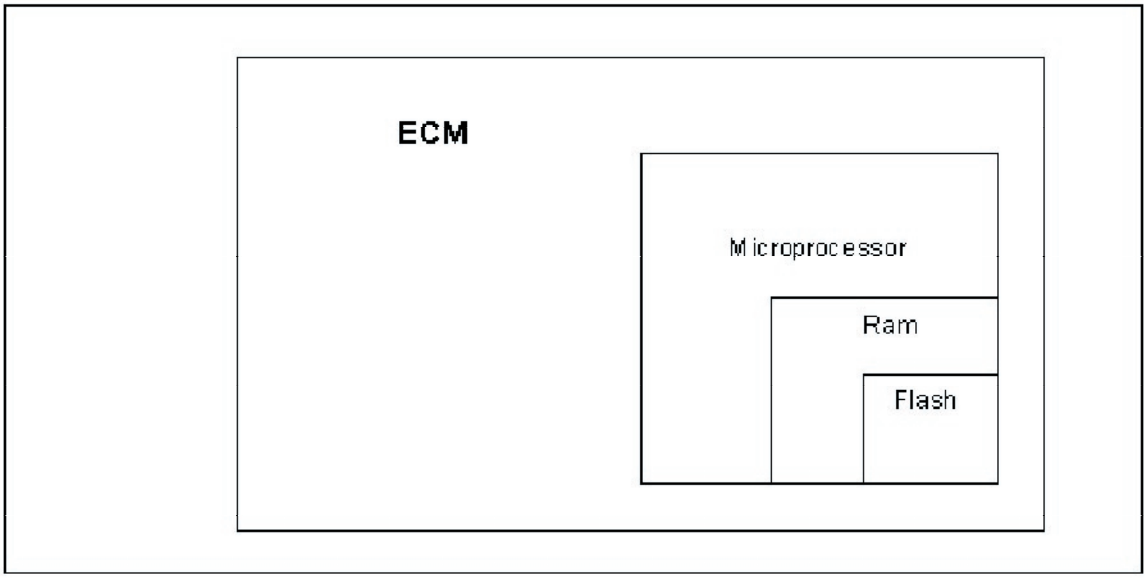
Circuit Description

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

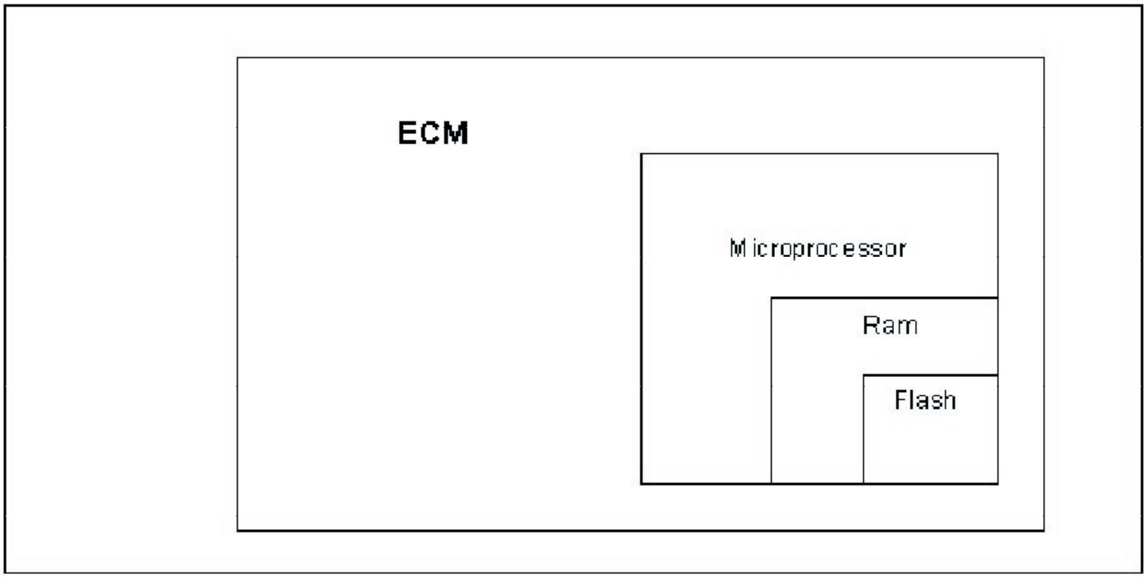
Circuit Description

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

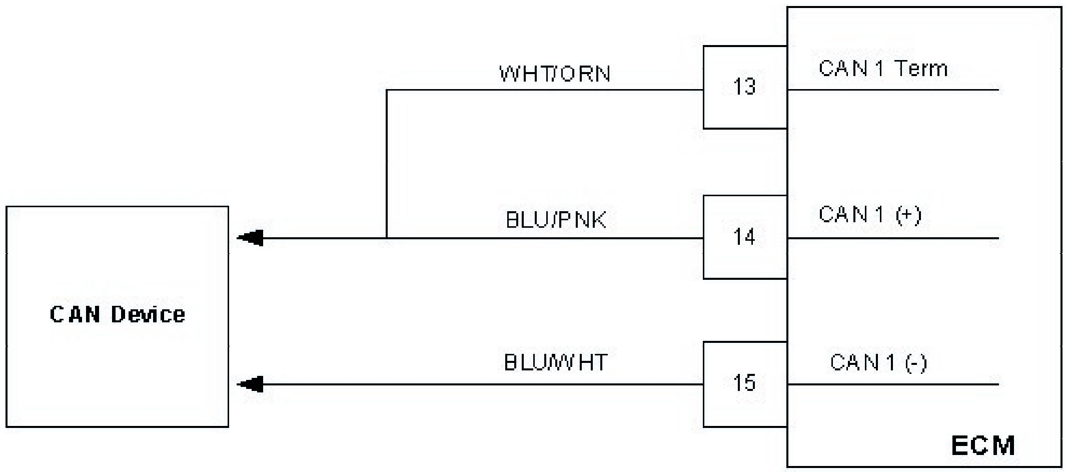
Circuit Description

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

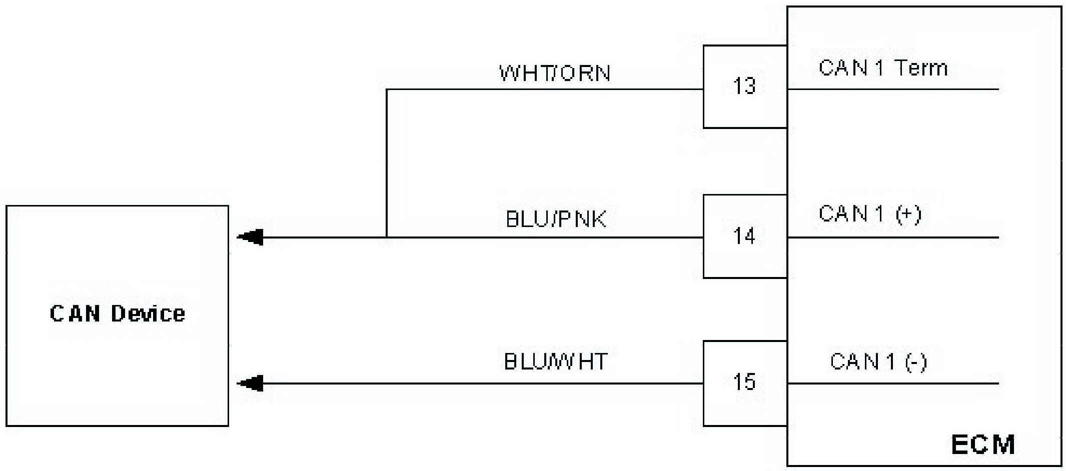
The CAN bus (controller area network) is used by the ECM to communicate with other digital devices used throughout the fuel system. Information is sent over the CAN bus in digital information “packets” that contain information for various control functions. This fault will set if the ECM detects 100 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

