IMPCO

Nissan K25

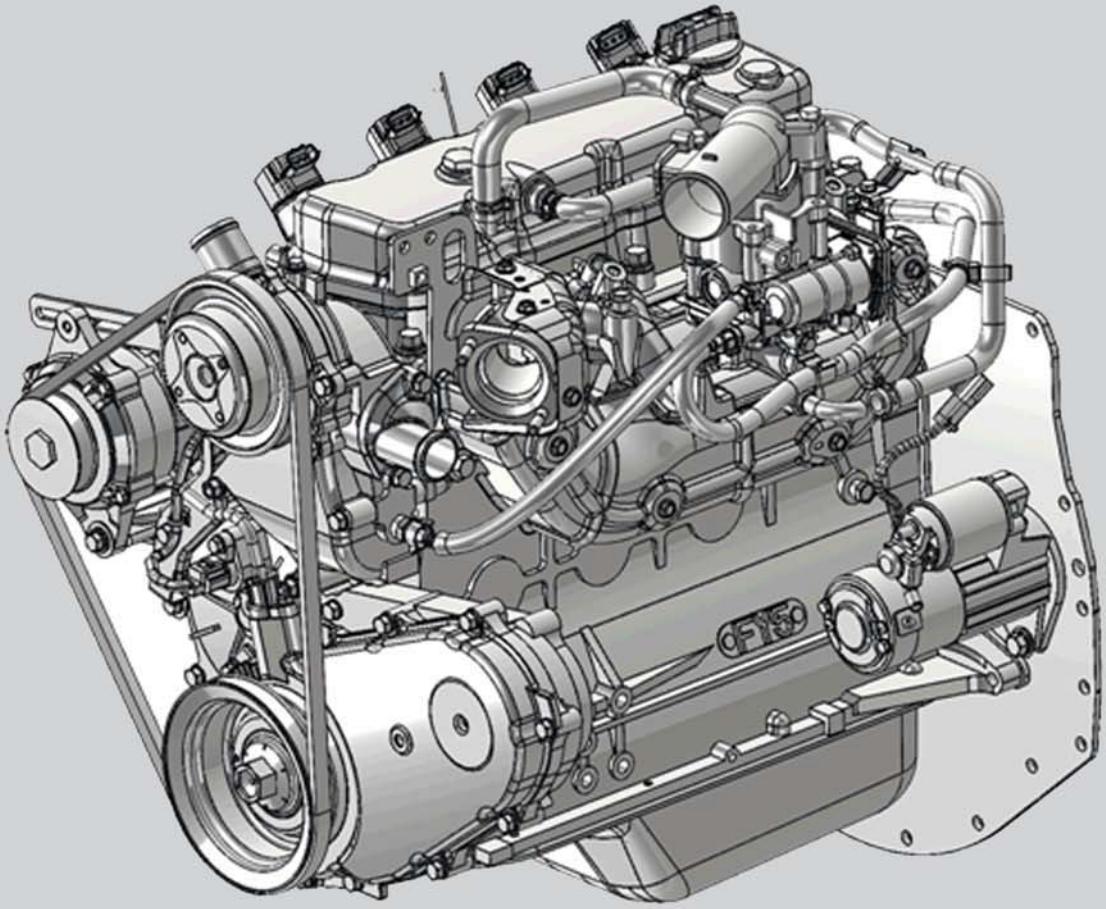
ENGINE
PARTS CATALOG
&
SERVICE MANUAL

DEC275/01 2016

IMPCO®

Nissan 2.5L Engine

Parts & Service Manual

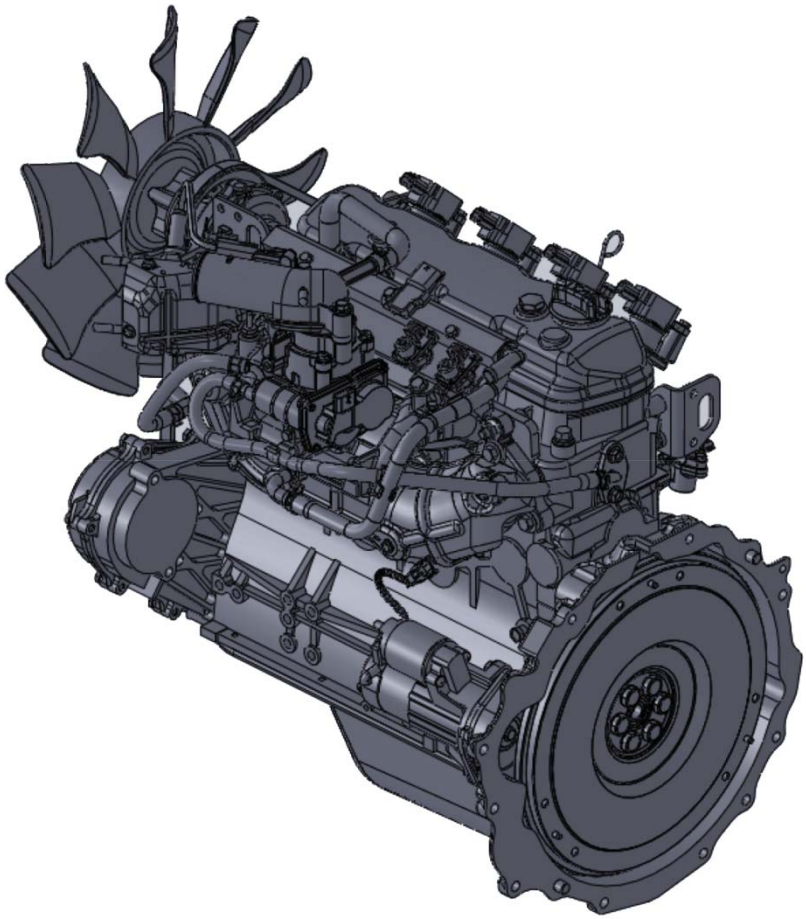


June, 2015

SPECTRUM by IMPCO

K25 Engine

Parts & Service Manual



June, 2015

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General Information

INTRODUCTION

This service manual is designed to provide the service technician with the basic understanding of the IMPCO fuel systems for the K25 engine.

SERVICING YOUR EMISSIONS CERTIFIED ENGINE

Any maintenance and repair should be performed by trained and experienced service technicians. Proper tools and equipment should be used to prevent injury to the servicing technician and damage to the vehicle or components. Service repairs should always be performed in a safe environment and the technician should always wear protective clothing to prevent injury.
For parts or labor to be reimbursed under the IMPCO Technologies Inc. emission warranty, only work performed by IMPCO or OEM trained technicians using only IMPCO-specified parts will qualify for reimbursement.
For parts or labor not reimbursed under warranty, a repair shop or person of the owner's choosing may maintain, replace, or repair emission-control devices and systems. It is strongly recommended that only OEM replacement parts be used for maintenance or for the repair of emission control systems. The use of other than genuine IMPCO replacement parts may impair the effectiveness of emission control systems, therefore, the owner should assure that such parts are warranted by their manufacturer to be equivalent to genuine IMPCO OEM parts in performance and durability.

FUEL QUALITY

LPG engines and fuel systems are designed to operate on HD-5 or HD-10 specification LPG fuel. Fuel other than HD-5 or HD-10 may cause harm to the engine's emission control system and a warranty claim may be denied on this basis if operators can readily find the proper fuel. Use of any other fuel may result in engine operation outside of CARB or EPA emissions requirements.

FUEL LINE CONNECTIONS

Loctite® 567 is recommended for all NPT connections.

WARNING

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

AIR FILTRATION REQUIREMENTS

Dry filtration is required with maximum recommended 10" W.C. restriction @ 155 cfm. IMPCO strongly recommends the use of OEM or factory replacement parts.

WASHING

The engine should be periodically cleaned to remove any build up of oil, grease, dirt or any other debris. Caution should be used when pressure washing the under hood of any electrical system. Avoid direct pressure spray on the system electrical connectors. The connectors are splash proof but if high pressure water or steam is sprayed directly at the connector moisture can become trapped behind the connector seal and cause serious system problems, many of them showing up as intermittent.

FUEL SYSTEM CAUTIONS

WARNING

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

CAUTION

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

CAUTION

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

CAUTION

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

CAUTION

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

WARNINGS, CAUTIONS AND NOTES

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

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

Typical Warning Label:

WARNING

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

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

CAUTION

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

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

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

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

PROPER USE OF THIS SERVICE MANUAL, TOOLS AND EQUIPMENT

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

- The service procedures defined in this manual, when followed, have been found to be a safe and efficient process to repair the fuel

system. In some cases special tools may be required to perform the necessary procedures to safely remove and replace a failed component.

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

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

WARNING

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

Maintenance

LPG CERTIFIED ENGINE MAINTENANCE REQUIREMENTS

For maintenance or other work that is not performed under warranty, maintenance, replacement, or repair of the emission control devices and systems may be performed by any engine repair establishment or individual. Perform the following maintenance on the engine at the hours indicated and at equivalent hour intervals thereafter.

This maintenance schedule represents the manufacturer's recommended maintenance intervals to maintain proper engine/equipment function. Federal, State, or Local regulations may require additional or more frequent inspection or maintenance intervals than those specified above. Check with the authority having jurisdiction for details.		Maintenance Interval													
	Months	1	2	3	4	5	6	7	8	9	10	11	12	···	18
	Hundreds of hours	2	4	6	8	10	12	14	16	18	20	22	24	···	36
General Maintenance															
Visual check for fluid leaks		Inspect Prior To Each Use													
Check exhaust system		Inspect Prior To Each Use													
Check coolant level, coolant hoses and radiator		Inspect Prior To Each Use													
Check fuel lines, connectors and storage cylinder		Inspect Prior To Each Use													
Check engine oil level		Inspect Prior To Each Use													
Change engine oil and oil filter		200 hours or 1 month, then every 500 hours or 2.5 months of operation													
Inspect/Replace drive belts for cracks, breaks, splits, etc.		I	I	I	I	I	I	I	I	I	I	I	I	···	I
Adjust intake & exhaust valve clearance (operating temp.)		A		A			A			A			A	···	A
Inspect PCV and hose for leaks				I			I			I			I	···	I
Tighten manifold nuts		T												···	
Tighten cylinder head bolts		T												···	
Engine Cooling															
Clean debris from radiator core		Every 100 hours or 60 days* of operation													
Change coolant													R	···	
Inspect coolant hoses for cracks, swelling or deterioration						I					I			···	
Engine Electrical System															
Inspect battery and case for leaks or damage						I					I			···	
Inspect battery cables for damage, corrosion or contamination						I					I			···	
Check all electrical connector retainer locks						I					I			···	
Inspect electrical system wiring for cuts, abrasions or corrosion											I			···	
Inspect/Replace spark plugs		I	I	I	I	I	I	I	I	I	I	I	I	···	R
Fuel System Maintenance															
Inspect/Replace air cleaner		If the filter is found to be clogged or dirty, it should be replaced or cleaned.													
Drain Regulator oil build up		Every 500 hours													
Replace LPG Filter between Regulator and Fuel Rail		If the filter is found to be clogged or dirty, it should be replaced or cleaned.													
Inspect/Replace Vapor LPG Filters built into vaporizer						I					R			···	
Replace liquid LPG Filter of the vaporizer											R				
Leak check fuel lines											I			···	
Check air induction for leaks											I			···	
Check intake manifold for vacuum leaks											I			···	
Inspect all vacuum lines and fittings for cracks, breaks or hardening						I					I			···	
Check injector & rails for leaks											I			···	
Leak check fuel system for leaks		Before and after any service or maintenance activity													
Engine Exhaust System															
Inspect exhaust manifold, piping, and muffler for leaks											I			···	
Check HEGO sensor connector & wires for burns, cuts or damage											I			···	
Inspect catalyst for mechanical damage and leaks											I			···	

A=Adjust (if necessary), I=Inspect, R=Replace, T=Tighten (Retighten)

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

Refer to the Maintenance Instructions on the following pages for additional information.

MAINTENANCE

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

WARNING

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

GENERAL MAINTENANCE

Prior to each use, the engine should be inspected for any type of fluid leaks by a visually inspecting the engine as well as the surface on which the vehicle is parked. Check the coolant hose, radiator and coolant level. Also check the engine oil level and all drive belts for any signs of damage. Inspect fuel lines for any leaks and to make sure all connections are secure. The inspection should include the exhaust system for signs of damage or loose connections in the piping.

INSPECTION AND MAINTENANCE OF THE FUEL STORAGE CYLINDER

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

When refueling or exchanging the fuel cylinder, check the quick fill valve for thread damage. Also verify O-ring is in place and inspect for cracks, chunking or separation. If damage to the o-ring is found, replace prior to filling. Check the service line quick coupler for any thread damage.

IMPORTANT:

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

ENGINE CRANKCASE OIL

OIL RECOMMENDATION

Use SAE 10W-30 SL class oil that has the American Petroleum Institute's (API) Starburst logo, which shows that the oil meets the ILSAC GF-5 requirements:

API logo

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

SYNTHETIC OILS

Synthetic oils have been available for use in industrial engines and may offer advantages in cold and hot temperatures. The use of synthetic oils does not permit the extension of oil change intervals.

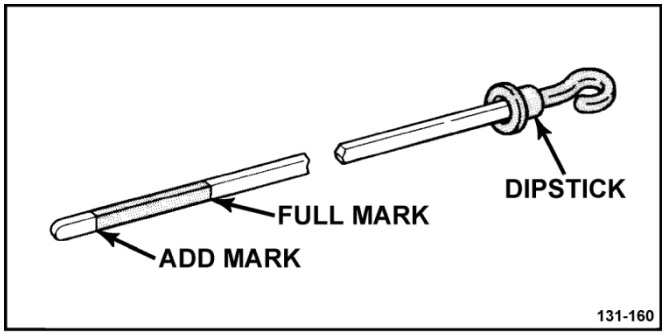
CHECKING/FILLING ENGINE OIL LEVEL

IMPORTANT:

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

1. Stop engine.
2. Allow approximately five minutes for the oil to drain back into the oil pan.
3. Remove the dipstick. Wipe with a clean cloth or

paper towel and reinstall. Push the dipstick all the way into the dipstick tube.
4. Remove the dipstick and note the amount of oil on the dipstick. The oil level must be between the "FULL" and "ADD" marks.



Engine Oil Dip Stick (Typical)

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

CAUTION

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

CHANGING ENGINE OIL

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

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

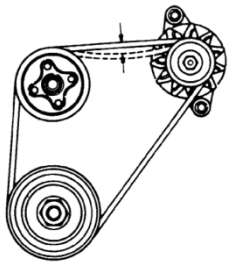
IMPORTANT:
Change oil when engine is warm and the old oil flows more freely.

2. Stop engine
3. Remove drain plug and allow the oil to drain.
4. Remove and discard oil filter and its sealing ring.
5. Coat sealing ring on the new filter with clean engine oil, wipe the sealing surface on the filter mounting surface to remove any dust, dirt or debris.
6. Screw in the oil filter by hand until it contacts bracket surface, and then screw in another 2/3 of a turn.
7. Check sealing ring on drain plug for any damage, replace if necessary, wipe plug with clean rag, wipe pan sealing surface with clean rag and re-install plug into the pan. Tightening torque is **29.4 to 39.2 Nm (22 to 29 ft.lbs)**.
8. Fill crankcase with oil of the recommended specifications and check the oil level with the oil level gauge.
9. Start engine and check the area around the drain plug and oil filter for oil leaks.
10. Dispose of oil and filter in a safe and responsible manner.

ENGINE BELTS

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

- Cracks
- Chunking of the belt
- Splits
- Material hanging loose from the belt
- Glazing or hardening
- Deflection by pressing at the center between the pulleys. **Fan belt deflection: 11 to 13 mm (0.43 to 0.51 in) using 8N (22 lbs) of force.**



If any of these conditions exist the belt should be replaced with the recommended OEM replacement belt.
IMPORTANT: The use of "belt dressing" or "anti-slipping agents" on belts is not recommended.

ENGINE COOLING SYSTEM

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

NOTE: The LPG vaporizer is connected to the cooling system and the fuel system may be adversely affected by low coolant levels and restricted or plugged radiator cores. Therefore, the cooling system must be maintained according to the recommend maintenance schedule in this section, including:

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

COOLANT

WARNING

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

WARNING

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

Check coolant level in coolant recovery tank and add coolant as required.

IMPORTANT: A mixture of 70% pure water and 30% coolant that meets the performance requirements JIS K2234 class 2 (LLC) is recommended. Do not add plain water. Replace coolant per the recommended schedule.

IMPORTANT: Only replace coolant with same color originally included or shipped with the engine. Do not mix coolant.

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

ENGINE ELECTRICAL SYSTEM

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

- Check Positive and Negative cables for corrosion, rubbing, chafing, burning and to ensure tight connections at both ends.
- Check battery for cracks or damage to the case and replace if necessary.
- Inspect engine wire harness for rubbing, chafing, pinching, burning, and cracks or breaks in the wiring.
- Verify that engine harness connectors are correctly locked in by pushing in and then pulling the connector halves outward.
- Verify that all electrical components are securely mounted to the engine or chassis.
- Verify that the MIL, charging, and oil pressure lights illuminate momentarily during Key On.

SPARK PLUGS

Replace spark plugs at the required intervals per the recommended maintenance schedule.

Inspection

- Visually check electrode for dirt and damage and insulator for burning.
- Check if the electrode gap is within the standard using a plug gap gauge.
- Adjust if outside the standard.
- Replace if necessary.

IMPORTANT: Use only K25 specified spark plugs. Spark plugs should be gapped 0.034 to 0.035 inches (0.8 to 0.9 mm).

FUEL SYSTEM INSPECTION AND MAINTENANCE

The LPG fuel system installed on this industrial engine has been designed to meet the emission standard applicable for the 2015 model year. To ensure compliance to these standards, follow the recommended maintenance schedule contained in this section.

AIR INTAKE FILTER

Regular inspection of the air intake filter is necessary to ensure proper airflow to the engine. In some cases, light dust covering the air filter can be removed using compressed air. If the dirt or contaminants cannot be removed or if the air filter is damaged in any way, it must be replaced.

INSPECTION OF THE FUEL FILTER

The LPG system on this engine utilizes two filters: a liquid LPG filter and a dry filter for LPG vapor. Both filters are components of the LPG regulator and require replacement per the recommended maintenance schedule.

NOTE: The LPG vapor filter can be inspected and possibly cleaned, however, the LPG liquid filter is not serviceable and can only be replaced. Refer to *Servicing the Fuel System, Regulator*, for instructions on inspecting and replacing the filters.

IMPORTANT:
The Pressure Regulator components have been specifically designed and calibrated to meet the fuel system requirements of the engine. If the Regulator fails to operate or develops a leak, it should be repaired or replaced with the OEM recommended replacement parts.

IMPORTANT
Always inspect the LPG fuel system for leaks after servicing. 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

- Check for any fuel leaks at the inlet and outlet fittings of all fuel lines.
- Check for any fuel leaks in the regulator body.
- Check for any fuel leaks around the fuel rail and injectors.
- Check to ensure the Regulator is securely mounted and the mounting bolts are tight.
- Check the Regulator for external damage.
- Check the Regulator electrical connections to ensure the connector is seated and locked.

CAUTION

The LPG fuel system operates at pressure up to 21.5 bar (312 psi). To minimize personal injury, relieve the LPG fuel system pressure before servicing the LPG fuel system components. Refer to the *Fuel Pressure Relief Procedure* in *Servicing the Fuel System* in this manual.

WARNING

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

CAUTION

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

AIR INDUCTION/VACUUM

To maintain proper air/fuel ratio, the air induction system, air intake and vacuum hoses also require periodic inspection (refer to *LPG CERTIFIED ENGINE MAINTENANCE REQUIREMENTS* table for the recommended interval).

Inspect all air intake connections between the air inlet filter and engine, including the throttle body and intake manifold. Also inspect all vacuum hoses, ensuring they are securely connected and are not loose. Inspect the vacuum hoses for breaks, hardening, cracks or pinching.

EXHAUST SYSTEM AND CATALYTIC CONVERTER

When inspecting the Exhaust system check the following:

- Listen for excessive noise during normal engine operation that might indicate an exhaust leak.

CAUTION

Exhaust system components may be extremely hot and contact with any of these components may cause severe burns. Allow the engine to cool prior to coming in contact with the engine or any exhaust component.

- Examining the exhaust manifold at the cylinder head for leaks and verify that all retaining bolts and shields are in place.
- Inspect manifold to exhaust pipe connections and fasteners to ensure they are tight and that there are no exhaust leaks. Repair if necessary.
- Visually inspect converter to ensure muffler and/or catalytic converter is securely mounted and tail pipe is properly directed away from the vehicle and its operator.
- Inspect the HEGO electrical connections and inspect the wires for any damage or burning of the insulation. Verify they are properly routed to prevent contact with any surfaces that might burn or chaff the wires.