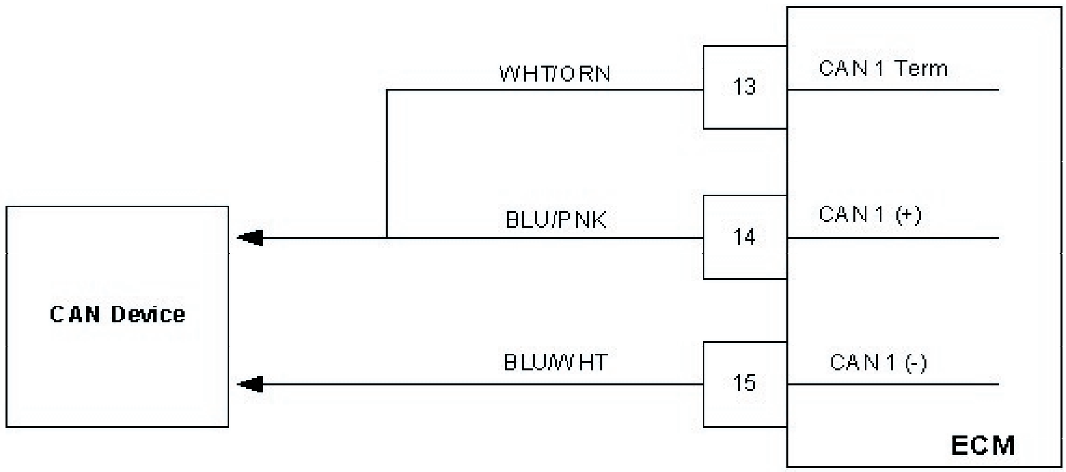
The CAN bus (controller area network) is used by the ECM to communicate with other digital devices used throughout the fuel system. Information is sent over the CAN bus in digital information “packets” that contain information for various control functions. This fault will set if the ECM detects 100 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

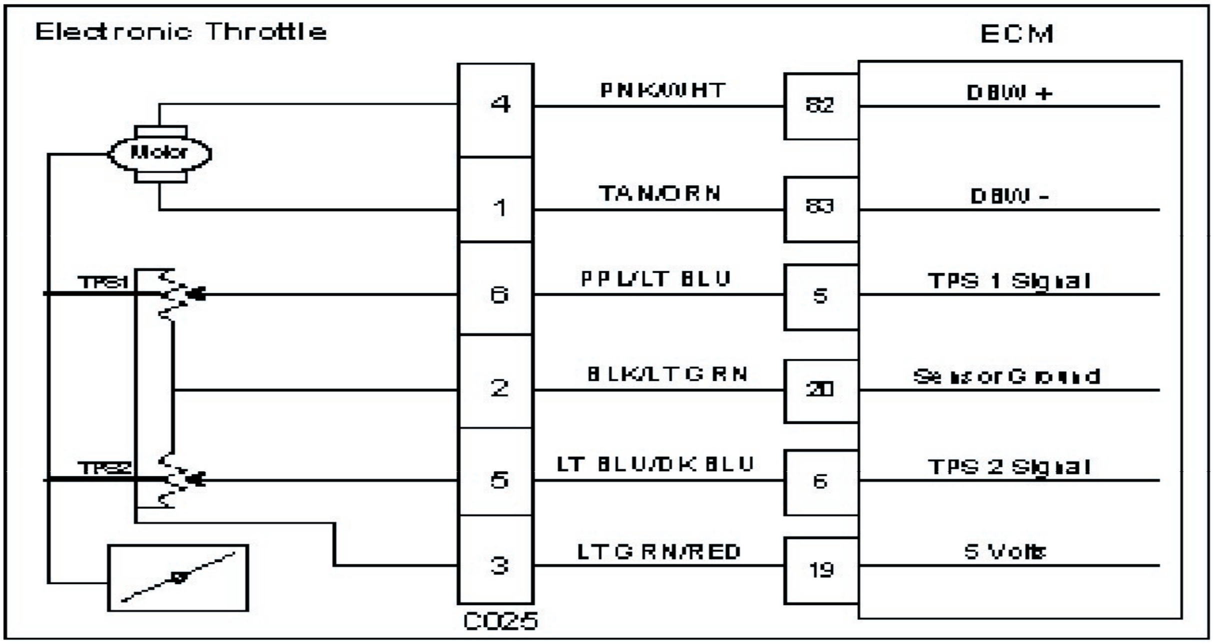
Circuit description

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 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 1 signal 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)	-