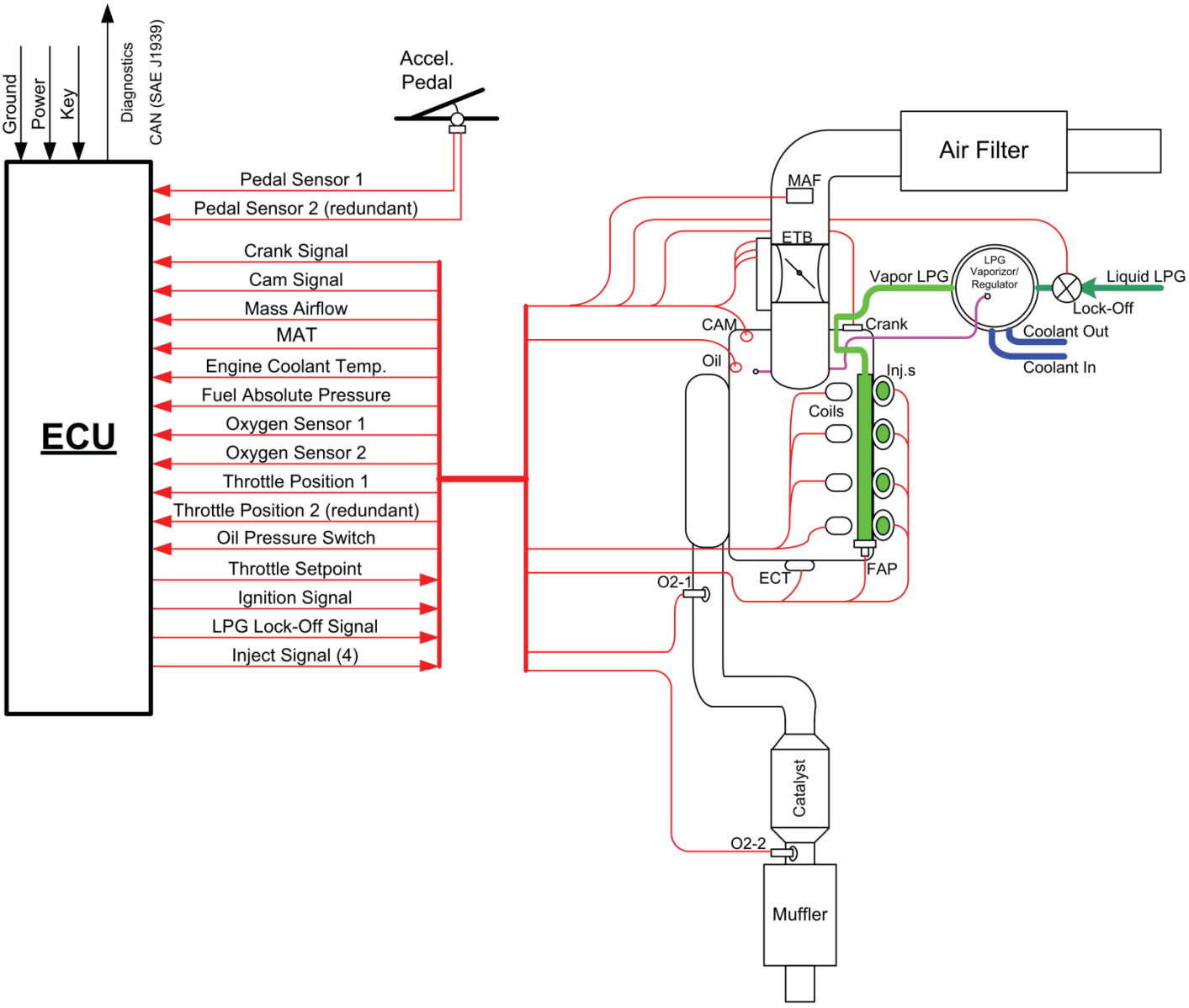
IMPORTANT:
The exhaust system on this emission certified engine contains Heated Exhaust Gas Oxygen Sensors (HEGOs) which provides feed back to the ECM on the amount of oxygen present in the exhaust stream after combustion. HEGO voltages vary, but they are generally less than one volt. Therefore, it is imperative that all HEGO electrical connections remain secured and air tight.

SECURING HOSES AND ELECTRICAL WIRES

All hoses (fuel, vacuum, coolant, air, PCV etc.) should be periodically inspected to ensure they are securely mounted, strain relieved and not rubbing against other components. Vibration and strain or tension can create a premature failure. Similarly, electrical wires may become subject to failure due to strain and vibration and over time, break.

LPG Fuel System Overview

LPG FUEL SYSTEM OPERATION



DESCRIPTION AND OPERATION OF THE FUEL SYSTEMS

The following is a description of the fuel system and its components.

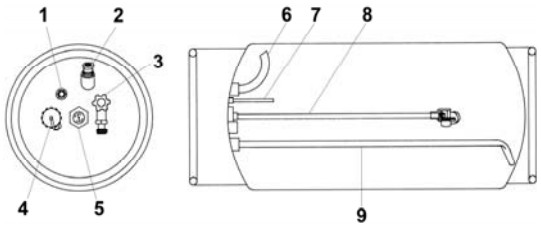
LPG FUEL TANK

LPG is stored in the fuel tank as a liquid. The approximate pressure of the fuel in the tank is 155 psi (10.6 bar) when the tank is full at an ambient temperature of 70°F (21°C). The boiling point, (temperature at which the liquid fuel becomes vapor) is approximately -40°F (-40°C). 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 pickup tube located near the bottom of the fuel cylinder.

TABLE #1

TEMPERATURE		VAPOR PRESSURE	
deg. F	deg. C	PSIG	kPa
130	54	257	1794
110	43	197	1358
100	38	172	1186
90	32	149	1027
80	27	128	883
60	16	92	637
30	-1	51	356
0	-18	24	162
-20	-29	11	74
-44	-42	propane begins to boil @ sea level	
-45	-43	0	0

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 downstream fuel transport components. A safety relief valve is installed into the tank. Normally set at 25.8 bar (375 psi), it will release pressure to prevent tank rupture due to over-pressurization or over filling of the cylinder



Typical LPG Cylinder

1. Liquid Outage Fill Check Valve
2. Pressure Relief Valve
3. Liquid Outage valve w/quick disconnect coupling
4. Filler Valve
5. Fuel Gauge
6. Relief Valve Tube (Vapor)
7. 80% Limiter Tube
8. Fuel Level Float
9. Liquid Withdrawal Tube

SERVICE LINE

LPG flows from the fuel tank to the Regulator via the service line connected to the tank utilizing a quick coupler. The other end of the service line is connected to a bulkhead connector, allowing for a safe means of passing through the sheet metal and into the engine compartment. The service line is made of high pressure hose with special material or possibly tubing which is compatible with the LPG fuel and should always be replaced with an OEM supplied part. The service line must include a hydrostatic relief valve, usually mounted in the bulkhead, if not already a component of the service valve.

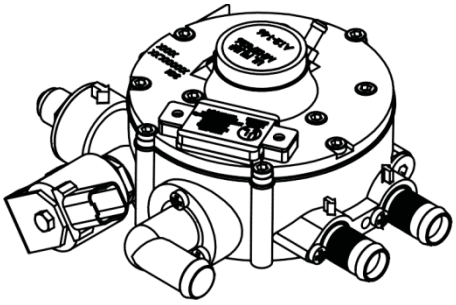
CAUTION

The bulkhead assembly should never be removed. Never run a service line through the sheet metal.

REGULATOR

The Regulator is a combination vaporizer and pressure regulating device. The Regulator also features a built-in fuel shutoff and two LPG fuel filters.

The fuel shutoff is a normally closed valve on the vaporizer and is controlled by the ECM. The valve is opened when the ignition is first turned on, allowing LPG to pass into the regulator. The fuel vapor pressure is then reduced and delivered to the fuel rail at a pressure of 12.6 psig (88 kPag) above the manifold pressure. Any liquid LPG that flows into the Regulator is vaporized by heat provided by the engine coolant that also passes through the Regulator.



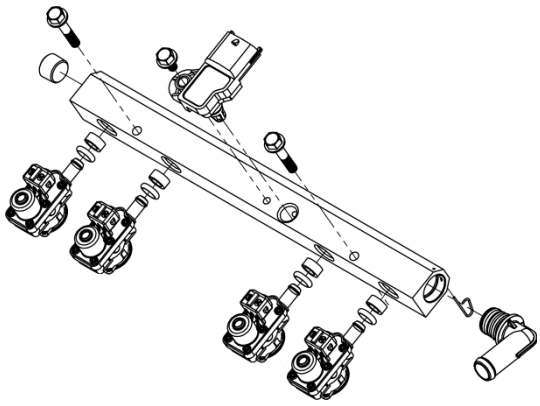
Regulator

LPG, fuel like all other motor fuels, is subject to contamination and is filtered using two fuel filters, one for liquid and one for LPG vapor to remove contaminants. Both filters are components of the Regulator and are serviceable. Maintenance of the filters is critical to proper operation of the fuel system and should be replaced according to the maintenance schedule or more frequently under severe operating conditions.

FUEL RAIL ASSEMBLY AND INJECTORS

The assembly consists of a rail, fuel injectors and a fuel temperature and pressure sensor. The gaseous LPG pressure is in the fuel rail is controlled by the regulator at a nominal pressure of 12.6 psig (88 kPag) above manifold pressure and equally distributed to the four LPG injectors. The ECM controls the injectors, opening them during the engine's intake cycle and changing the pulse width or duration the injectors are open to control the amount of fuel delivered to each cylinder.

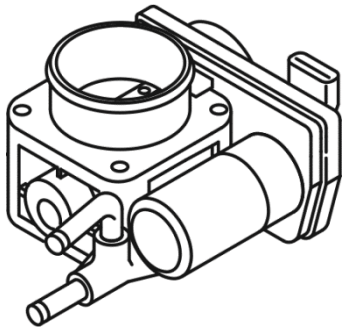
A combination Fuel Temperature and Pressure Sensor (FAP/FRT) is mounted on the fuel rail to monitor the temperature and pressure of the LPG. The Sensor contains variable resistors and is monitored by the ECM.



Fuel Rail Assembly

THROTTLE CONTROL DEVICE—DRIVE BY WIRE

Engine torque is maintained by the amount of pressure applied to the foot pedal located in the engine Compartment. In this Drive By Wire (DBW) application, the foot pedal has an electronic connection with the throttle and there is no direct mechanical (cable) connection between the pedal and the throttle shaft. The ECM monitors the foot pedal position sensor when the engine is running. When the operator depresses or releases the foot pedal, the ECM sends an electrical signal to the motor on the electronic throttle to increase or decrease the angle of the throttle blade, thereby increasing or decreasing the volume of air delivered to the engine. The ECM is programmed to ensure correct speed and emission control for all throttle ranges and loads.



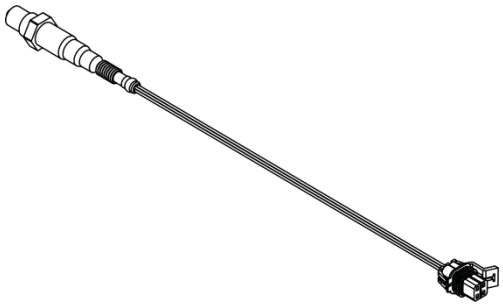
Throttle Body

Two internal Throttle Position Sensors (TPSs) provide feedback to the ECM indicating the position of the throttle shaft and blade. Two sensors are used in both the accelerator foot pedal and the throttle body to prevent a single failure and uncontrolled throttle response. A throttle related failure will cause a "Limp Home" mode of operation, where the engine power is derated and has little or no response to the pedal.

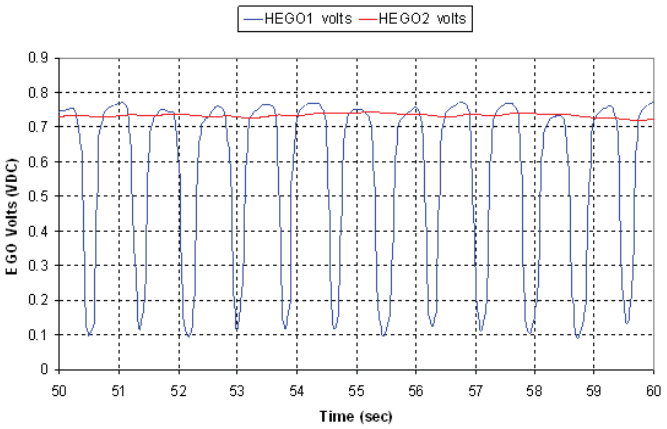
HEATED EXHAUST GAS OXYGEN SENSORS

The Heated Exhaust Gas Oxygen (HEGO) Sensors are mounted in the exhaust system, one upstream and one downstream of the catalytic converter. The HEGO sensors are used to measure the amount of oxygen present in the exhaust stream to determine whether the fuel air ratio is too rich or too lean and communicates this measurement to the ECM as an electrical signal with voltage usually less than a volt. If the HEGO sensor signal indicates that the exhaust stream is

too rich or too lean, the ECM will increase or decrease the amount of fuel delivered to the engine. If the ECM determines that a rich or lean condition is present for an extended period of time which cannot be corrected, the ECM will set a diagnostic code and turn on the MIL light in the dash.



The Heat Exhaust Gas Oxygen (HEGO) Sensor

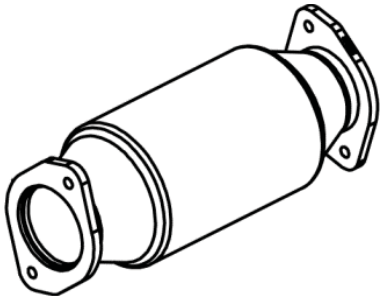


HEGO1 (upstream or before the catalytic converter) and HEGO2 (downstream) voltage output.

CATALYTIC CONVERTER

The Catalytic Converter is a component of the emissions system which is designed and calibrated to meet the 2015 emission standards.

The exhaust gases pass through the honeycomb catalyst which is coated with a mixture of metals (such as platinum, palladium, and rhodium) to oxidize and reduce CO, HC and NOX emission gases.

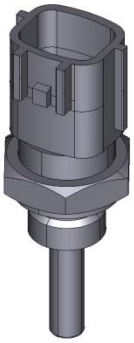


Catalytic Converter

MASS AIR FLOW SENSOR (MAF)/MANIFOLD AIR TEMPARATURE SENSOR (MAT)

A combination air flow sensor (MAF) and manifold air temperature sensor (MAT) is attached to the air horn. The MAF measures the flow rate of the intake air and the MAT. The MAT portion of the sensor is a negative coefficient thermistor. This means that as the temperature goes up, the resistance drops. Five volts is supplied across the sensor, and the voltage drop, which varies by temperature, is used to determine the manifold air temp.

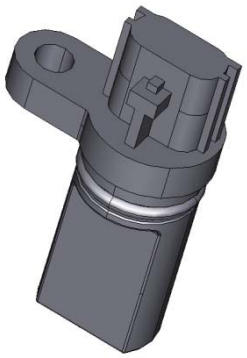
COOLANT TEMPERATURE SENSOR



Coolant Temperature Sensor

The engine coolant temperature sensor (ECT) is a variable resistance thermistor that changes resistance as the engine's coolant temperature changes. Engine temperature is monitored by the ECM and may be displayed on the temp gauge of the truck.

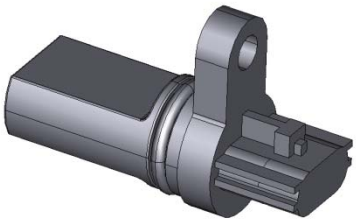
CRANK OR CKP SENSOR



Crank/ CKP Sensor

A variable reluctance sensor reads the toothed wheel (mounted behind the crankshaft pulley), sending an AC signal to the ECM when the engine is running. A missing tooth in the toothed wheel is used to determine a reference position of the crankshaft. The ECM uses this reference position along with the camshaft sensor information to determine when the cylinders are at top dead center of their compression strokes.

CAMSHAFT SENSOR OR CMP

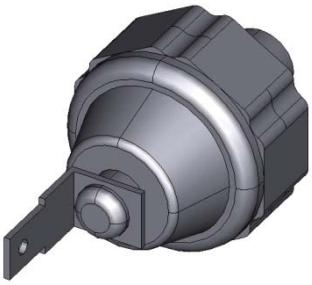


Camshaft or CMP Sensor

This Hall Effect sensor monitors the camshaft position. When used in conjunction with the crank sensor, the ECM can determine both TDC and engine phase and determine when to fire the spark plugs and open the injectors.

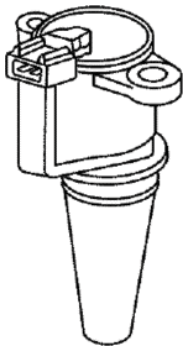
OIL PRESSURE SWITCH

The engine Oil Pressure Switch is designed to alert the user if the engine oil pressure is low. If the oil pressure drops below a certain level, the normally closed oil switch will be opened and the ECM will illuminate the MIL. The oil switch is mounted on the engine block.



Oil Pressure Switch

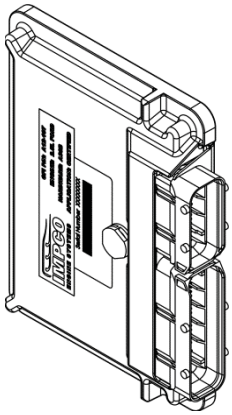
IGNITION COILS



Ignition Coil

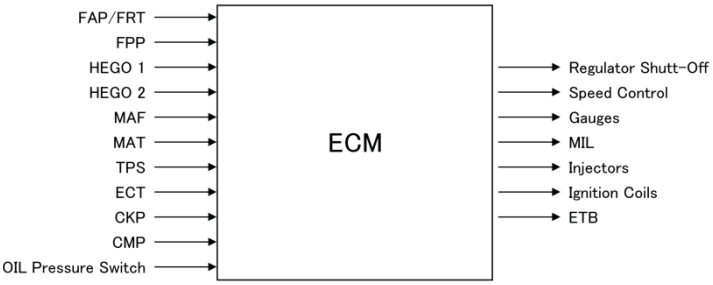
The K25 engine uses a coil on plug (COP) or individual coils mounted on top of each spark plug. The coils are used to generate a high voltage spark across the spark plug when signaled by the ECM.

ENGINE CONTROL MODULE



Engine Control Module

To obtain maximum effect from the catalyst and accurate control of the air fuel ratio, the emission certified engine is equipped with an onboard computer or Engine Control Module (ECM). The ECM receives input data from sensors mounted to the engine and fuel system and then outputs various signals to control engine operation. Inputs from the sensors are processed by the ECM and based on its program or calibration, the ECM will richen or lean the air/fuel mixture delivered to the engine to meet the demands of the operator, load and emission requirements.



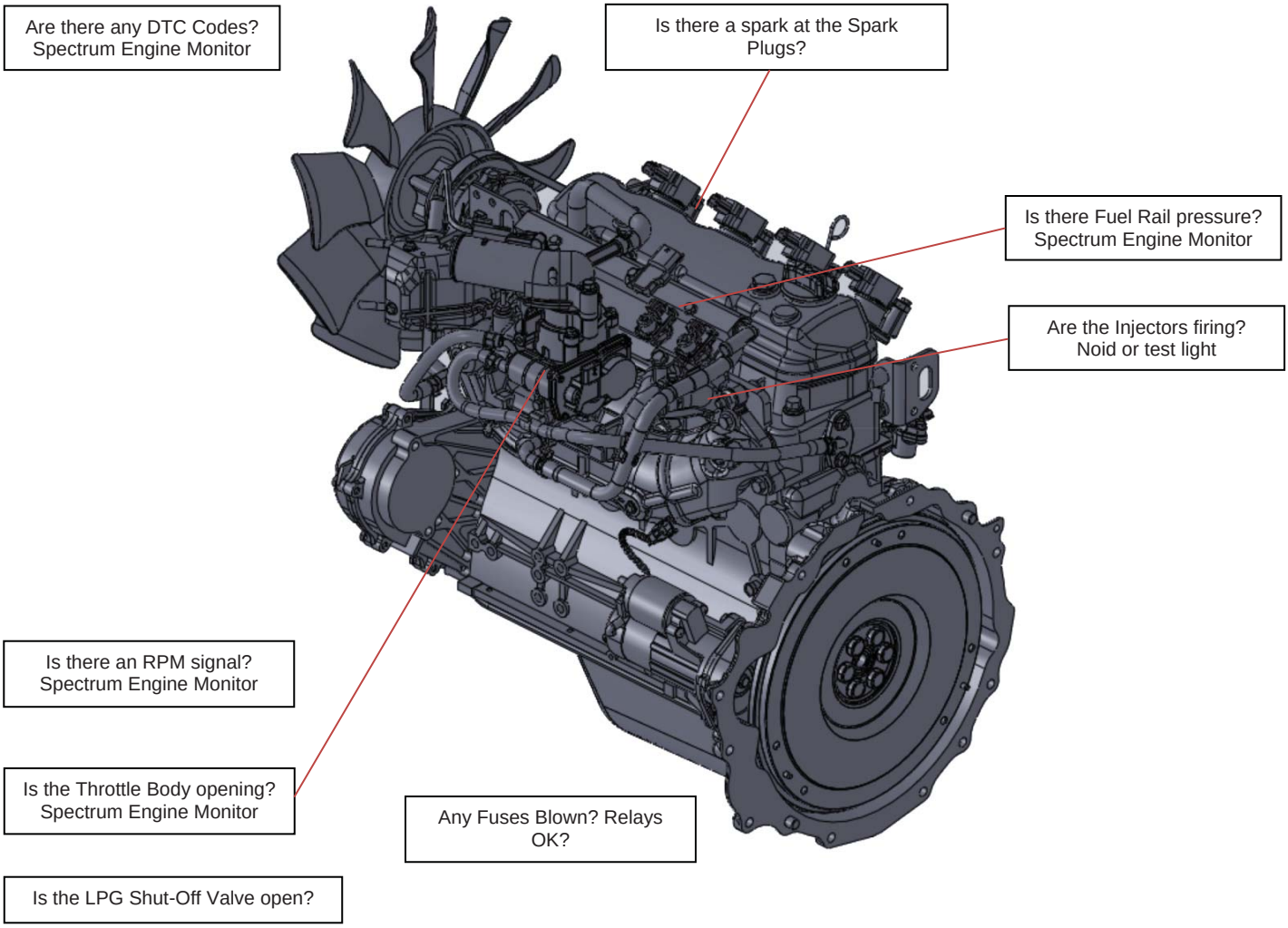
Inputs and outputs of the Engine Control Module (ECM)

One specific function of the controller is to maintain a closed loop fuel control which is accomplished by use of the Heated Exhaust Gas Oxygen sensors (HEGOs) mounted in the exhaust system. The HEGO sensors send a voltage signal to the ECM, indicating the amount of oxygen in the exhaust. Based on this measurement, the ECM richens or leans the fuel delivered to the engine.

The controller also performs diagnostic functions on the fuel system and notifies the operator of engine malfunctions by turning on a Malfunction Indicator Light (MIL) mounted in the dash. Malfunctions in the system are identified by a Diagnostic Trouble Code (DTC) number which is stored in the ECM's memory. A technician can than utilize a computerized diagnostic scan tool to retrieve the stored diagnostic code and by using the diagnostic charts in this manual, to determine the cause of the malfunction.

Quick Trouble Shooting Guide

Additional assistance can be obtained by contacting IMPCO Technical Assistance at (1-714-656-1200) between the hours of 8:00 a.m. and 5:00 p.m. Pacific Time Monday through Friday except holidaysor by e-mail: IndTech@impcotechnologies.com



Diagnostic Tools

The following tools may be used to test the engine and diagnose problems:

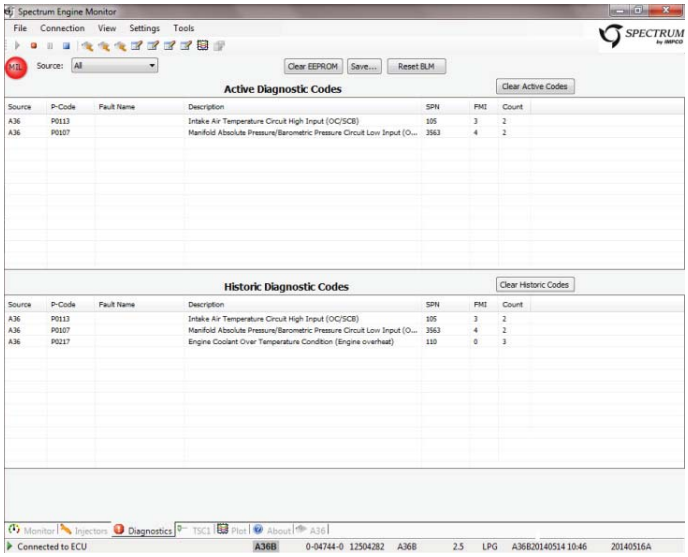
- Spectrum Engine Monitor—downloaded from http://www.impcotechnologies.com/spectrum-test-tools.asp
- USB Interface Cable (one of the following):
  - isCAN USB from IFAK Systems
  - Kvaser Leaf Light from Kvaser
- Diagnostic Connector Cable from IMPCO (Part # 1534008)
- Engine Harness Schematic—included in this manual
- Digital Voltmeter—for voltage, resistance, diode & continuity test
- Noid Light
- Spark Tester

Your emissions certified K25 engine and fuel system is continually self monitoring to ensure proper operation and adherence to emissions standards. When a sensor or component detects a value out of range, a fault is created and in nearly all cases, the MIL (frequently referred to as a “Check Engine Light”) is turned on to notify the operator that a problem has occurred. Both Active and Historic faults are stored in the ECM memory and can be retrieved by a technician using the Spectrum Engine Monitor. Once the DTC(s) is/are known, the technician can easily isolate the condition or component(s) creating the fault and systematically diagnose and correct the problem.