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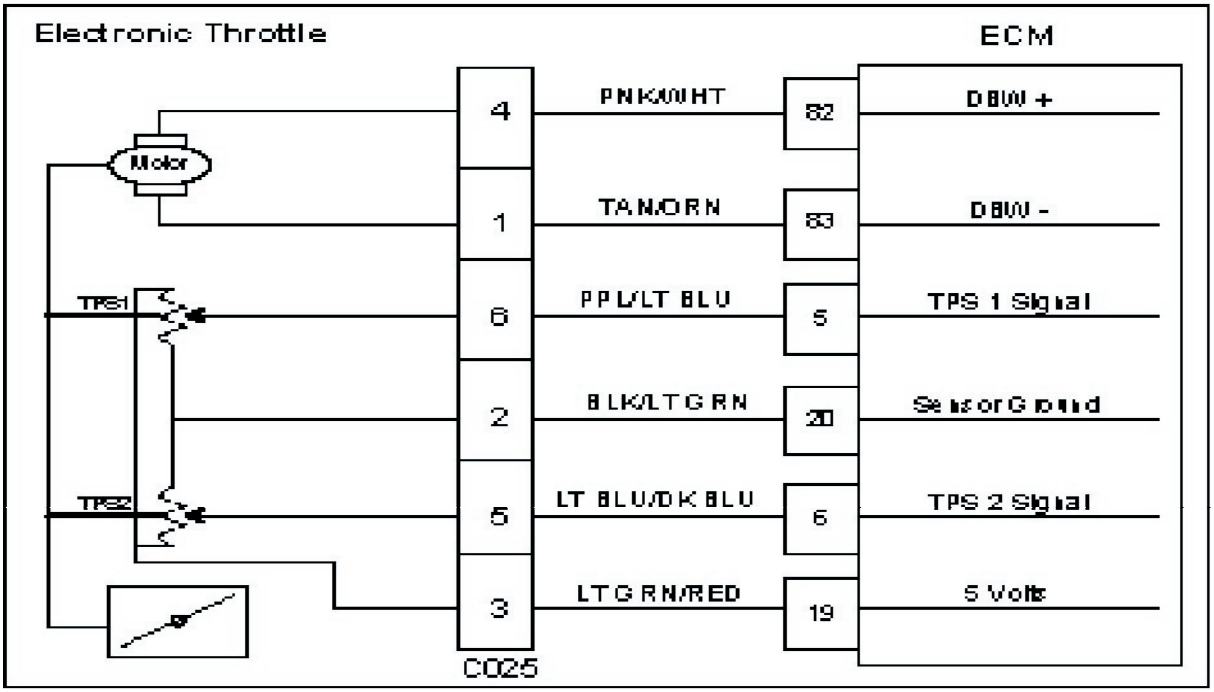
Step	Action	Value(s)	Yes	No
13	• Remove all test equipment except the DST. • Connect any disconnected components, fuses, etc. • Using the DST clear DTC information from the ECM. • Turn the ignition OFF and wait 30 seconds. • Start the engine and operate the vehicle to full operating temperature • Observe 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

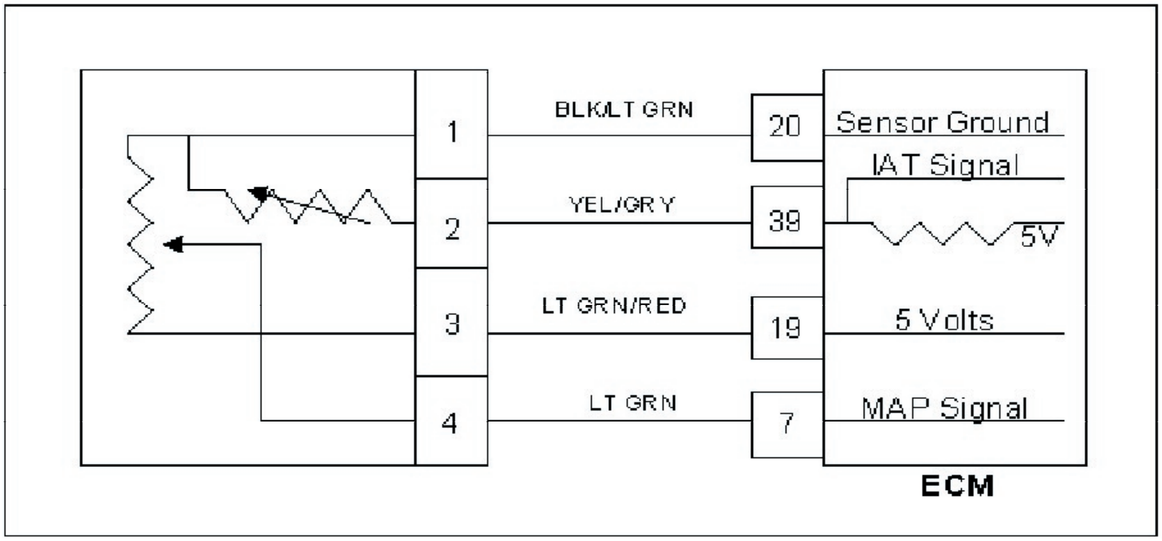
There are two Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS 1 will read low voltage when closed and TPS 2 will read high voltage when closed. The TPS 1 and TPS 2 percentages are calculated from these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