The Spectrum Engine Monitor is imperative for proper diagnosis. **Parts should only be serviced or replaced when determined to be faulty. The replacement of parts based on guess work is a waste of both time and money, neither of which is covered under warranty.**

FIRST CHECK FOR DTCs

Connect the Spectrum Engine Monitor and establish communications (Refer to the instructions included in this manual). Check and note if there are any Diagnostic Trouble Codes (DTC's). Check both "Active" and "Historic."



The Diagnostics tab of the Spectrum Engine Monitor showing DTCs.

If any codes are present press the "Save" button in the diagnostic window of the Spectrum Monitor (refer to the *Spectrum Engine Monitor Diagnostic Scan Tool* in this manual). This will create a file (an HTML file with the default name "diagnostics.html"). Note that if a file was saved previously, the new one must be renamed or it will be overwritten and replaced with the new one (be sure to keep the .html extension). By opening the file in your Internet Browser (Internet Explorer, Chrome, etc.), the codes stored in your ECM will be listed as well as the ECM serial number and calibration.

Refer to the section *IMPCO A36 ECM Diagnostic Trouble Codes (DTCs)* in this manual to trouble shoot and repair the cause of the active DTC.

The Spectrum Engine Monitor provides advanced diagnostic capabilities, however, some items are still left to the basics of general engine mechanics. Adherence to the recommended maintenance schedule is the best way to avoid most problems. Additionally, mechanical engine problems such as leaks, noise, vibration, etc. may not set a DTC and can be corrected by following testing and diagnostic procedures according to K25 engine information. The following Troubleshooting guide is for use when the Spectrum Engine Monitor is not able to communicate with the ECM and/or a problem occurs and/or no DTC codes are created.

Many times the basics are overlooked and can be attributed to improper maintenance. Some general rules to follow are:

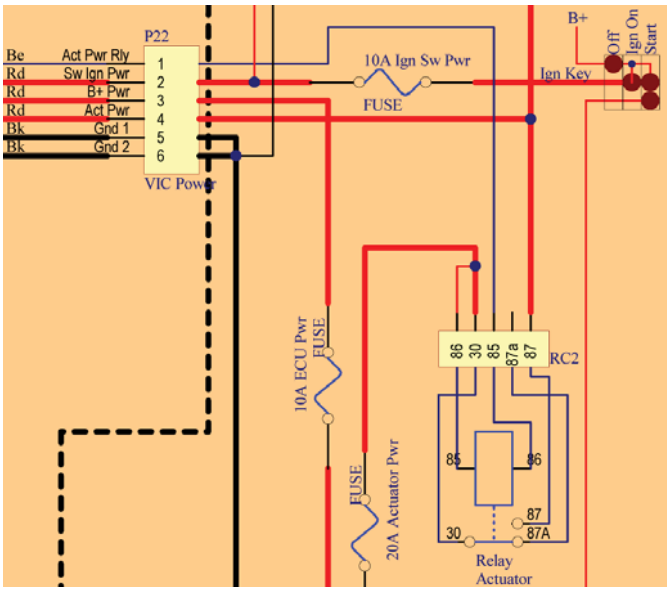
- Check general engine tune up items such as spark plugs, ignition coils, air and fuel filters.
- Check that the charging system is working correctly.
- Check battery terminals and fuel supply systems for proper operation

IF ECM CANNOT COMMUNICATE WITH THE SPECTRUM ENGINE MONITOR:

Refer to the instructions included in this manual. Also refer to http://www.impcotechnologies.com/spectrum-test-tools.asp to ensure the latest software revisions are used for both the USB driver and Spectrum Engine Monitor. Most connection errors can be resolved with a simple setting change. Review the step by step instructions available on the above website to ensure all steps have taken place. If the Spectrum Engine Monitor still cannot connect, try a different truck to determine if the CAN bus Adapter/Laptop/Software are the issue, or the truck.

If the computer connection and software appear to operating correctly, check for power to the ECM.

If the Spectrum Monitor cannot connect to the ECM and the truck is suspect, the ECM may not be receiving power. Check the Actuator Fuses and, relays, power circuits and grounds.



Power or Actuator Relay Schematic (sample). Note that the schematic to the right of the dashed line is part of the OEM harness and may vary.

Note that the Actuator or Power relay layout may vary by OEM. The Vehicle Interface Connector (VIC) will always remain the same. Testing can be done at either location, however, the Actuator Schematic should be easier.

- Probe Power Relay connector pins 86 or 30 (or VIC pin 3) with key in the OFF position (The Power Relay can be back probed or lifted up approx. 1/8" to expose contact legs while still making contact with the relay socket/connector and probe the relay pins).
- Power Relay Pins 86 and 30 (VIC pin 3), should have battery voltage when the negative voltmeter lead is grounded.
- Turn Key On.
- The switched power lead (VIC pin 4) should rise to battery or system voltage.
- Check for 12 Volts on both sides of the Power fuse. If power is found on one side of the fuse but not the other, replace fuse.
- Back probe VIC 1 and VIC 2 while cranking and test for system voltage (note that voltage is less during cranking but should be less than 9.6 volts).

If voltage can't be measured at these pins, check for blown fuses, battery connections and battery voltage. If VIC pin 4 fails to show battery voltage with key ON, check fuses and if they are good, replace the bad relay.

If voltage is detected but the starter won't engage to crank the engine, check the Key switch by lifting up the 10A Ignition Switch Power fuse and test voltage at both terminals (by touching the voltmeter probes to the exposed metal points on sides of the fuse) to ensure power is delivered to the starter when the key is turned to the Crank position.

WARNING

Extra care must be taken when probing electrical pins and terminals. Do not bend or spread these terminals as this can also be a source of intermittent problems cause by improper handling of these low voltage connectors and terminals. When running electrical diagnostics avoid back probing the wire connectors as this may damage the wire seal. When running the continuity checks, just touch the wire terminal; forcing the electrical probe into the terminal may cause the terminal to spread leading to permanent damage.

IMPORTANT: When the key is first turned ON the Actuator relay is energized supplying power to the Fuel Shut-off Solenoid, Ignition Coil, Fuel Injectors and O2 Sensor. If the engine is not being cranked or running, after 3 seconds the Actuator relay will be turned off. The Actuator relay will be turned on again if an engine rpm signal is sensed (engine cranking or running). Note that turning the key OFF and ON again quickly will not result in another 3 seconds of Power. Only after the key has been off for 20 seconds and then turned on again will the 3 seconds priming power be seen again. So it is necessary to crank the engine to troubleshoot the Actuator Relay circuits.

CRANKS BUT WILL NOT START AND NO DTCs

Engine Electrical

1. Does the engine rpm show on the Spectrum Engine Monitor while cranking? If there is no rpm showing on the Monitor tab and communication is properly working with the ECM, then the cranking rpm is too low or the engine crank sensor is not functioning. Verify there is at least 9.6 volts at the battery during cranking. If the voltage is lower than 9.6,

verify that the battery has sufficient charge. If charged, test the battery and replace if necessary. The minimum cranking speed which can be detected by the ECM is 60 rpm. Using the Spectrum Engine Monitor, verify that the engine speed (rpm) shows on the Engine speed box of the Monitor page or plotted on the Plot page when the engine is cranked. If no crank signal is produced, check the electrical connections to the sensor and verify the sensor is correctly positioned. If the connections and position are good, test with a digital voltmeter set for AC voltage. The sensor should output approximately 1.2-1.8 volts. If the Crankshaft Sensor output is outside of this range, replace the sensor.

2. Is there spark at each spark plug? Using a commercially available spark tester, crank the engine and watch for spark. If no spark is found, the spark plug or coil may be bad.
3. Is the LPG vaporizer Lock-Off opening? The LPG lock-off can be checked for activation with an iron bar (or other ferrous metal which is attracted to a magnet) by holding it close but not touching the solenoid on the regulator. When the lock-off solenoid is energized, at key ON (for 3 seconds as mentioned above) magnetic attraction can be detected. If the lock-off solenoid is not energized, inspect the actuator relay and fuse circuit.

NOTE: The 12 Volt power to the Fuel Shut-off Solenoid, ignition coil and injectors is supplied through the Actuator Relay. If there is no fuel pressure, spark or injector firing, check the power output at the Actuator Fuse.

FUEL

1. Is there the proper fuel in the tank and is the fuel tank open?
2. Has the Excess Flow Valve on the tank been tripped shut?
3. Is there fuel pressure at fuel rail? Fuel pressure can be read via the Monitor tab on the Spectrum Engine Monitor. The fuel pressure should be approximately 180 to 210 kPa (26 to 30.5 PSI (when the key is ON, but the engine is not running) and 88 kPa (12.7 PSI) above manifold pressure when it is running—approximately or 125 to 140 kPa (18.1 to 20.3 PSI at idle). Low fuel rail pressure may be the result of:
   - Empty fuel tank
   - Tripped Excess Fuel Valve on the fuel tank.
   - Dirty or clogged fuel filter(s).
   - Closed or stuck lock-off valve or bad electrical connection to the lock-off valve.
4. Inspect the vacuum line between the manifold and vaporizer to make sure it is securely connected and not cracked, rotten or plugged.
5. Are the Injectors firing? The best and most thorough way to check the injector circuit is to insert a “noid” light in place of each injector (one at a time) and cranking the engine to see that the light flashes. If the injector is receiving an electrical pulse yet remains suspect, the best test is to replace it with a known good injector.
6. Is an injector leaking? To perform this test, using the Spectrum Engine Monitor, with Key ON, and engine not running, note the fuel rail pressure. The pressure should not drop more than 3 kPa/minute. If the fuel rail pressure drops faster than 3 kPa/minute, there’s a leak downstream of the regulator or one or more injectors are stuck open/leaking and require replacement. Also refer to *XXII. LPG FUEL SYSTEM LEAK TEST* in the *Servicing the Fuel System* section.

IF ECM POWERS UP AND SPECTRUM MONITOR CAN COMMUNICATE:

If the engine starts and runs, record the engine operation at idle using the Spectrum Engine Monitor and under the condition that it’s operation is unacceptable (for example acceleration). Note to see if the engine operation has gone closed loop (the “Control Mode” for the appropriate bank should show “Closed” approx 1 minute after start-up if a room temperature start).

CHECK THE DESIRED SPEED

With the Monitor tab page open and the engine idling (0 Pedal) check to see what the Pedal Position Sensor reads on the Monitor pages. Also plot the “PedalPositionSensor” and the “Desired EngineSpeed” to verify that they change when the foot or accelerator pedal is pressed.

IS THE THROTTLE IN LIMP HOME MODE?

If a fault occurs in any of the pedal, throttle or 5 volt power supply circuits, the Electronic Throttle Body (ETB) will go into "Limp Home" mode designed to prevent a run-away engine or engine damage. Power to the ETB will be removed. The throttle plate will take a neutral position of approximately. 18% and will not move. Any of the following Diagnostic Trouble Codes (DTC's) will cause the throttle to go into Limp Home mode:

DTC	SPN- FMI	Description
P0638	3464-7	Desired and actual throttle positions do not match
P0643	3509-3	5V Sensor Power Supply 1 voltage high
P0122	51-4	TPS1 signal circuit voltage low
P0123	51-3	TPS1 signal circuit voltage high
P0222	3673-4	TPS2 signal circuit voltage low
P0223	3673-3	TPS2 signal circuit voltage high
P1521	5419-7	Detected rest position of throttle does not match expected value
P1522	5419-14	After spanning, resting positions of redundant TPSs have failed to
P2100	5419-4	Open circuit in ETC motor circuit
P2103	5419-6	Short to high in ETC motor circuit
P2109	51-1	Electronic throttle could not complete its self span
P2111	5419-0	Throttle is stuck open and does not move as commanded
P2112	5419-1	Throttle is stuck close and does not move as commanded
P2113	3673-1	Electronic throttle could not complete its self span
P2119	5445-4	Electronic throttle could not complete its self span
P2135	51-7	Readings from TPS1 and TPS2 signal lines do not correlate
P2163	3464-13	Electronic throttle could not complete its self span
P2164	3464-13	Electronic throttle could not complete its self span
P2176	5419-13	ECM was not able to perform throttle span after key-off

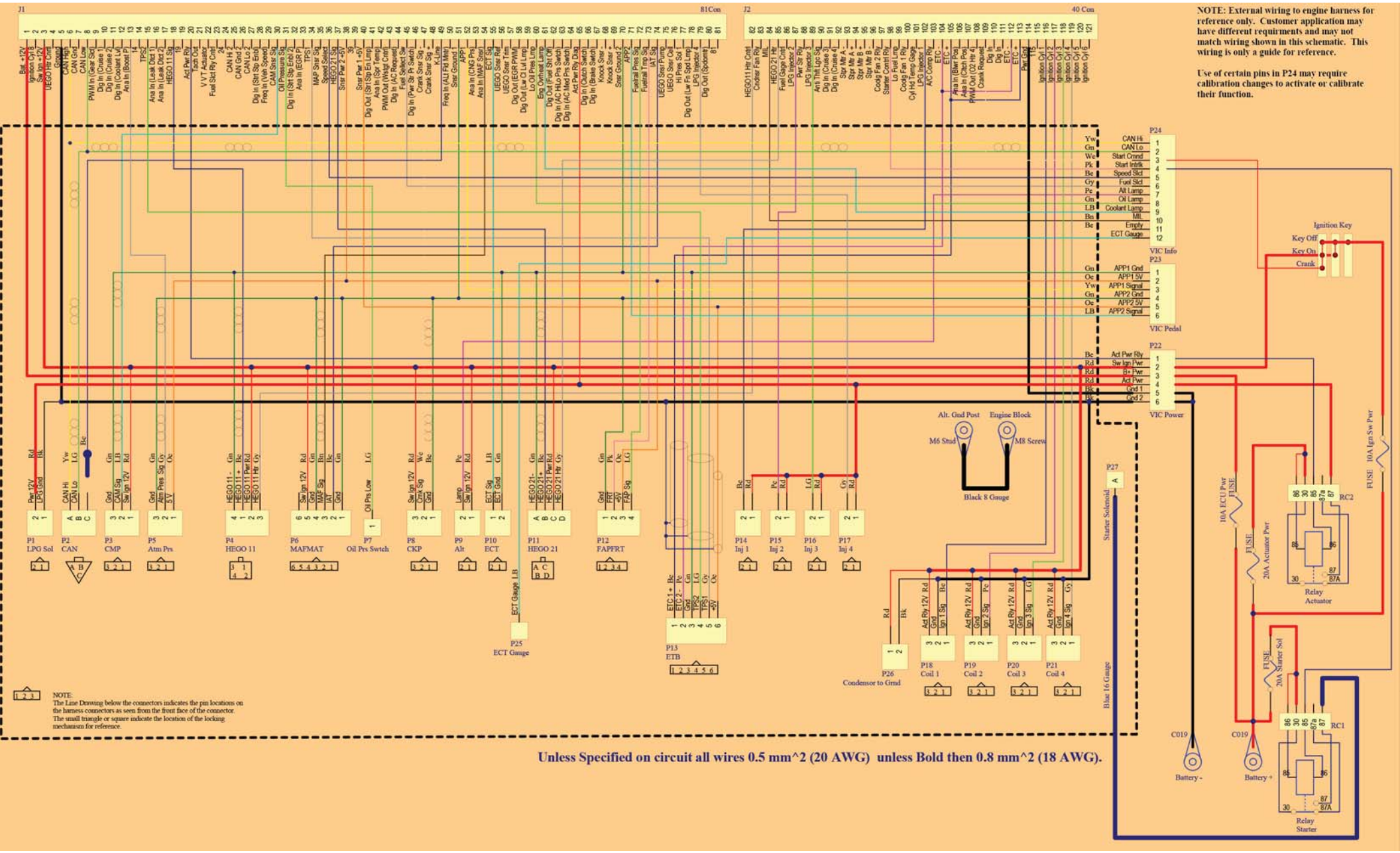
If the ETB goes into Limp Home mode the cause of the DTC must remedied, the DTC must be cleared and then the truck keyed off for at least 20 seconds.

Engine Won't Crank (Power is applied, but the starter won't engage).

- Verify battery voltage is sufficient.
- Check to see if the starter relay is providing power to the starter solenoid.
- Check all electrical connections, including the battery posts.
- Check ignition switch.
- If sufficient voltage is supplied to the starter and it won't turn, replace the starter.

NOTE: Other OEM equipment may include a seat interlock and fuses. Refer to the OEM manuals.

Engine Electrical



Unless Specified on circuit all wires 0.5 mm^2 (20 AWG) unless Bold then 0.8 mm^2 (18 AWG).

Engine Wire Harness Repair

ON-VEHICLE SERVICE
WIRE HARNESS REPAIR

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

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

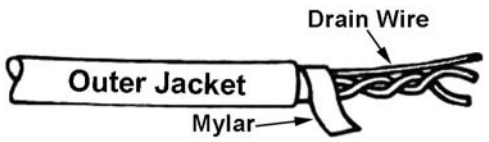
CONNECTORS AND TERMINALS

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

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

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

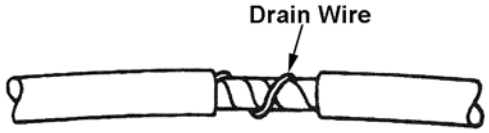
REPAIRING TWISTED/SHIELDED CABLE



1. Remove outer jacket

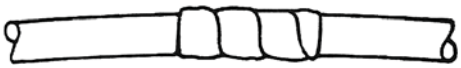
2. Unwrap aluminum/Mylar tape. Do not remove Mylar.

3. Untwist conductors, strip insulation as necessary.



4. Splice wire using splice clips and rosin core solder. Wrap each splice to insulate.

5. Wrap with Mylar and drain wire (uninsulated) wire.



6. Tape over entire juncture and secure.

REPAIRING TWISTED LEADS

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

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

4. Cover splice with tape to insulated from other wires.
5. Retwist as before and tape with electrical tape and hold in place.

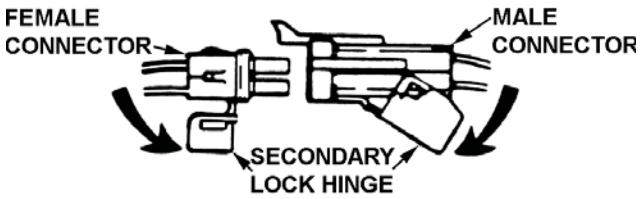
WEATHER-PACK

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

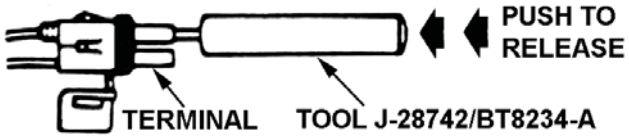
Use tool J M28742, or BT8234-A or equivalent to remove the pin and sleeve terminals. If the removal is attempted with an ordinary pick, there is a good chance that the terminal will be bent, or deformed. Unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

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

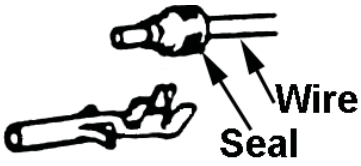
WEATHER-PACK TERMINAL REPAIR



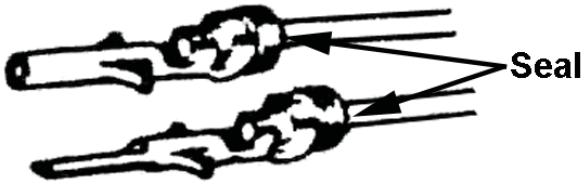
1. Open secondary lock hinge on connector.



2. Remove terminal using tool.



3. Cut wire immediately behind cable seal



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

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

Spectrum Engine Monitor Diagnostic Scan Tool

Spectrum Engine Monitor Diagnostic Scan Tool
Software Installation Instructions

- Installation of the USB to CAN adapter driver and utility.
- Installation of the Spectrum Engine Monitor software.

INSTALLATION INSTRUCTIONS

Before installing the Spectrum Engine Monitor software, please be sure your computer meets the minimum system requirements.

Supported operating systems are:

- Windows 8 (32 or 64 bit)
- Windows 7 (32 or 64 bit)
- Windows XP (32 or 64 bit)
- Windows Vista (32 or 64 bit)
- Windows 2000 (32 bit)

Minimum processor speed:

- Pentium III 1.0 GHz

Minimum RAM requirement:

- Windows 8 1 GB
- Windows 7 1 GB
- Windows Vista 512 MB
- Windows XP 256 MB

Additional:

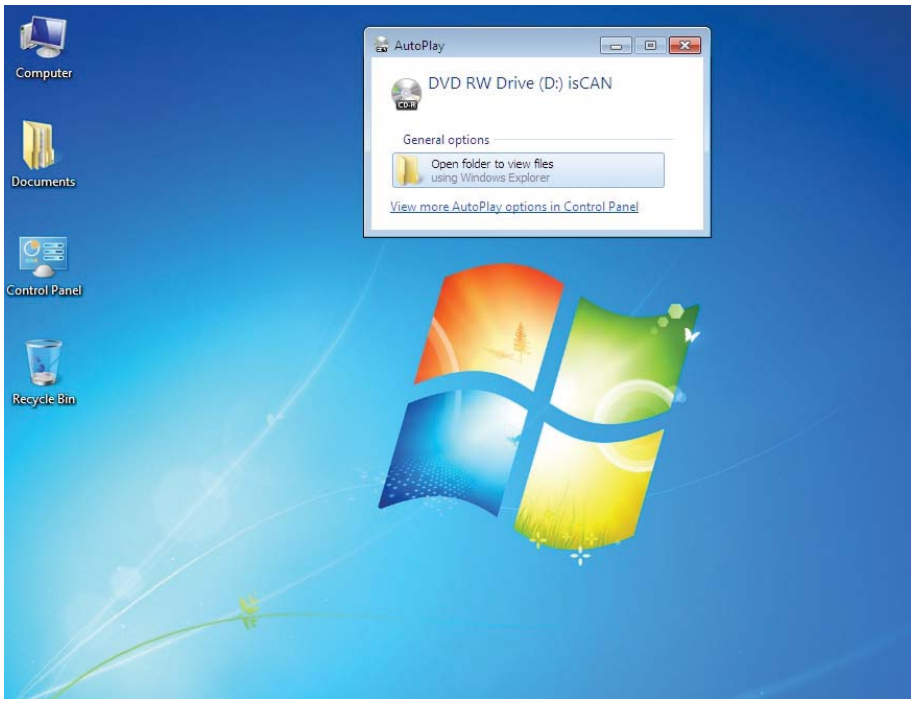
- Display capable of at least 1024 x 768 screen resolution and one available USB port.

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

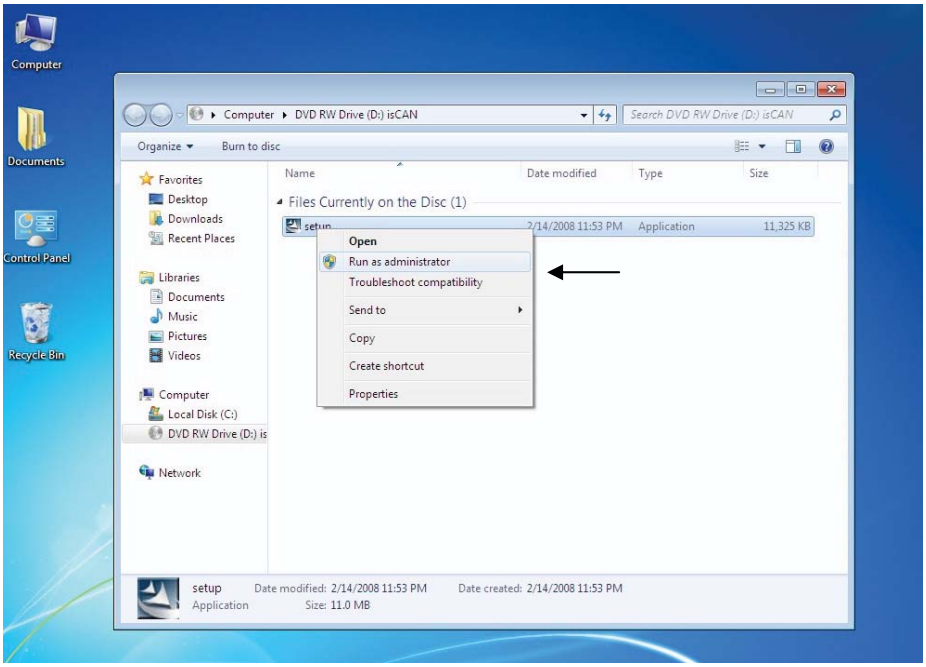
Ifak* Driver and Utility Installation:

**If Kvaser models are used, skip this step.*

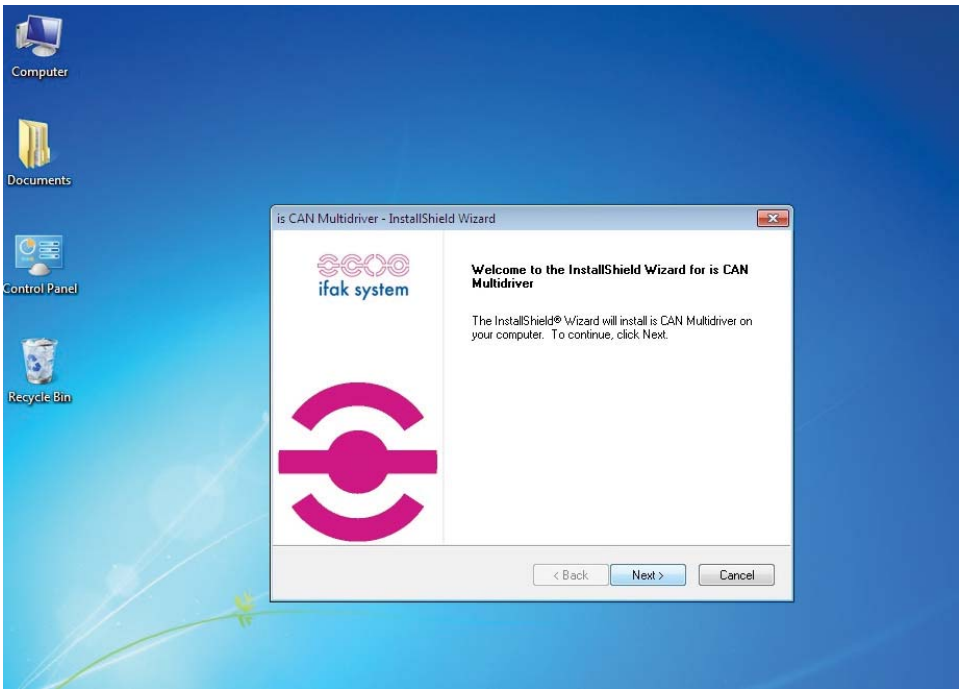
NOTE: Close any open applications prior to installing the Spectrum Engine Monitor.



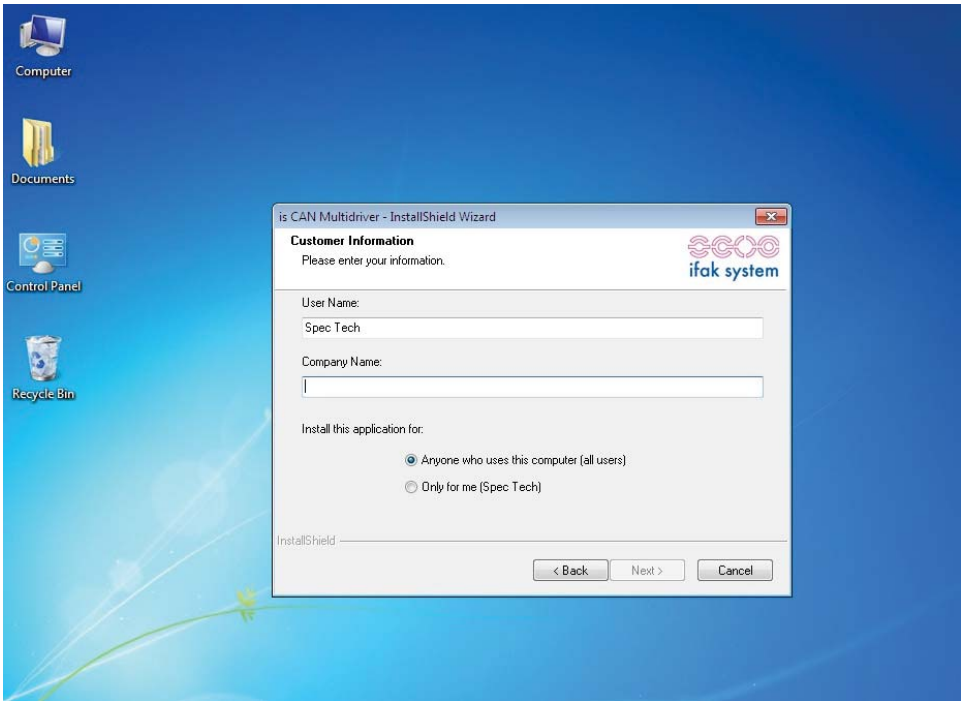
Insert the Ifak CD included with your USB to CAN adapter and open the file folder.



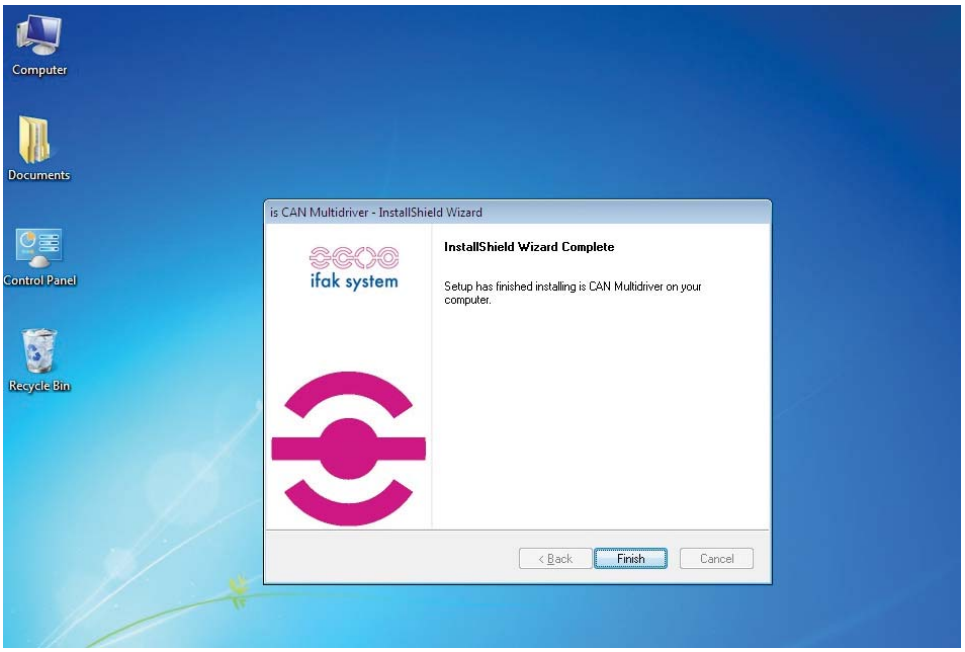
For users with restricted rights using Windows 7 or Windows Vista, select **Run as administrator** as shown above. For all others, select the **Setup file**. You may receive a Windows message asking you to confirm the installation request by an unknown publisher. You must select **Yes** to continue the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



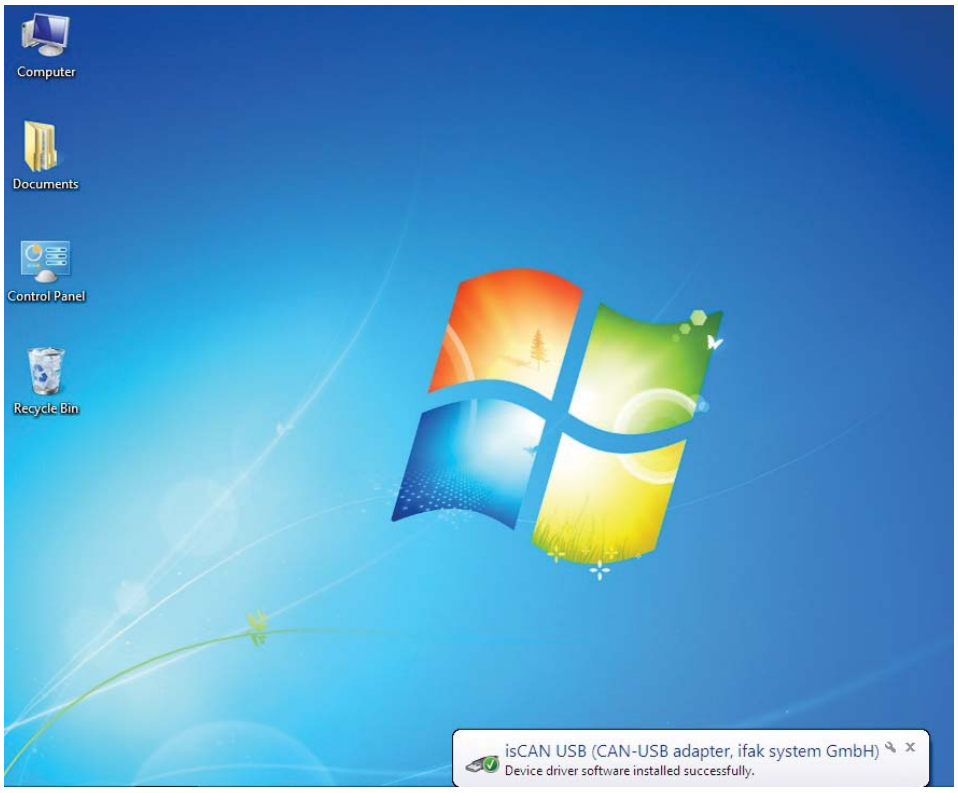
Select the **Next** box to continue with the installation.



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

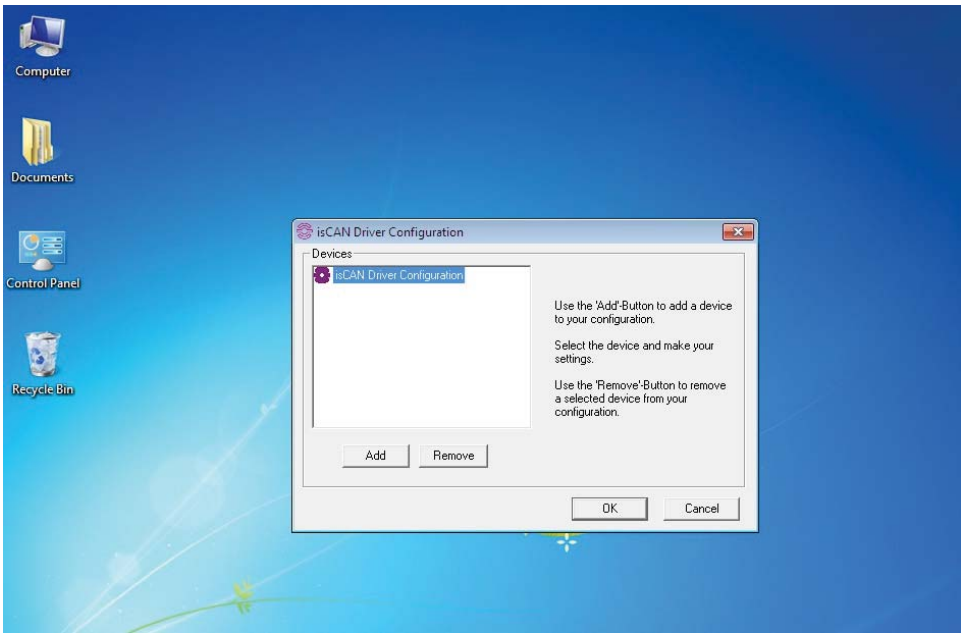


Click the **Finish** box to complete the installation. It is now recommended you re-boot your computer.

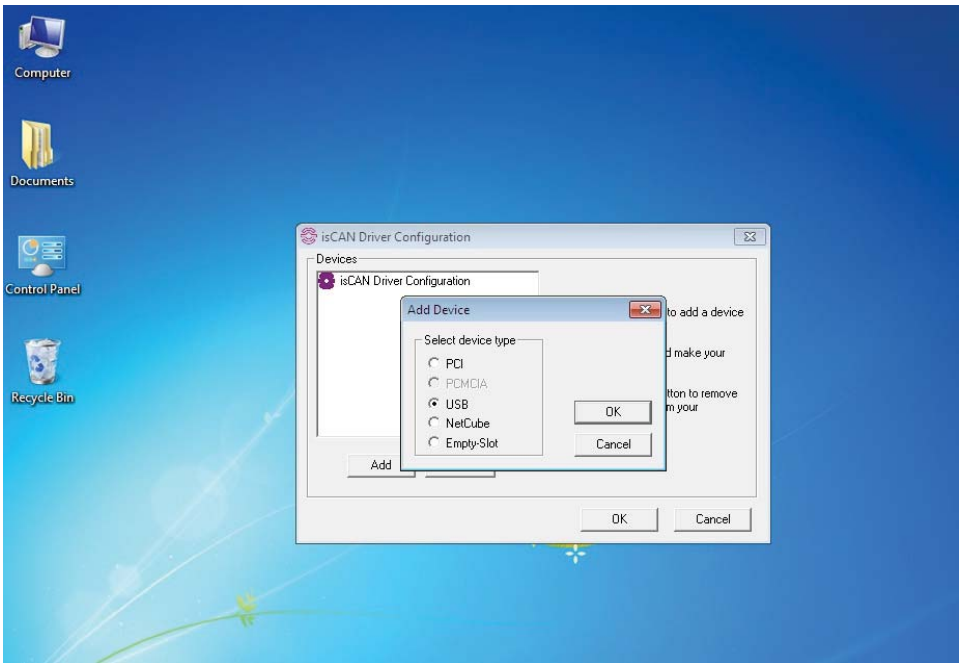


Connect the Ifak adapter to an available USB port. You may see a message confirming you wish to make changes to the computer from an unknown publisher. If so, you must select the **Yes** box to continue the installation. Windows will now install the Ifak driver to your computer. You should see a message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

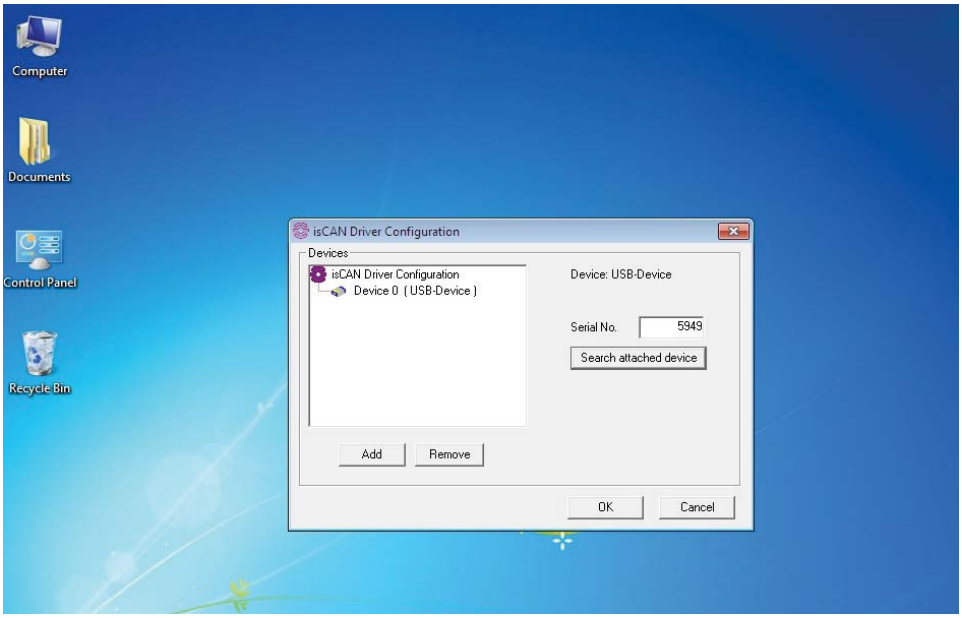
Open the **Start** menu. You should see the is CAN Configuration utility confirming the utility installation. Select the **is CAN Configurator**.



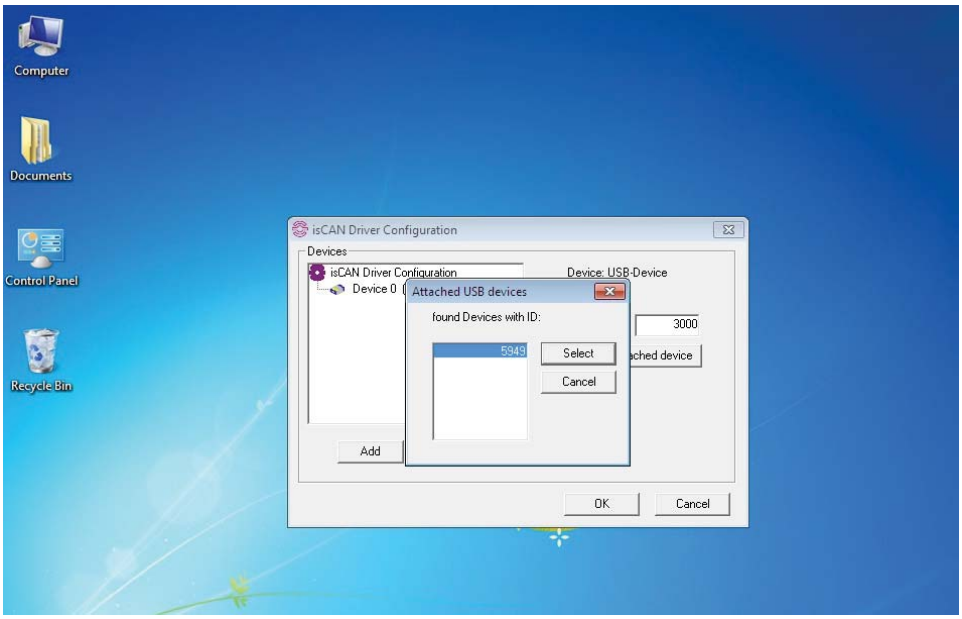
Click the **Add** box.



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



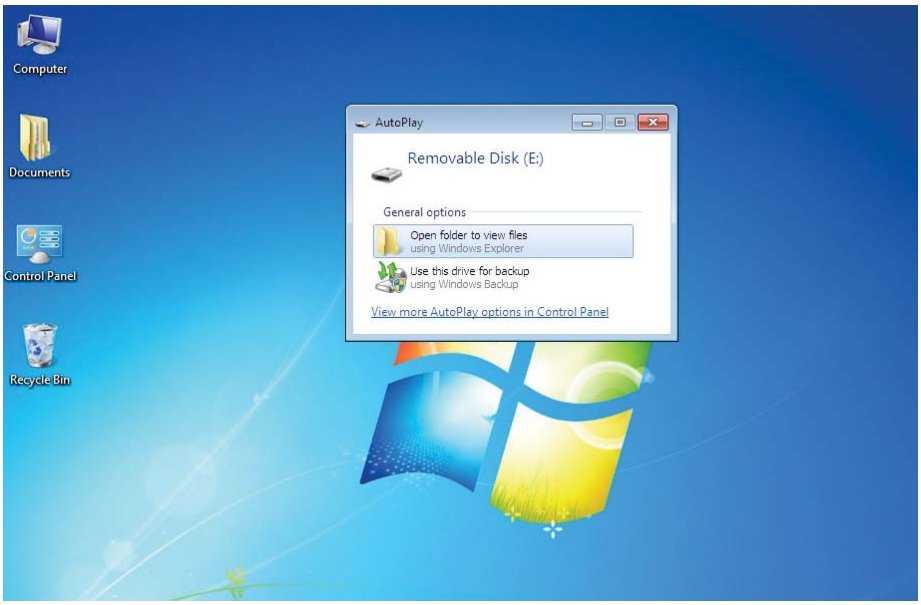
Click on the **Search attached device** box.



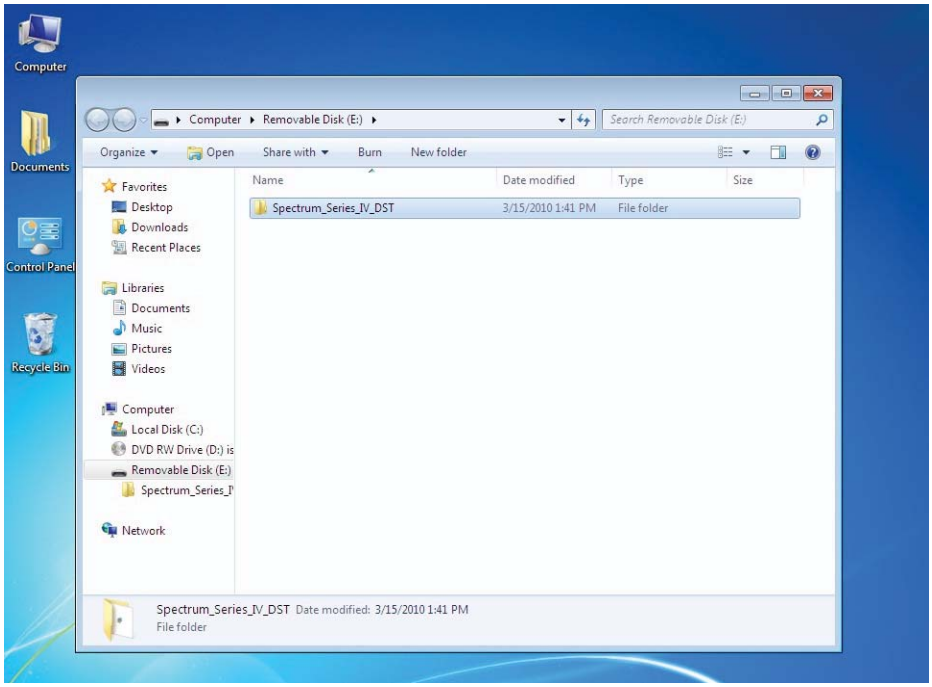
When the Ifak device serial number is shown, click the **Select** box, then click the **OK** box. The Ifak driver and utility installation is now complete. If you had problems during this installation please see the additional information and test instructions for your Ifak adapter included with your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

Spectrum Engine Monitor Software Installation:

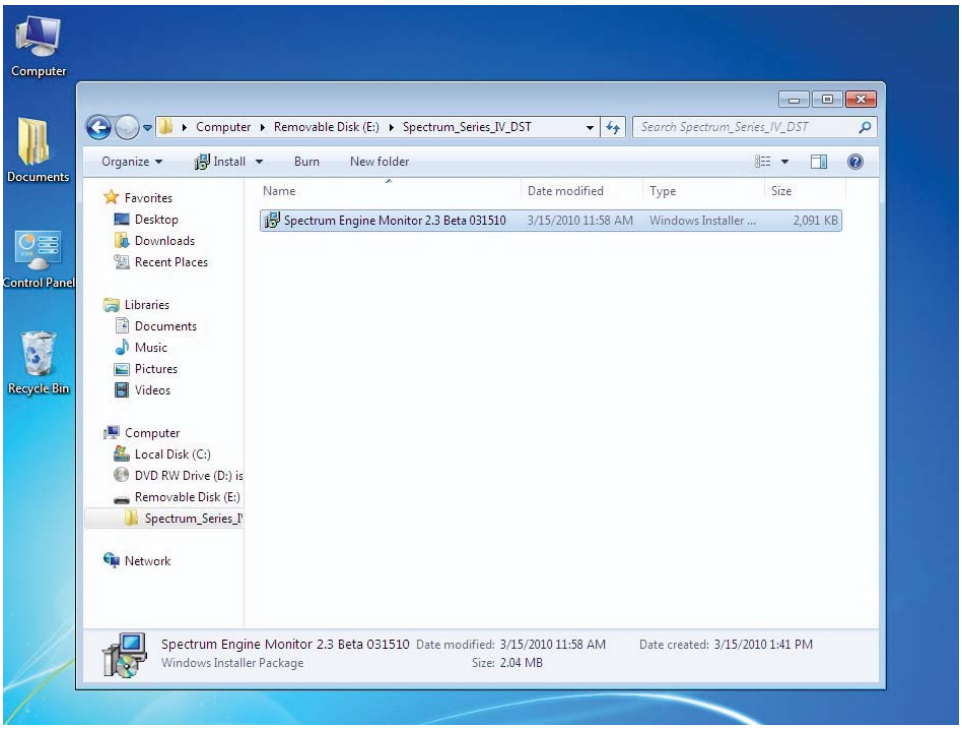
In most instances, the OEM manufacturer will have supplied you the Spectrum Engine Monitor software installation files. The installation files may have been provided to you by internet download, CD or other media storage. Regardless of the delivery system, please follow the instructions to install the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



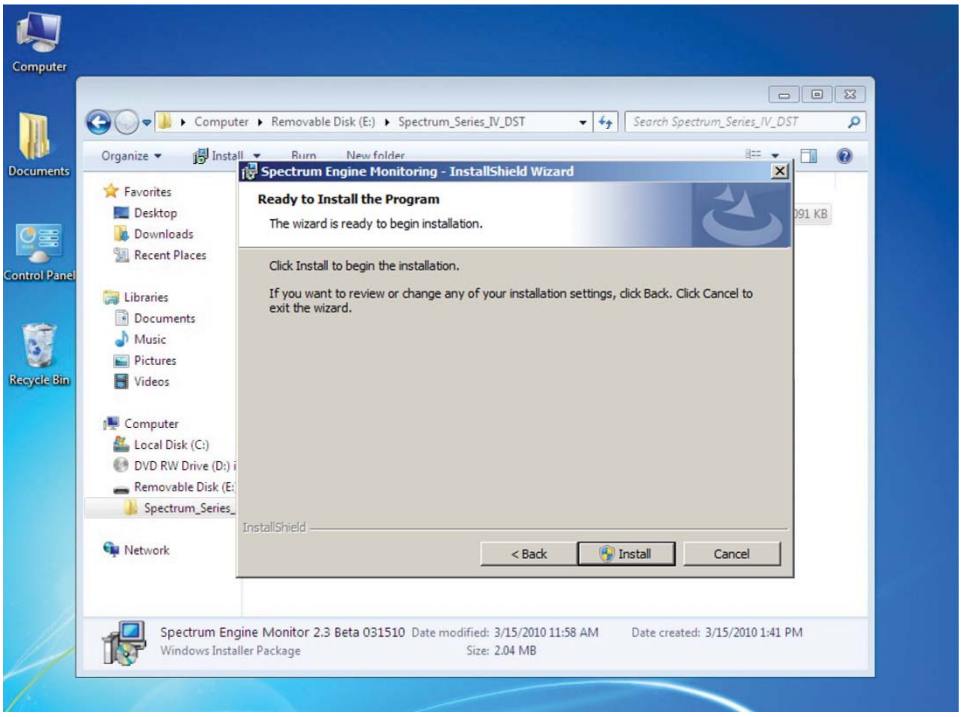
Insert the CD, USB flash drive, other storage media or find the location where the Spectrum Engine Monitor software has been saved on your computer.



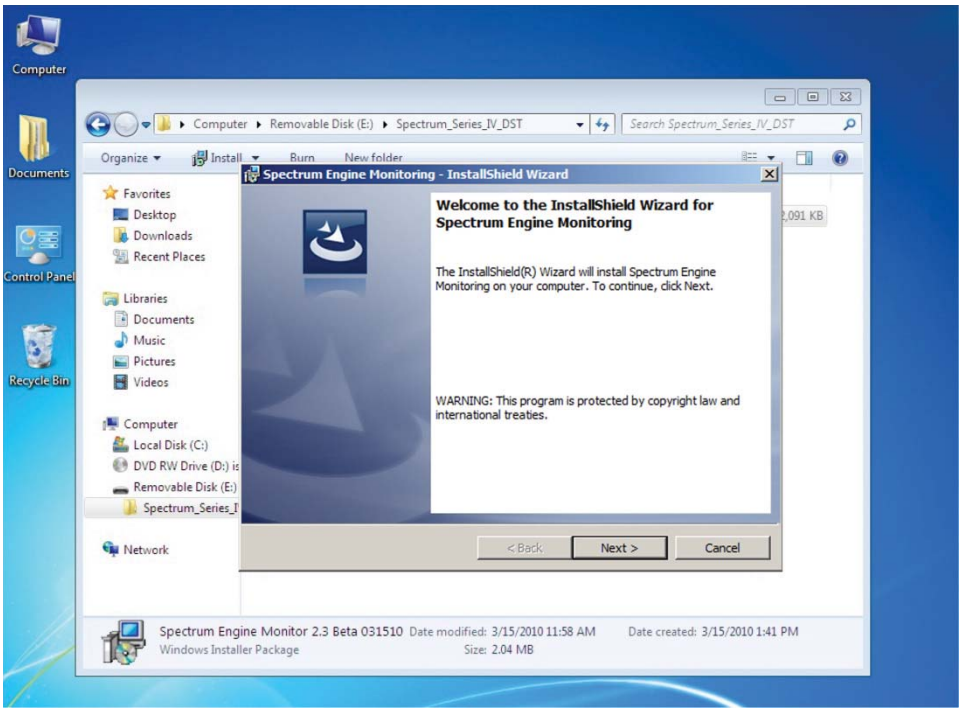
Open the **Spectrum_Series_IV_DST** (sample folder—actual name may differ) file folder.



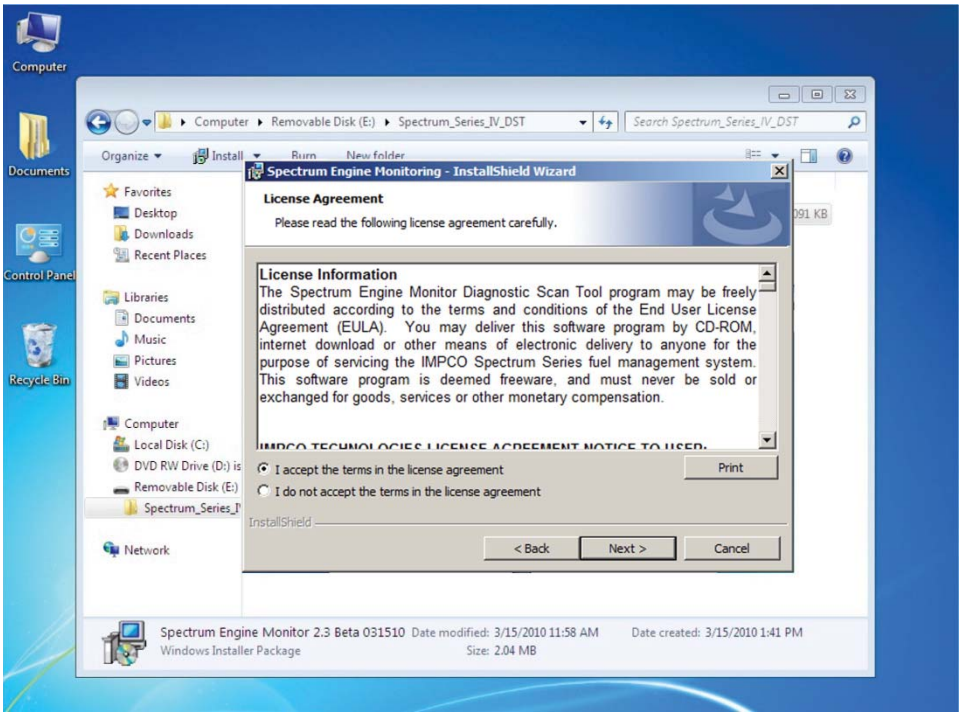
For users with restricted rights: it may be necessary to select the **Run as administrator** box similar to the Ifak USB driver installation. For all others, click the **Spectrum Engine Monitor.msi** file. You may receive a Windows message asking you to confirm the installation request by an unknown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



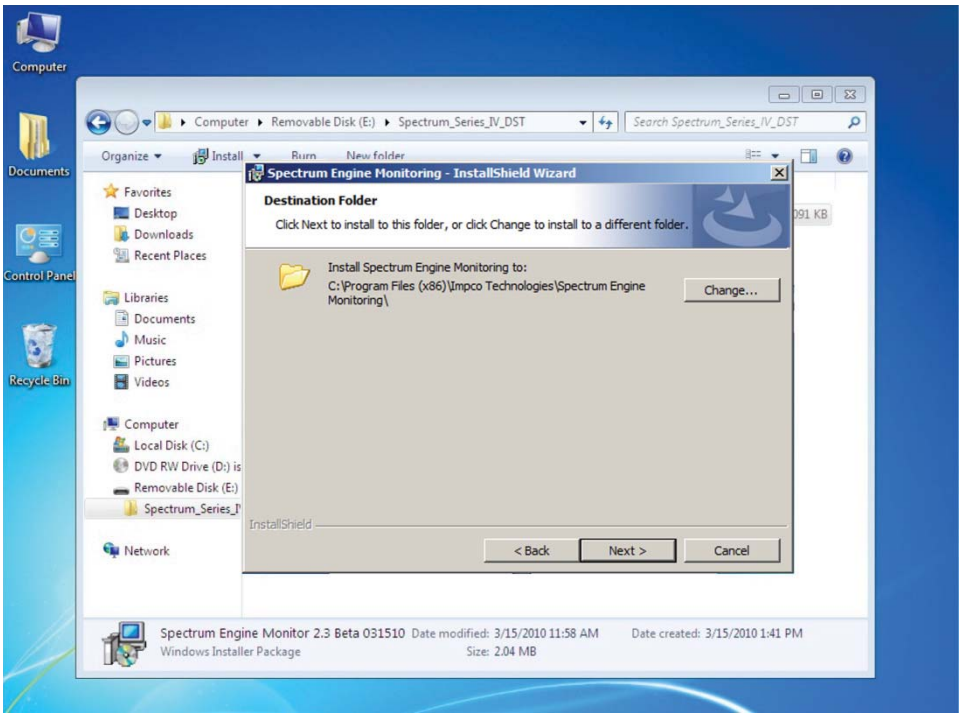
Click on the **Install** button to begin the installation.



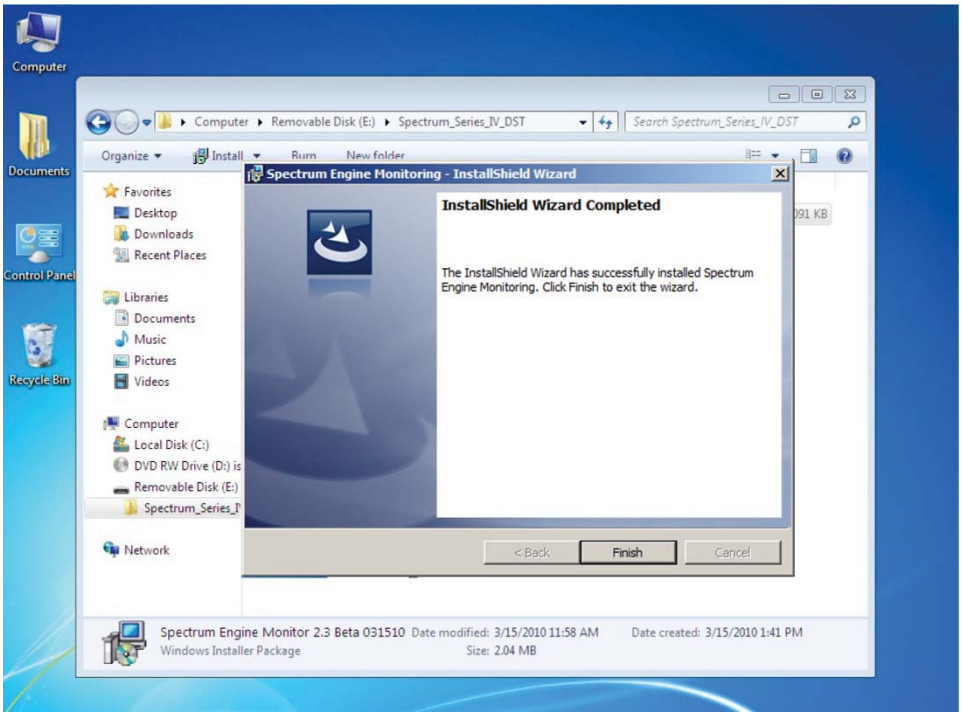
Click the **Next** box.



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



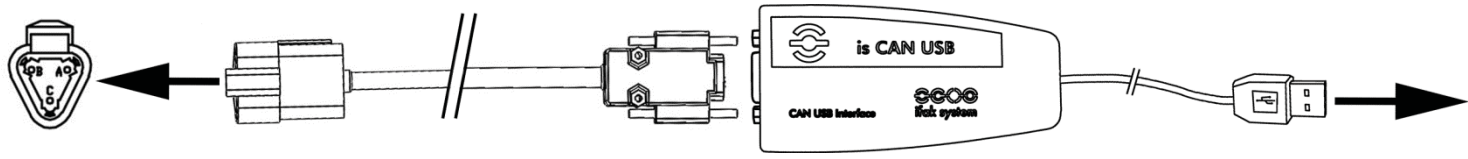
Select the destination folder.



Once the installation is completed, click on the **Finish** button.

The Spectrum 4 logo shortcut will be placed on the desktop. It is now recommended that you restart your computer.

Connecting the Spectrum Engine Monitor:



Triangular 3-Pin Connector on Truck

Triangular 3-Pin Connector on orange cable (P/N 1534008)

RS232 15-pin Connector on orange cable (P/N 1534008)

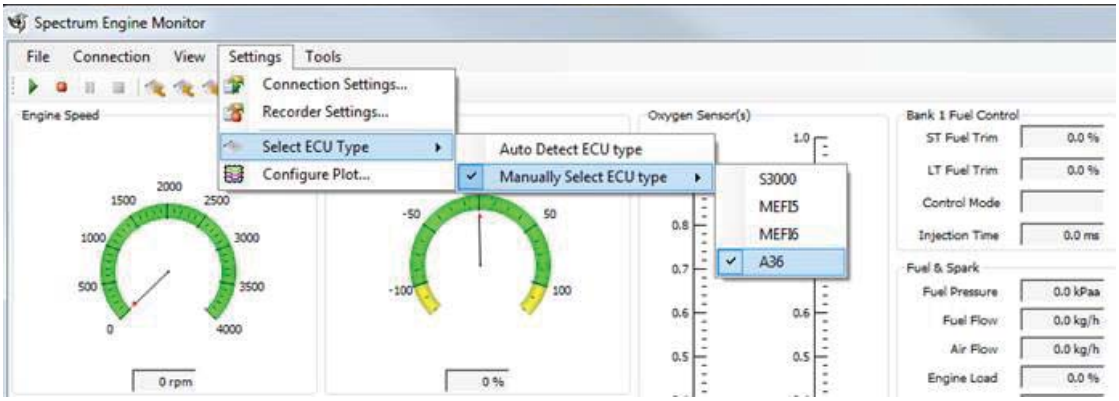
iFak CAN Bus Adapter (P/N ISCAN)

USB Connector plugs into USB port on Laptop

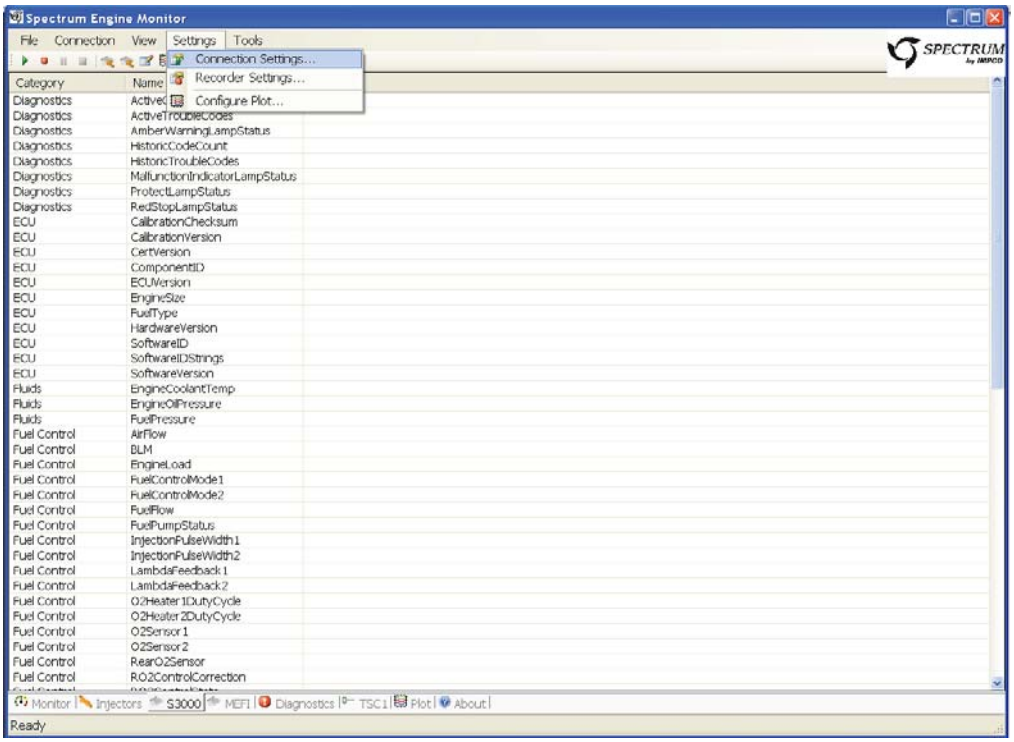
Connect the 15-pin RS232 connector on the Orange cable (P/N 1534008) to the matching connector on the end of the iFak, then connect the 3-pin triangular connector on Ifak connector to matching connector on the truck's wiring harness.

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

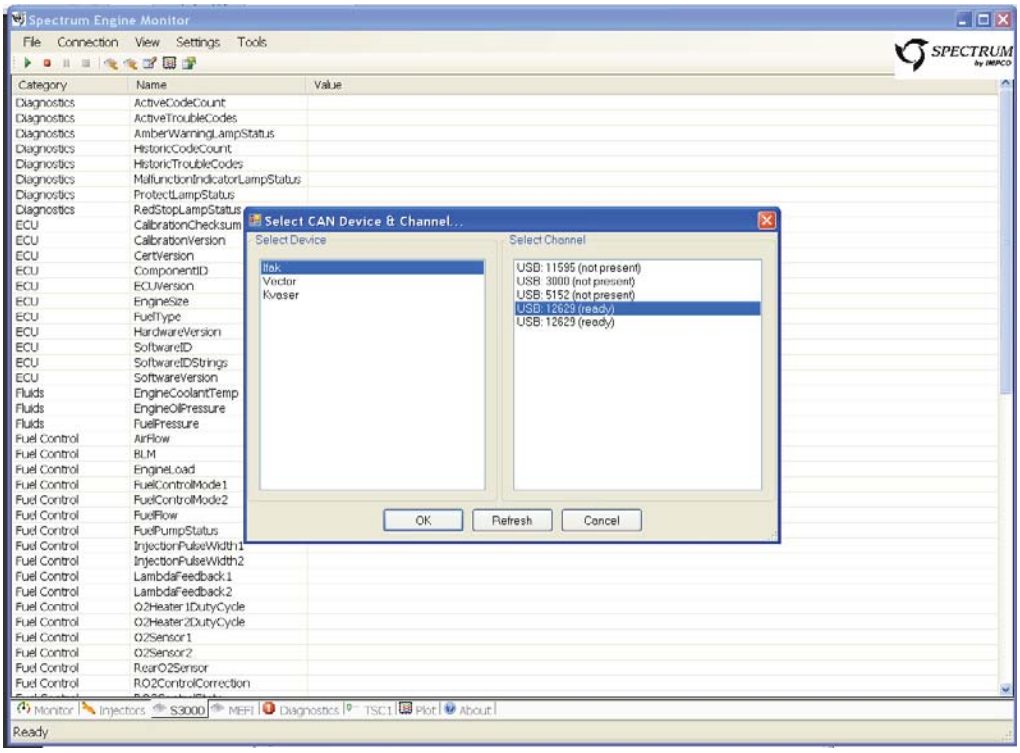
The Spectrum Engine Monitor should automatically connect to the A36 ECM.



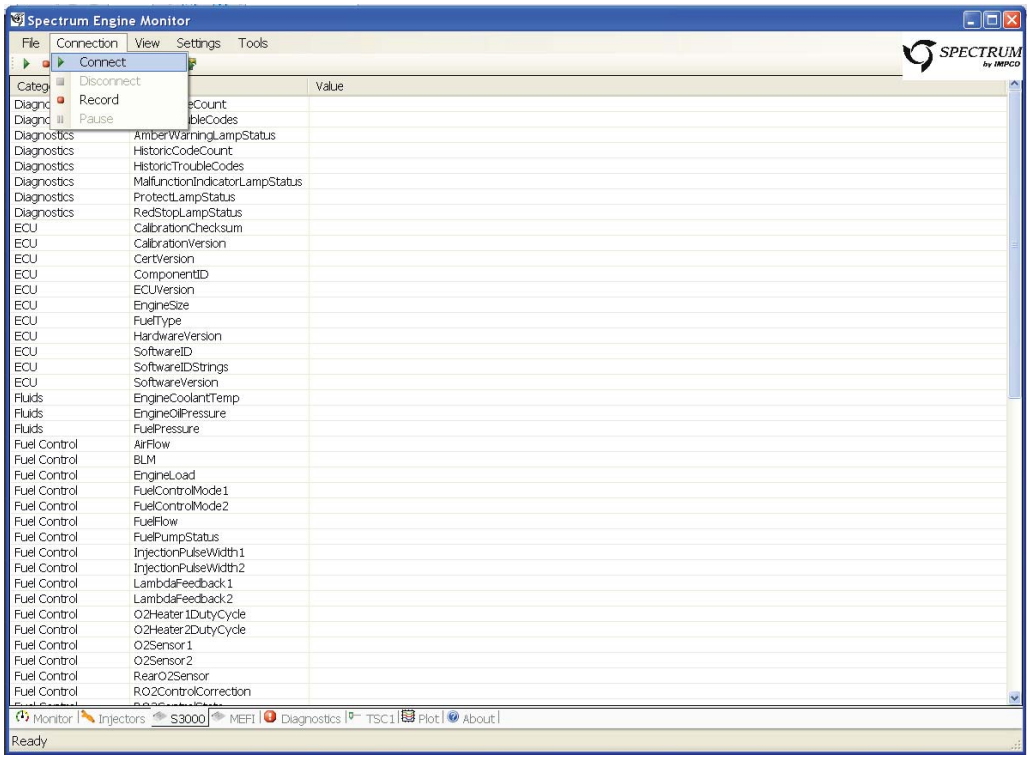
Note that the ECM can be manually connected by clicking on Settings, then Select ECU type/Manually Select ECU Type/A36. The connection setting is saved when exiting, providing File is clicked and “Exit” is selected.



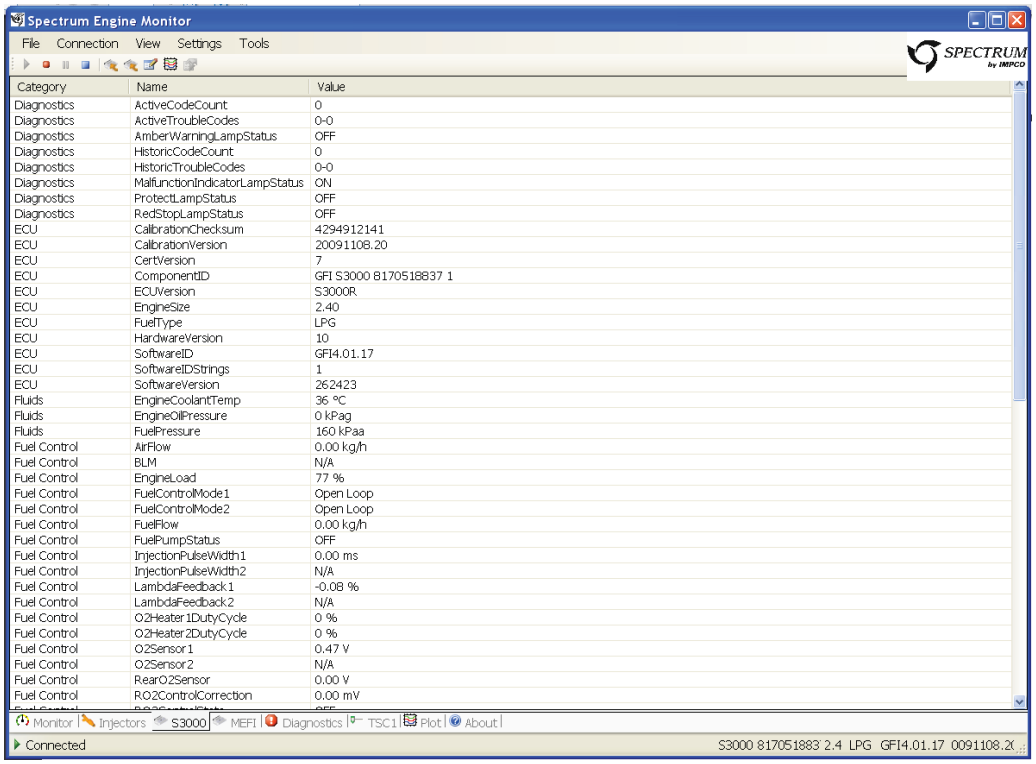
On the data stream page, pull down the **Settings** menu and click on **Connection Settings**



The **Select CAN Device & Channel** dialog box will appear. To select the **Ifak** device, look for the option in the right panel that matches the serial number of your iFak dongle with “Ready” or “Active” noted at the right. Select this channel then click the **OK** box. Kvaser users: If you only see two options that say "Kvaser Virtual CAN Driver Channel 1" your dongle is not plugged in or you need to close the Spectrum Engine Monitor, plug in the dongle and then restart the program. Select the "Kvaser Leaf Light HS Channel 0" then click the **OK** box.



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



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

Using the Spectrum Engine Monitor

The Spectrum Engine Monitor is the next generation all CAN (Controller Area Network) enabled diagnostic tool. This is a new tool for emission year 2015. It is designed to be compatible for all 2015 Spectrum fuel systems that use the A36 ECM application. The Spectrum Engine Monitor operates on an expandable platform and its functions are planned to increase in the future. The functions are listed below:

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

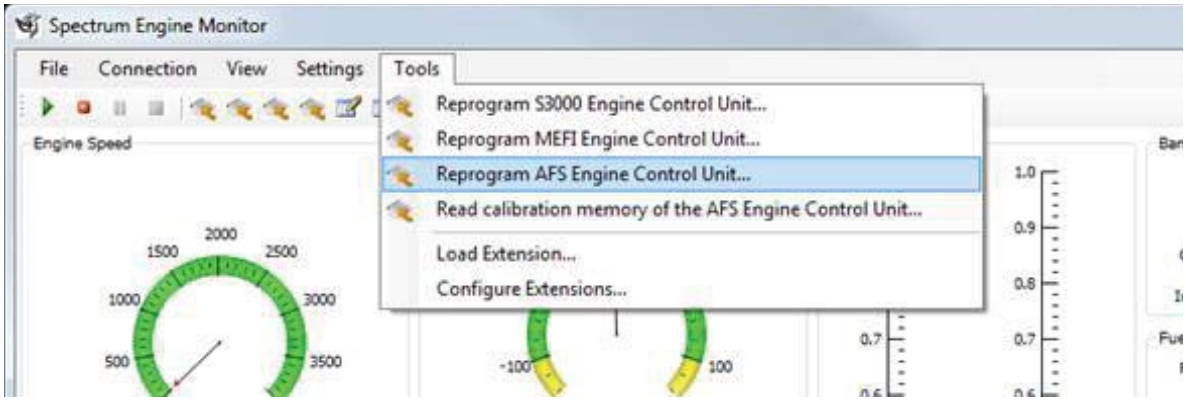
Updating the ECM Calibration

In field updates (also known as “reflashing”) where the ECM software or calibration is update are possible with the A36 ECM using the Spectrum Engine Monitor. Calibration files are supplied in the .afs file format and may be supplied to you by the OEM. A password will not be necessary if the fuel type, engine size, certification level and hardware version of your engine matches those in the new calibration file; passwords are only necessary to override/change these variables. Before re-programming the ECM, shut down any other programs running on your PC including wireless and e-mail programs. The PC must be dedicated to the re-programming process at this time. Be sure your PC battery is adequately charged. Failure to follow these instructions may render the ECM not unusable in the field.

Before reflashing, connect to the ECM to ensure all software is installed and functioning properly (as shown in the previous pages covering the Spectrum Engine Monitor).

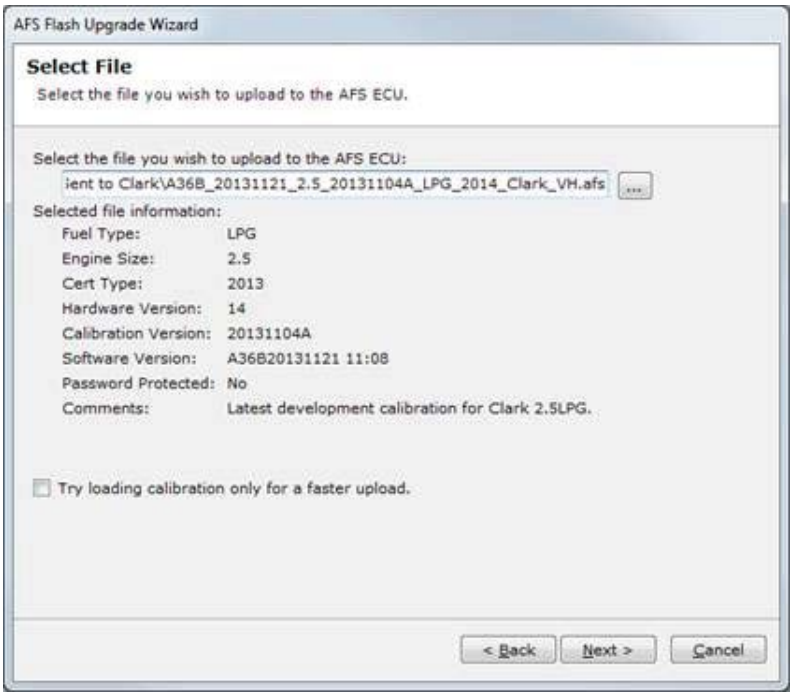
PROCEDURE TO FLASH NEW CODE/CALIBRATION INTO THE ECM

1. Turn the truck ignition key OFF and shut down the Spectrum software on your PC.
2. Connect one end of the orange diagnostic cable to the grey triangular connector on the engine wire harness, located at the back of the engine.
3. Connect the other end of the orange diagnostic cable to the Kvaser or IFak dongle (9 pin connector).
4. Connect the USB end of Kvaser or IFak to the USB port of the PC.
5. Start the Spectrum Monitor software on your PC.

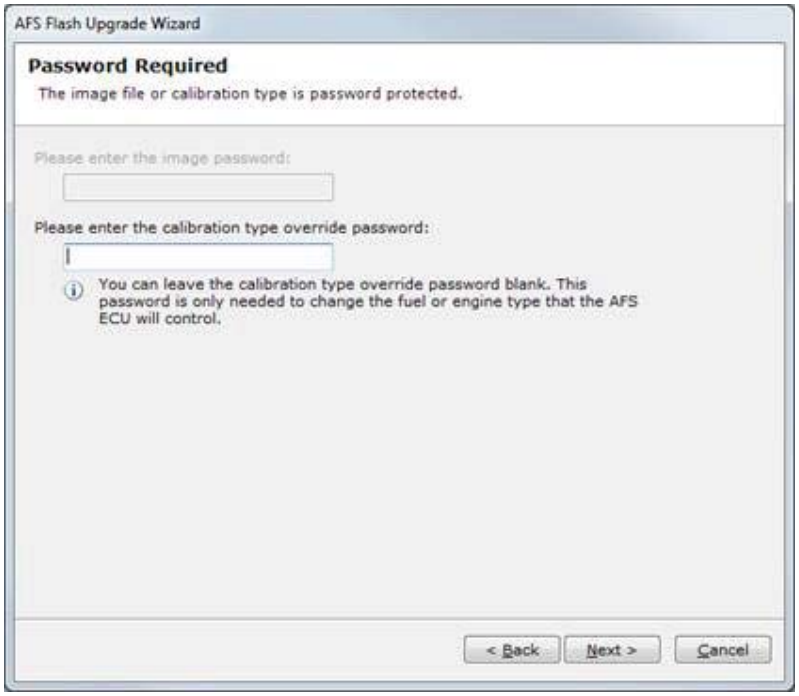


6. Select "Tools" then "Reprogram AFS Engine Control Unit...".
7. On the Welcome page select **Next**.

8. Select the "Browse Button" to the right of the Select File window (small button ...).
9. Find the .afs file you want to Flash and double click on it.
10. Uncheck the "Try loading Calibration only for faster upload." button. Then select **Next**.

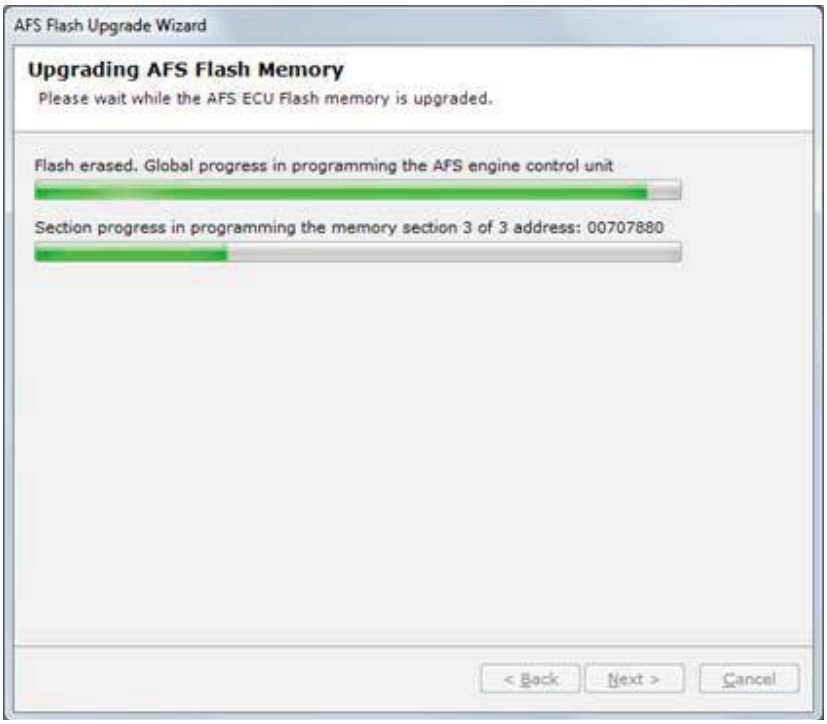


11. You should not need to enter any passwords if the fuel type, engine size, certification level and hardware version of your engine matches those in the new calibration file.
12. Select **Next**.



13. When you get to this screen turn the truck ignition key to ON and wait 5 seconds.

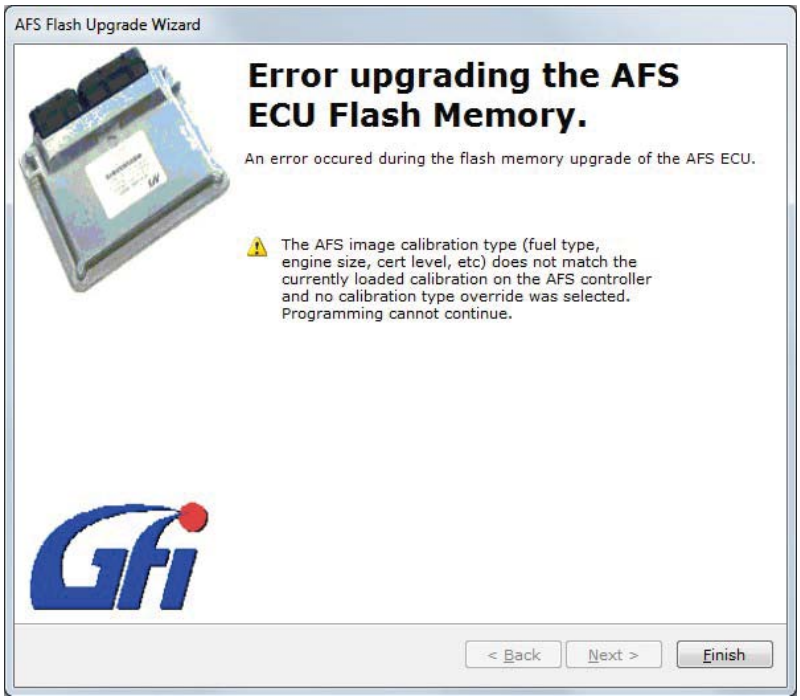
14. Select **Next**.



You should see the green progress bars moving. The flashing may take 3 to 5 minutes
If after a few seconds you do not see the green progress bars but instead see the following error message, you will need to try using the override password if you have one.

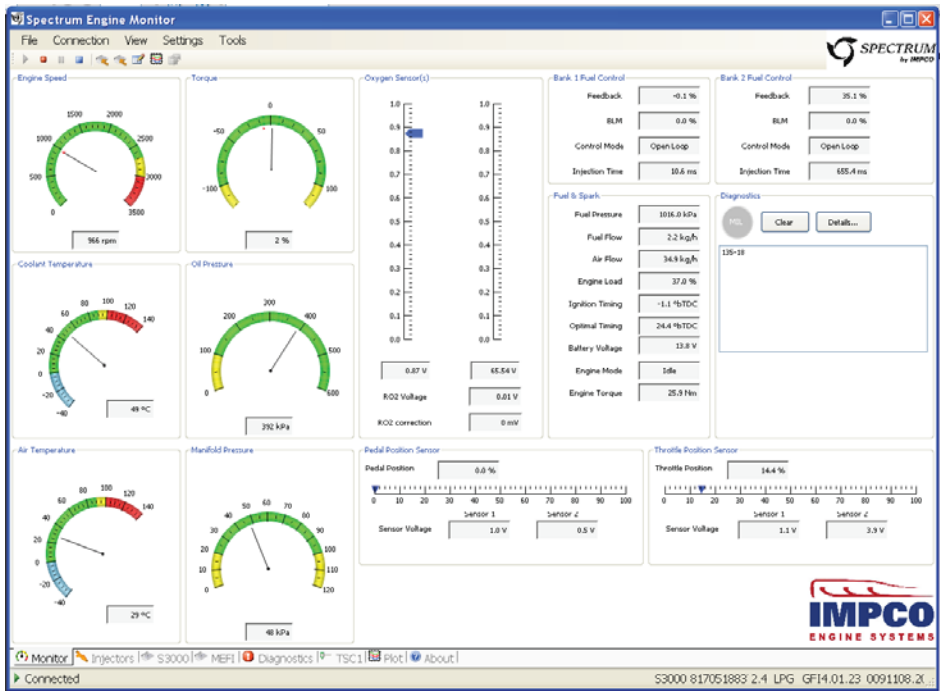
This message indicates the ECM currently in the truck has a different fuel type, engine size, certification level or hardware version then what is in the pending calibration you are trying to load. You will need to select **Finish** on the error message and then repeat steps 6 to 14, at which point you have

the opportunity to enter the override password again. In the override password window enter "overrideit" and then select **Next**.



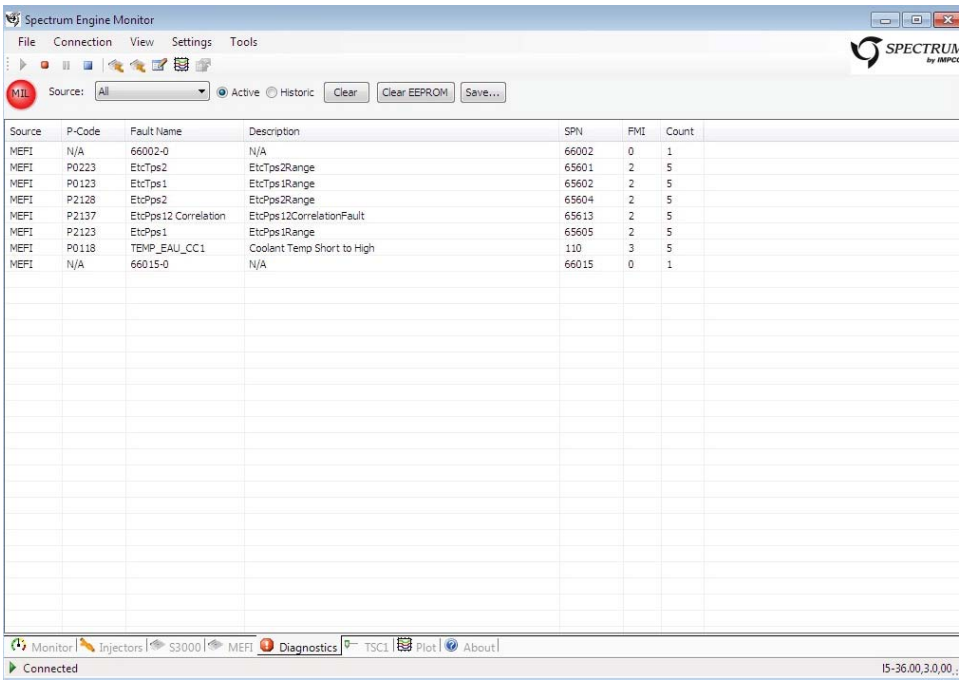
15. When flashing is complete (if you get a warning at the end about code version does not match ignore it as is not important, the engine will still function properly). Close the flash wizard window and try to connect to the ECM with Spectrum Engine Monitor by selecting the green triangle in the upper left corner or by Selecting "Connection" and then "Connect". The Spectrum Engine Monitor should connect and after 5 to 20 seconds, you should see the new Code and Calibration versions in the right side of the Status bar along the bottom of the Spectrum screen.
16. Disconnect Spectrum, Key OFF the truck, wait 30 seconds then key on and start the engine.
17. Turn the ignition ON. Verify the calibration updated with the new file number in the **ECM Part Number** data stream shown above. The reprogramming process is now complete.

Graphic Display Interface



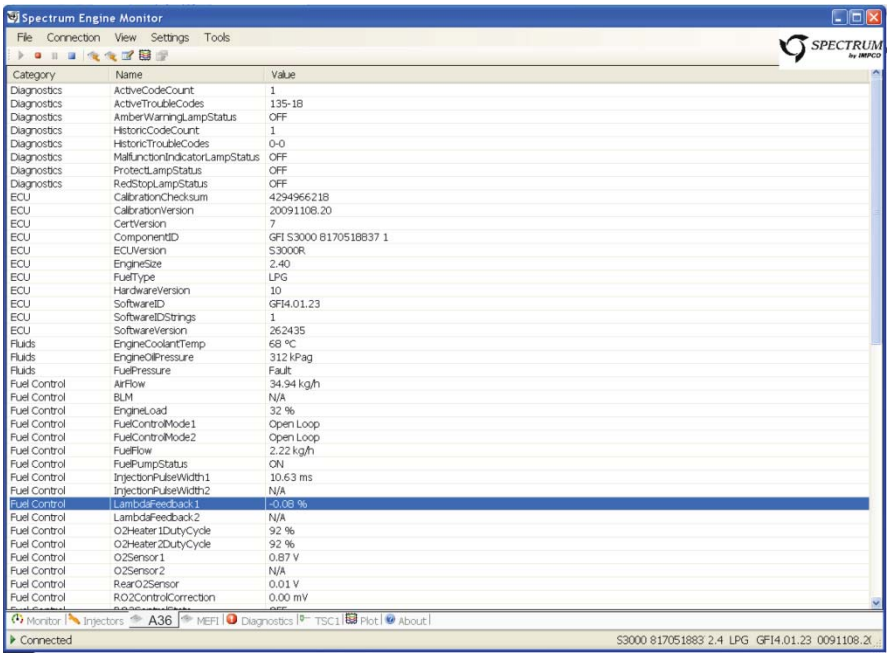
Shown as the monitor page in the Spectrum Engine Monitor, the above page is the default entry page that opens with the Spectrum Engine Monitor program. It provides a graphical interface for important engine parameters. Graphics shown in gray are not available for the specific application the Spectrum Engine Monitor may be connected to as shown above. This function is controlled by the ECM calibration file and cannot be changed by the service technician.

Display DTC (Diagnostic Trouble Codes)



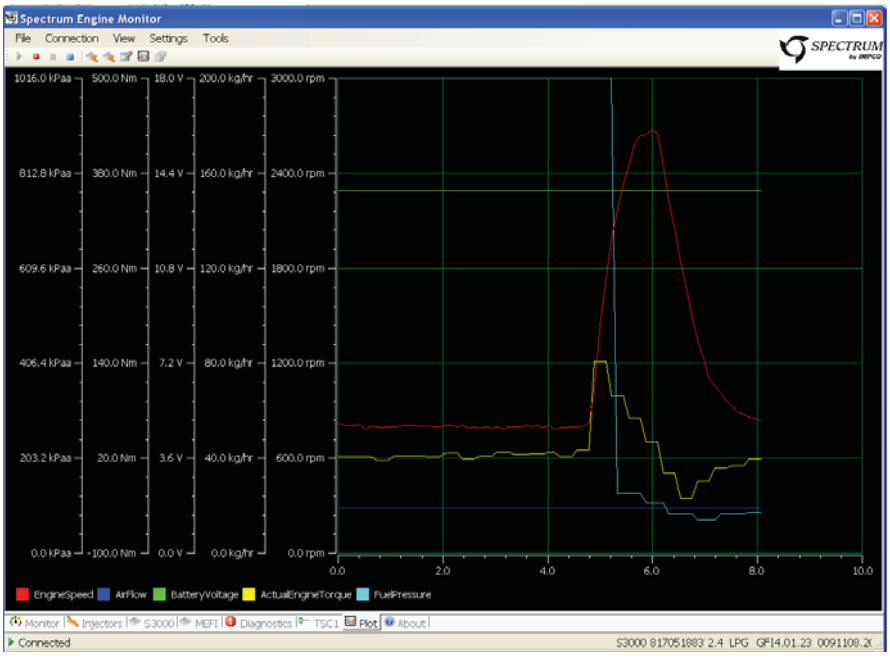
DTC codes can be read by clicking on the **Diagnostics** tab at the bottom of the monitor page. The source of the DTC stream can be set manually, or left in the default **All** position for auto detection of the DTC codes. Codes that can be viewed are set in two categories, active and historic. Active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

Data Stream:

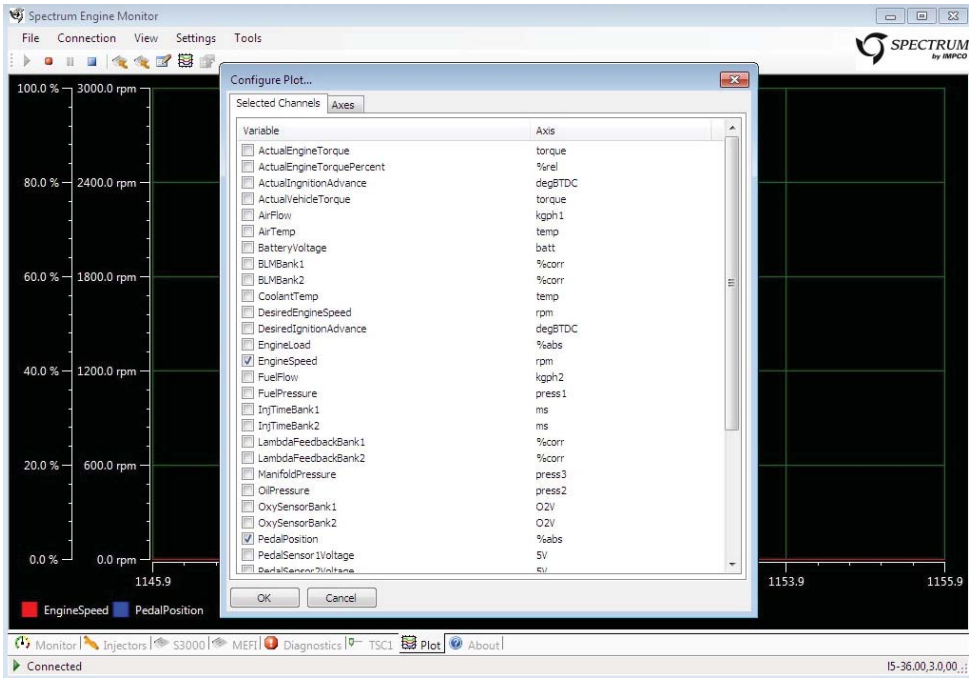


The data stream page can be accessed by selecting the A36 tab shown at the lower left above.

Plot Data:



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



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

Diagnosing Intermittent Problems

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

IMPCO A36 ECM Diagnostic Trouble Codes (DTCs)

The certified fuel system is designed to notify the end user of a problem with engine operation. The ECM constantly monitors engine performance through a variety or sensors and if one or more of the sensors provides a value out of range, a MIL (Malfunction Indicator Light, frequently referred to as a "check engine light") may notify the end user of a problem by illuminating. A technician may connect a Spectrum Engine Monitor(diagnostic scan tool) to determine which DTC(s) (Diagnostic Trouble Code(s) were recorded by the ECM (both active and historic) and by referring to the solution tables on the pages that follow, the problem can be systematically diagnosed and corrected.

Use of the Spectrum Engine Monitor is imperative for proper diagnosis. **Parts should only be serviced or replaced if determined to be faulty. The replacement of parts based on guess work wastes both time and money, neither of which is covered under warranty.**

Mechanical engine problems such as leaks, noise, vibration, etc. may not set a DTC and can be corrected by following testing and diagnostic procedures according to K25 engine information.

SPN-FMI 51-0	**P-Code** P2163
WOT position not found by TPS1 during electronic throttle self-span	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are translated into a relative position value that the ECU requires for throttle position control and airflow estimation. If the TPS1 voltage reading does not correspond to the expected throttle range during this self-span, the code will be set and the MIL is activated.

OBD II Definition: Throttle Position Sensor A Maximum Stop Performance

Necessary conditions for fault:
Primary: Voltage range on TPS1 recorded during throttle span < 3.5V
Secondary: n/a

ECM substitution or action:
MIL is activated
Disable ETC (Limp Home)

Possible causes:
Short to battery or ground in TPS1 circuit
Short to ground in power supply line
Faulty ETB assembly

Troubleshooting:
Troubleshoot active DTCs related to sensor power supply
Troubleshoot active DTCs related to TPS1
Check ETB for blockage and if throttle is able to move freely

SPN-FMI 51-1	**P-Code** P2109
Zero throttle position not found by TPS1 during electronic throttle self-span	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are translated into a relative position value that the ECM requires for throttle position control and airflow estimation. If readings for the throttle rest position on TPS1 do not translate into a position between 5% and 35%, the code will be set and the MIL is activated.

OBD II Definition: Throttle Position Sensor A Minimum Stop Performance

Necessary conditions for fault:
Primary: TPS1 readings for throttle rest position are not between 5% and 35%
Secondary: n/a

ECM substitution or action:
MIL is activated
Disable ETC (Limp Home)

Possible causes:
Short to battery or ground in TPS1 circuit
Short to ground in power supply line
Faulty ETB assembly

Troubleshooting:
Troubleshoot active DTCs related to sensor power supply
Troubleshoot active DTCs related to TPS1
Check ETB for blockage and if throttle is able to move freely

SPN-FMI 51-3	**P-Code** P0123
TPS1 signal circuit voltage high	

This code is referring to the first of two throttle position sensors (TPS1) in the electronic throttle body. The ECM monitors the TPS1 signal voltage. If the voltage exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch A Circuit High

Necessary conditions for fault:
Primary: Voltage on TPS1 signal line > 4.92V (ETB connector TPS1 pin) for > 0.016s
Secondary: No 5V power supply faults present

ECM substitution or action:
MIL is activated
Backup TPS and exit cruise control
Substitute default or modelled value

Possible causes:
TPS1 signal line shorted to Supply +5V power line
TPS1 signal line shorted to battery
Faulty ETB assembly

Troubleshooting:
Check ETB connector for proper connection
Check voltage on TPS1 pin
Check for pinched or bare wires

SPN-FMI 51-4	**P-Code** P0122
TPS1 signal circuit voltage low	

This code is actually referring to the first of two throttle position sensors, (TPS1) in the electronic throttle body. The ECM monitors the TPS1 signal voltage. If the voltage drops below the calibrated threshold for longer than the calibrated time, the code will be set and the MIL activated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch A Circuit Low

Necessary conditions for fault:
Primary: Voltage on TPS1 signal line < 0.1V (ETB connector TPS1 pin) for > 0.016s
Secondary: No 5V power supply faults present

ECM substitution or action:
MIL is activated
Backup TPS and exit cruise control
Substitute default or modelled value

Possible causes:
TPS1 signal line open circuit
TPS1 signal line shorted to ground
ETB connector disconnected
Faulty ETB assembly

Troubleshooting:
Check ETB connector for proper connection
Check voltage on TPS1 pin
Check voltage on Supply +5V pin
Check for pinched or bare wires

SPN-FMI 51-7	**P-Code** P2135
Readings from TPS1 and TPS2 signal lines do not correlate	

The ECM reads the voltages from the TPS1 and TPS2 and normalizes both signals to be positive position values from 0 to 1.0. It then compares the two readings and if they differ by more than a calibrated amount, the code will be set and the MIL is activated. The throttle will be put in “Limp Home” mode. This throttle no power position will allow the engine to continue to run at a minimal speed and load without being actively actuated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch A / B Voltage Correlation

Necessary conditions for fault:
Primary: Error between calculated positions from TPS1 and TPS2 signals > 6% for > 1s.
Secondary: No 5V power supply faults present

ECM substitution or action:
MIL is activated
Backup TPS and exit cruise control
Substitute default or modelled value
Throttle actuation will be disabled (limp home mode)

Possible causes:
Faulty ETB assembly
TPS1 or TPS2 signal partially shorted to high or low voltage

Troubleshooting:
Check continuity of TPS1 and TPS2 lines between ETB and ECM connectors
Check circuits for shorts to ground or battery
Check voltage on Supply +5V pin
Check pins are seated and locked in connector

SPN-FMI 91-3	**P-Code** P2123
APP1 sensor signal circuit voltage high	

The ECM monitors the APP1 sensor signal voltage. If the voltage exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch D Circuit High Input

Necessary conditions for fault:
Primary: Voltage on APP1 sensor signal line > 4.82V (VIC Pedal connector APP1 pin) for >0.25s.
Secondary: No 5V power supply faults present

ECM substitution or action:
MIL is activated
Backup APP Unless both APP1 & APP2 have failed in which case the throttle goes into Limp Home mode and will not respond to the pedal and will remain fixed.

Possible causes:
APP1 sensor signal line shorted to APP1 5V supply line
APP1 sensor signal line shorted to battery
Faulty APP assembly

Troubleshooting:
Check VIC Pedal connector for proper connection
Check voltage on APP1 pin

Check for pinched or bare wires

SPN-FMI 91-4	**P-Code** P2122
APP1 sensor signal circuit voltage low	

The ECM monitors the APP1 sensor signal voltage. If the voltage drops below the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch D Circuit Low Input

Necessary conditions for fault:
Primary: Voltage on APP1 sensor signal line < 0.08V (VIC Pedal connector APP1 pin) for > 0.25s
Secondary: No 5V power supply faults present

ECM substitution or action:
MIL is activated
Backup APP Unless both APP1 & APP2 have failed in which case the throttle goes into Limp Home mode and will not respond to the pedal and will remain fixed.

Possible causes:
APP1 sensor signal line open circuit
APP1 sensor signal line shorted to ground
VIC Pedal connector disconnected
Faulty APP assembly

Troubleshooting:
Check VIC Pedal connector for proper connection
Check voltage on APP1 pin
Check voltage on APP1 5V pin
Check for pinched or bare wires

SPN-FMI 91-7	**P-Code** P2138
Readings from APP1 and APP2 sensors do not correlate	

The ECM reads the voltages from the APP1 and APP2 sensors and normalizes both signals to be positive position values from 0 to 1.0. It then compares the two readings and if they differ by more than a calibrated amount, the code will be set and the MIL is activated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch D / E Voltage Correlation

Necessary conditions for fault:
At low pedal position:
Primary: Error between calculated positions from APP1 and APP2 signals > 9% for > 1s
Secondary: No 5V power supply faults present ***At full pedal position:***
Primary: Error between calculated positions from APP1 and APP2 signals > 25% for > 1s
Secondary: No 5V power supply faults present

ECM substitution or action:
MIL is activated
Throttle goes into Limp Home mode and will not respond to the pedal and will remain fixed.

Possible causes:
Faulty accelerator pedal assembly
APP1 or APP2 sensor signal partially shorted to high or low voltage

Troubleshooting:

Check continuity of APP1 and APP2 lines between pedal and ECM connectors
Check circuits for shorts to ground or battery
Check voltage on Supply +5V pins
Check pins are seated and locked in connector

SPN-FMI 100-18	**P-Code** P0524
Engine oil pressure is too low for safe engine operation	

The ECM monitors engine oil pressure to protect the engine from possible damage. If the oil pressure drops below a calibrated threshold for longer than a calibrated time, this code will set and the MIL is activated.

OBD II Definition: Engine Oil Pressure Too Low

Necessary conditions for fault:
Primary: Oil pressure < oil switch threshold for > engine speed dependent time
Secondary: No 5V power supply faults present

ECM substitution or action:

MIL is activated
Engine de-rate to idle if enabled
Emergency engine shut down if enabled

Possible causes:

Engine low on oil
Oil not circulating properly

Troubleshooting:

Check engine oil level
Check for oil leaks

SPN-FMI 105-3	**P-Code** P0113
IAT sensor signal circuit voltage high	

The ECM monitors IAT signal voltage. The engine airflow estimation and ignition timing is dependent on intake air temperature. If voltage on the IAT sensor signal line exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The IAT measurement will be replaced by a modelled value.

OBD II Definition: Intake Air Temperature Circuit High Input

Necessary conditions for fault:
Primary: Voltage on IAT signal line > 4.87V (MAPMAT connector IAT pin) for > 1s
Secondary: n/a

ECM substitution or action:

MIL is activated

Possible causes:

IAT signal line shorted to +5V power line
IAT signal wire may be open circuit
MAPMAT connector disconnected
IAT signal line shorted to battery
Faulty MAPMAT assembly

Troubleshooting:

Check MAPMAT connector for proper connection
Check for open circuit in IAT signal circuit
Check voltage on IAT pin
Check sensor resistance and verify against specification
Check for pinched or bare wires

SPN-FMI 105-4	**P-Code** P0112
IAT sensor signal circuit voltage low	

The ECM monitors IAT signal voltage. The engine airflow estimation and ignition timing is dependent on intake air temperature. If voltage on the IAT sensor signal line drops below the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The IAT measurement will be replaced by a modelled value.

OBD II Definition: Intake Air Temperature Circuit Low Input

Necessary conditions for fault:

Primary: Voltage on IAT signal line < 0.1V (MAPMAT connector IAT pin) for > 1s
Secondary: n/a

ECM substitution or action:

MIL is activated

Possible causes:

IAT signal line shorted to ground
Faulty MATMAP assembly

Troubleshooting:

Check MATMAP connector for proper connection
Check voltage on IAT pin
Check sensor resistance and verify against specification
Check for pinched or bare wires

SPN-FMI 110-0	**P-Code** P0217
Engine cooling system overheat	

The ECM monitors CHT signal voltage and translates it into a temperature value. The coolant temperature is monitored to determine engine overheat for protection purposes. If the coolant temperature exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the Engine Coolant Warning Lamp is activated. Engine may depending on calibration first de-rate and eventually shut down based on calibrated temperature thresholds. If Coolant temperature drops below a calibrated value Coolant Lamp will be shut off and any de-rate will be shut off. No MIL will be activated.

OBD II Definition: Engine Coolant Over Temperature Condition

Necessary conditions for fault:

Primary: Temperature recorded with CHT sensor > 117°C for > 10s
Secondary: Minimum engine run-time > 30s

ECM substitute or action:

Engine de-rate and de-rate to idle based on calibrated temperature thresholds if enabled
Emergency engine shut down based on calibrated temperature threshold if enabled

Possible causes:

Faulty component in coolant system (water pump, radiator, fan, hoses etc.)
Air in coolant system

Troubleshooting:

Check coolant level
Check if thermostat is functioning properly
Check if thermostat temperature rating is correct
Check if water pump is functioning properly
Check for blockage in radiator or coolant lines
Check if coolant fan is functioning properly

SPN-FMI 110-3	**P-Code** P0118
ECT sensor signal circuit voltage high	

The ECM monitors CHT signal voltage. If the voltage on the CHT sensor signal line exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The CHT measurement will be replaced by a modelled value.

OBD II Definition: Engine Coolant Temperature Circuit High Input

Necessary conditions for fault:

Primary: Voltage on CHT signal line > 4.92V (CHT connector CHT Sig pin) for > 1s
Secondary: n/a

ECM substitution or action:

MIL is activated
Substitute default or modelled value
Long-term fuel trims are disabled
Trip logic will not utilize engine coolant temperature in its calculations

Possible causes:

CHT signal line shorted to battery
CHT line open circuit
CHT sensor disconnected
Faulty CHT sensor

Troubleshooting:

Check CHT connector for proper connection
Check voltage on CHT Sig pin
Check sensor resistance and verify against specification
Check for pinched or bare wires

SPN-FMI 110-4	**P-Code** P0117
ECT sensor signal circuit voltage low	

The ECM monitors CHT signal voltage. If voltage on the CHT sensor signal line drops below the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The CHT measurement will be replaced by a modelled value.

OBD II Definition: Engine Coolant Temperature Circuit Low Input

Necessary conditions for fault:

Primary: Voltage on CHT signal line < 0.15V (CHT connector CHT Sig pin) for > 1s
Secondary: n/a

ECM substitution or action:

MIL is activated
Substitute default or modelled value
Long-term fuel trims are disabled
Trip logic will not utilize engine coolant temperature in its calculations

Possible causes:

CHT sensor signal line short to ground
Faulty CHT sensor

Troubleshooting:

Check CHT connector for proper connection
Check voltage on CHT Sig pin
Check sensor resistance and verify against specification
Check for pinched or bare wires

SPN-FMI 159-3	**P-Code** P0193
Fuel pressure sensor signal circuit voltage high	

The ECM monitors FAP signal voltage and determines fuel injector pulse width based on the FAP reading. If voltage exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The FAP will be estimated using a modelled value.

OBD II Definition: Fuel Rail Pressure Sensor Circuit High

Necessary conditions for fault:

Primary: Voltage on FAP signal line > 4.92V (FAPFRT connector FAP Sig pin) for > 1s
Secondary: No 5V power supply faults present

ECM substitution or action:

MIL is activated
Substitute default or modelled value

Possible causes:

FAP signal line shorted to +5V power line
FAP signal line shorted to battery
Faulty FAPFRT assembly

Troubleshooting:

Check FAPFRT connector for proper connection
Check voltage on FAP Sig pin
Check for pinched or bare wires

SPN-FMI 159-4	**P-Code** P0192
Fuel pressure sensor signal circuit voltage low	

The ECM monitors FAP signal voltage and determines fuel injector pulse width based on the FAP reading. If voltage drops below the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The FAP will be estimated using a modelled value.

OBD II Definition: Fuel Rail Pressure Sensor Circuit Low

Necessary conditions for fault:

Primary: Voltage on FAP signal line < 0.15V (FAPFRT connector FAP Sig pin) for > 1s
Secondary: No 5V power supply faults present

ECM substitution or action:
MIL is activated
Substitute default or modelled value
Possible causes:
FAP signal line open circuit
FAP signal line shorted to ground
FAPFRT connector disconnected
Faulty FAPFRT assembly
Troubleshooting:
Check FAPFRT connector for proper connection
Check voltage on FAP Sig pin
Check voltage on +5V pin
Check for pinched or bare wires

SPN-FMI 159-16	**P-Code** P0088
Fuel rail pressure measures too high during engine running condition	

The ECM monitors FAP signal voltage and translates it into a pressure value. The fuel injector pulse width is determined based on the FAP reading. The calibration variable for this DTC is based on the ratio of FAP over a certain reference pressure. If this ratio exceeds a calibrated threshold for longer than the calibrated time, the code will be set.

OBD II Definition: Fuel Rail/System Pressure Too High

Necessary conditions for fault:
Primary: Pressure ratio of (FAP over MAP+88kPa) > 1.4 for > 5s
Secondary: n/a

ECM substitution or action:
MIL is activated
Possible causes:
Vaporizer Pressure too high
Vaporizer MAP Reference Line Disconnected or leaking
Fuel Pressure Sensor Faulty
Faulty component in fuel system
Troubleshooting:
Check pressure regulator for proper operation
Check vaporizer reference line

SPN-FMI 167-3	**P-Code** P0563
High voltage detected in charging system or battery	

The ECM monitors the voltage in the charging system and battery to detect unwanted fluctuations and deviations from the nominal value. The ignition dwell control, fuel injection control, ECM power-up and power-down sequencing, and voltage diagnostics are dependent on a stable system voltage. If the voltage in the charging system or battery exceeds a calibrated threshold for longer than a calibrated time, the code will set and the MIL is activated.

OBD II Definition: System Voltage High

Necessary conditions for fault:
Primary: System voltage > 16V for > 10s
Secondary: n/a

ECM substitution or action:
MIL is activated
Possible causes: Faulty alternator
Alternator Sense Line not connected
Troubleshooting:
Check alternator output at raised engine speed of 1200rpm
Check all grounds (harness, engine and chassis)
Check battery for corrosion damage and water level

SPN-FMI 167-4	**P-Code** P0562
Low voltage detected in charging system or battery	

The ECM monitors the voltage in the charging system and battery to detect unwanted fluctuations and deviations from the nominal value. The ignition dwell control, fuel injection control, ECM power-up and power-down sequencing, and voltage diagnostics are dependent on a stable system voltage. If the voltage in the charging system or battery drops below a calibrated threshold for longer than a calibrated time, the code will set and the MIL is activated.

OBD II Definition: System Voltage Low

Necessary conditions for fault:
Primary: System voltage < 9.5V for > 30s
Secondary: Engine running and engine speed > 500rpm

ECM substitution or action:
MIL is activated
Possible causes:
Faulty alternator
Faulty battery
Troubleshooting:
Check alternator output at raised engine speed of 1200rpm
Check all grounds (harness, engine and chassis)
Check battery for corrosion damage and water level

SPN-FMI 174-3	**P-Code** P0183
Fuel temperature sensor signal circuit voltage high	

The ECM monitors FRT signal voltage. If voltage on the FRT sensor signal line exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The FRT measurement will be replaced by a modelled value.

OBD II Definition: Fuel Temperature Sensor A Circuit High

Necessary conditions for fault:
Primary: Voltage on FRT signal line > 4.95V (FAPFRT connector FRT pin) for > 1s
Secondary: n/a

ECM substitution or action:
MIL is activated
Substitutes default or modelled value
15deg lower temperature
Possible causes:

FAPFRT connector disconnected
FRT sensor signal line open circuit
FRT signal line shorted to +5V power line
FRT signal line shorted to battery
Faulty FAPFRT assembly

Troubleshooting:

Check FAPFRT connector for proper connection
Check voltage on FRT signal pin
Check sensor resistance and verify against specification
Check for pinched or bare wires

SPN-FMI 174-4	**P-Code** P0182
Fuel temperature sensor signal circuit voltage low	

The ECM monitors FRT signal voltage. If voltage on the FRT sensor signal line drops below the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The FRT measurement will be replaced by a modelled value.

OBD II Definition: Fuel Temperature Sensor A Circuit Low

Necessary conditions for fault:

Primary: Voltage on FRT signal line < 0.15V (FAPFRT connector FRT pin) for > 1s
Secondary: n/a

ECM substitution or action:

MIL is activated
Substitute default or modelled value

Possible causes: FRT signal line shorted to ground
Faulty FAPFRT assembly

Troubleshooting: Check FAPFRT connector for proper connection
Check voltage on FRT pin
Check sensor resistance and verify against specification
Check for pinched or bare wires

SPN-FMI 628-31	**P-Code** P0605
Corrupted ECM Read Only Memory	

The ECM firmware is stored in flash memory. On power up a checksum is performed on the flash memory array. If the checksum is incorrect, the ECM will not run and this DTC will be reported.

OBD II Definition: Internal Control Module Read Only Memory (ROM) Error

Necessary conditions for fault:

Primary: Internal memory error in ECM

ECM substitution or action:

MIL is activated
Engine will not start

Possible causes: Electrical damage to ECM

Troubleshooting:

SPN-FMI 636-31	**P-Code** P0335

CKP sensor not reading reliably

The ECM monitors engine position based on the CKP sensor measurement. The crankshaft position is crucial for engine timing and camshaft synchronization. If the ECM records more than a calibrated number of camshaft transitions without crankshaft activity, this code will set and the MIL is activated. Please note, that the engine will not run without a signal from the crankshaft position sensor.

OBD II Definition: Crankshaft Position Sensor A Circuit

Necessary conditions for fault:
Primary: Camshaft transitions > 100 without a CKP sensor signal OR Synchronization fault count > 20 within 300s
Secondary: n/a

ECM substitution or action:
MIL is activated
Possible causes:
CKP sensor disconnected
Wrong polarity on CKP sensor
Faulty CKP sensor
Increased CKP sensor gap
Troubleshooting:
Check if cam sensor connector for proper connection
Check for pinched or bare wires
Check CKP sensor gap

SPN-FMI 637-14 **P-Code** P0340

Cam sensor not reading reliably

The ECM monitors the camshaft rotation to synchronize the ignition and injection to the crankshaft/engine position. If the
ECM records more than a calibrated number of crankshaft revolutions without camshaft sensor activity, this code will set and the
ECM will use random engine synchronization based only on the crankshaft sensor signal. Engine does not stall.

OBD II Definition: Camshaft Position Sensor A Circuit

Necessary conditions for fault:
Primary: Crankshaft revolutions without camshaft sensor activity > 10
Secondary: No sensor power supply faults present

ECM substitution or action:
MIL is activated
Random engine synchronization using only the CKP sensor signal
Possible causes:
CAM sensor disconnected
No power supplied to sensor
Faulty CAM sensor
Troubleshooting:
Check for sensor power supply fault
Check if cam sensor connector for proper connection
Check for pinched or bare wires

SPN-FMI 650-3	**P-Code** P0659
Actuator power supply voltage high	

The ECM monitors the actuator power voltage used to actuate the injectors and LPG solenoid lock-off. If the voltage exceeds the threshold for longer than 2s, the code will be set and the MIL is activated.

OBD II Definition: Actuator Supply Voltage A Circuit High

Necessary conditions for fault:
Actuator power relay commanded OFF:
Primary: Actuator power signal voltage > (key power voltage – 2V) for > 2s
Secondary: Actuator power relay commanded OFF
Actuator power relay commanded ON:
Primary: Actuator power signal voltage > (key power voltage + 2V) for > 2s
Secondary: Actuator power relay commanded ON

ECM substitution or action:
MIL is activated
Possible causes:
High system voltage
Faulty actuation power relay
Wiring problem in harness
Troubleshooting:
Check actuator power relay for proper functioning
Check VIC Power connector (P22) for proper connection
Check for pinched or bare wires

SPN-FMI 650-4	**P-Code** P0658
Actuator power supply voltage low	

The ECM monitors the actuator power voltage for fuel injector pulse width correction and voltage diagnostics. If the voltage drops below the threshold for longer than 2s, the code will set and the MIL is activated.

OBD II Definition: Actuator Supply Voltage A Circuit Low

Necessary conditions for fault:
Actuator power relay commanded ON:
Primary: Actuator power voltage < (key power voltage - 1.5 volts) for > 2s
Secondary: Actuator power relay commanded ON

ECM substitution or action:
MIL is activated
Possible causes:
Faulty actuation power relay
Wiring problem in harness
Troubleshooting:
Check for blown fuse
Troubleshoot SPN-FMI 167-4 if active
Check actuator power relay for proper functioning

Check VIC Power connector (P22) for proper connection
Check for pinched or bare wires

SPN-FMI 651-3	**P-Code** P0262
Cylinder 1 fuel injector circuit voltage high	

The ECM monitors the performance of the fuel injectors to detect a faulty injector or a problem in the wiring between the injector and the
ECM. If the voltage in the injector 1 circuit exceeds the threshold for longer than 1s, this code will set and the MIL is activated.

OBD II Definition: Cylinder 1 Injector Circuit High

Necessary conditions for fault:
Primary: Injector 1 control signal voltage > IC threshold for > 1s
Secondary: Engine must be running
No actuator power supply faults
Actuator power relay actuated

ECM substitution or action:
MIL is activated
Fueling goes Open loop and Long Term Fuel Trim is disabled
Possible causes:
Injector 1 control signal line shorted to actuator power line
Faulty fuel injector 1
Troubleshooting:
Check resistance across the fuel injector 1 for short circuit
Check wiring between injector 1 and ECM connector
Check for pinched or bare wires

SPN-FMI 651-4	**P-Code** P0261
Cylinder 1 fuel injector circuit voltage low	

The ECM monitors the performance of the fuel injectors to detect a faulty injector or a problem in the wiring between the injector and the
ECM. If the voltage in the injector 1 circuit drops below the threshold for longer than 1s, this code will set and the MIL is activated.

OBD II Definition: Cylinder 1 Injector Circuit Low

Necessary conditions for fault:
Primary: Injector 1 control signal voltage < IC threshold for > 1s
Secondary: Engine must be running
No actuator power supply faults
Actuator power relay actuated

ECM substitution or action:
MIL is activated
Fueling goes Open loop and Long Term Fuel Trim is disabled
Possible causes:
Injector 1 connector disconnected
Faulty fuel injector 1
Troubleshooting:

Check injector 1 connector for proper connection
Check if actuator power is available at this injector 1
Check resistance across the fuel injector 1 for short circuit
Check wiring between injector 1 and ECM connector
Check for pinched or bare wires

SPN-FMI 652-3	**P-Code** P0265
Cylinder 2 fuel injector circuit voltage high	

The ECM monitors the performance of the fuel injectors to detect a faulty injector or a problem in the wiring between the injector and the ECM. If the voltage in the injector 2 circuit exceeds the threshold for longer than 1s, this code will set and the MIL is activated.

OBD II Definition: Cylinder 2 Injector Circuit High

Necessary conditions for fault:
Primary: Injector 2 control signal voltage > IC threshold for > 1s
Secondary: Engine must be running
No actuator power supply faults
Actuator power relay actuated

ECM substitution or action:
MIL is activated
Fueling goes Open loop and Long Term Fuel Trim is disabled
Possible causes:
Injector 2 control signal line shorted to actuator power line
Faulty fuel injector 2
Troubleshooting:
Check resistance across the fuel injector 2 for short circuit
Check wiring between injector 2 and ECM connector
Check for pinched or bare wires

SPN-FMI 652-4	**P-Code** P0264
Cylinder 2 fuel injector circuit voltage low	

The ECM monitors the performance of the fuel injectors to detect a faulty injector or a problem in the wiring between the injector and the ECM. If the voltage in the injector 1 circuit drops below the threshold for longer than 1s, this code will set and the MIL is activated.

OBD II Definition: Cylinder 2 Injector Circuit Low

Necessary conditions for fault:
Primary: Injector 2 control signal voltage < IC threshold for > 1s
Secondary: Engine must be running
No actuator power supply faults
Actuator power relay actuated

ECM substitution or action:
MIL is activated
Fueling goes Open loop and Long Term Fuel Trim is disabled
Possible causes:
Injector 2 connector disconnected
Faulty fuel injector 2

Troubleshooting:

Check injector 2 connector for proper connection
Check if actuator power is available at this injector 2
Check resistance across the fuel injector 2 for short circuit
Check wiring between injector 2 and ECM connector
Check for pinched or bare wires

SPN-FMI 653-3	**P-Code** P0268
Cylinder 3 fuel injector circuit voltage high	

The ECM monitors the performance of the fuel injectors to detect a faulty injector or a problem in the wiring between the injector and the ECM. If the voltage in the injector 3 circuit exceeds the threshold for longer than 1s, this code will set and the MIL is activated.

OBD II Definition: Cylinder 3 Injector Circuit High

Necessary conditions for fault:

Primary: Injector 3 control signal voltage > IC threshold for > 1s
Secondary: Engine is running
No actuator power supply faults
Actuator power relay actuated

ECM substitution or action:

MIL is activated
Fueling goes Open loop and Long Term Fuel Trim is disabled

Possible causes:

Injector 3 control signal line shorted to actuator power line
Faulty fuel injector 3

Troubleshooting:

Check resistance across the fuel injector 3 for short circuit
Check wiring between injector 3 and ECM connector
Check for pinched or bare wires

SPN-FMI 653-4	**P-Code** P0267
Cylinder 3 fuel injector circuit voltage low	

The ECM monitors the performance of the fuel injectors to detect a faulty injector or a problem in the wiring between the injector and the ECM. If the voltage in the injector 1 circuit drops below the threshold for longer than 1s, this code will set and the MIL is activated.
OBD II Definition: Cylinder 1 Injector Circuit Low

Necessary conditions for fault:

Primary: Injector 3 control signal voltage < IC threshold for > 1s
Secondary: Engine is running
No actuator power supply faults
Actuator power relay actuated

ECM substitution or action:

MIL is activated
Fueling goes Open loop and Long Term Fuel Trim is disabled

Possible causes:

Injector 3 connector disconnected
Faulty fuel injector 3

Troubleshooting:

Check injector 3 connector for proper connection
Check if actuator power is available at this injector 3
Check resistance across the fuel injector 3 for short circuit
Check wiring between injector 3 and ECM connector
Check for pinched or bare wires

SPN-FMI 654-3	**P-Code** P0271
Cylinder 4 fuel injector circuit voltage high	

The ECM monitors the performance of the fuel injectors to detect a faulty injector or a problem in the wiring between the injector and the ECM. If the voltage in the injector 4 circuit exceeds the threshold for longer than 1s, this code will set and the MIL is activated.

OBD II Definition: Cylinder 4 Injector Circuit High

Necessary conditions for fault:

Primary: Injector 4 control signal voltage > IC threshold for > 1s
Secondary: Engine is running
No actuator power supply faults
Actuator power relay actuated

ECM substitution or action:

MIL is activated
Fueling goes Open loop and Long Term Fuel Trim is disabled

Possible causes:

Injector 4 control signal line shorted to actuator power line
Faulty fuel injector 4

Troubleshooting:

Check resistance across the fuel injector 4 for short circuit
Check wiring between injector 4 and ECM connector
Check for pinched or bare wires

SPN-FMI 654-4	**P-Code** P0270
Cylinder 4 fuel injector circuit voltage low	

The ECM monitors the performance of the fuel injectors to detect a faulty injector or a problem in the wiring between the injector and the ECM. If the voltage in the injector 1 circuit drops below the threshold for longer than 1s, this code will set and the MIL is activated.

OBD II Definition: Cylinder 4 Injector Circuit Low

Necessary conditions for fault:

Primary: Injector 4 control signal voltage < IC threshold for > 1s
Secondary: Engine is running
No actuator power supply faults
Actuator power relay actuated

ECM substitution or action:

MIL is activated
Fueling goes Open loop and Long Term Fuel Trim is disabled

Possible causes:

Injector 4 connector disconnected
Faulty fuel injector 4

Troubleshooting:

Check injector 4 connector for proper connection
Check if actuator power is available at this injector 4
Check resistance across the fuel injector 4 for short circuit
Check wiring between injector 4 and ECM connector
Check for pinched or bare wires

SPN-FMI 1213-31	**P-Code** P0650
Problem with the MIL circuit	

The ECM monitors the performance of the MIL to detect a problem in the wiring in the lamp circuit. If the voltage in the circuit drops below the threshold for more than 2s, the code will set.

OBD II Definition: Malfunction Indicator Lamp (MIL) Control Circuit

Necessary conditions for fault:
Primary: MIL circuit voltage > IC threshold for > 2s
Secondary: Key power voltage > 6V

ECM substitution or action:

MIL is activated

Possible causes:

MIL bulb burnt out
MIL control signal short to ground
MIL control signal open circuit

Troubleshooting:

Check if the rest of the instrument cluster is operational
Check wiring connection to lamp
Check for continuity between lamp and ECM
Check if lamp control signal line is shorted to ground

SPN-FMI 1268-5	**P-Code** P2300
Ignition coil 1 current below threshold during dwell-on time	

The ECM monitors the ignition currents to detect a faulty ignition coil or a problem in the wiring between the coils and the ECM. If the ignition current on coil 1 is below the threshold after dwell time for more than 20 times, the code will set and the MIL is activated.
OBD II Definition: Ignition Coil A Primary Control Circuit Low

Necessary conditions for fault:
Primary: Ignition current on ignition coil 1 < 2A for > 20 times
Secondary: No actuator power supply faults active
Actuator power relay actuated

ECM substitution or action:

MIL is activated

Possible causes:

Coil 1 connector disconnected
Short to ground or open circuit in ignition coil 1 control signal
Faulty ignition coil 1

Troubleshooting:

Verify that ignition power is available at the ignition coil 1
Check the ignition coil 1 primary resistance to verify that coil 1 is not damaged

Check connector at ignition coil 1
Check wiring between ignition coil 1 and ECM connector

SPN-FMI 1268-6	**P-Code** P2301
Ignition coil 1 current above threshold during dwell-on time	

The ECM monitors the ignition currents to detect a faulty ignition coil or a problem in the wiring between the coils and the ECM. If the ignition current in coil 1 reaches the threshold prior to the end of the calibrated dwell time for more than 20 times, the code will be set and the MIL is activated.

OBD II Definition: Ignition Coil A Primary Control Circuit High

Necessary conditions for fault:
Primary: Ignition coil 1 reached current of 9.5A prior to calibrated dwell-time end > 20 times
Secondary: No actuator power supply faults active
Actuator power relay actuated

ECM substitution or action:
MIL is activated
Possible causes:
Coil 1 control signal short to power
Faulty ignition coil 1
Troubleshooting:
Check electrical connection to ignition coil 1
Check key power voltage (if lower than voltage on coil 1, code will be set)
Check wiring between
ECM and ignition coil 1
If only one ignition coil 1 exhibits this fault, replace that ignition coil

SPN-FMI 1269-5	**P-Code** P2303
Ignition coil 2 current below threshold during dwell-on time	

The ECM monitors the ignition currents to detect a faulty ignition coil or a problem in the wiring between the coils and the ECM. If the ignition current on coil 2 is below the threshold after dwell time for more than 20 times, the code will set and the MIL is activated.

OBD II Definition: Ignition Coil B Primary Control Circuit Low

Necessary conditions for fault:
Primary: Ignition current on ignition coil 2 < 2A for > 20 times
Secondary: No actuator power supply faults active
Actuator power relay actuated

ECM substitution or action:
MIL is activated
Possible causes: Coil 2 connector disconnected
Short in ignition coil 2 control signal
Faulty ignition coil 2
Troubleshooting: Verify that ignition power is available at the ignition coil 2
Check the ignition coil 2 primary resistance to verify that coil 2 is not damaged
Check connector at ignition coil 2
Check wiring between ignition coil 1 and ECM connector

SPN-FMI 1269-6	**P-Code** P2304
Ignition coil 2 current above threshold during dwell-on time	

The ECM monitors the ignition currents to detect a faulty ignition coil or a problem in the wiring between the coils and the ECM. If the ignition current in coil 2 reaches the threshold prior to the end of the calibrated dwell time for more than 20 times, the code will be set and the MIL is activated.

OBD II Definition: Ignition Coil B Primary Control Circuit High

Necessary conditions for fault:
Primary: Ignition coil 2 reached current of 9.5A prior to calibrated dwell-time end > 20 time
Secondary: No actuator power supply faults active
Actuator power relay actuated

ECM substitution or action:
MIL is activated
The dwell time for ignition coil 2 is reduced
Possible causes: Coil 2 control signal short to power
Faulty ignition coil 2
Troubleshooting: Check electrical connection to ignition coil 2
Check key power voltage (if lower than voltage on coil 2, code will be set)
Check wiring between ECM and ignition coil 2
If only one ignition coil 2 exhibits this fault, replace this ignition coil

SPN-FMI 1270-5	**P-Code** P2306
Ignition coil 3current below threshold during dwell-on time	

The ECM monitors the ignition currents to detect a faulty ignition coil or a problem in the wiring between the coils and the ECM. If the ignition current on coil 3 is below the threshold after dwell time for more than 20 times, the code will set and the MIL is activated.

OBD II Definition: Ignition Coil C Primary Control Circuit Low

Necessary conditions for fault:
Primary: Ignition current on ignition coil 3 < 2A for > 20 times
Secondary: No actuator power supply faults active
Actuator power relay actuated

ECM substitution or action:
MIL is activated
Possible causes: Coil 3 connector disconnected
Short in ignition coil 3 control signal
Faulty ignition coil 3
Troubleshooting: Verify that ignition power is available at the ignition coil 3
Check the ignition coil 3 primary resistance to verify that coil 3 is not damaged
Check connector at ignition coil 3
Check wiring between ignition coil 3 and ECM connector

SPN-FMI 1270-6	**P-Code** P2307
Ignition coil 3 current above threshold during dwell-on time	

The ECM monitors the ignition currents to detect a faulty ignition coil or a problem in the wiring be-

tween the coils and the ECM. If the ignition current in coil 3 reaches the threshold prior to the end of the calibrated dwell time for more than 20 times, the code will be set and the MIL is activated.

OBD II Definition: Ignition Coil C Primary Control Circuit High

Necessary conditions for fault:
Primary: Ignition coil 3 reached current of 9.5A prior to calibrated dwell-time end > 20 time
Secondary: No actuator power supply faults active
Actuator power relay actuated

ECM substitution or action:
MIL is activated
The dwell time for ignition coil 3 is reduced

Possible causes:
Coil 3 control signal short to power
Faulty ignition coil 3

Troubleshooting:
Check electrical connection to ignition coil 3
Check key power voltage (if lower than voltage on coil 3, code will be set)
Check wiring between ECM and ignition coil 3
If only one ignition coil 3 exhibits this fault, replace this ignition coil

SPN-FMI 1271-5	**P-Code** P2309
Ignition coil 4 current below threshold during dwell-on time	

The ECM monitors the ignition currents to detect a faulty ignition coil or a problem in the wiring between the coils and the ECM. If the ignition current on coil 4 is below the threshold after dwell time for more than 20 times, the code will set and the MIL is activated.

OBD II Definition: Ignition Coil D Primary Control Circuit Low

Necessary conditions for fault:
Primary: Ignition current on ignition coil 4 < 2A for > 20 times
Secondary: No actuator power supply faults active
Actuator power relay actuated

ECM substitution or action:
MIL is activated

Possible causes:
Coil 4 connector disconnected
Short in ignition coil 4 control signal
Faulty ignition coil 4

Troubleshooting:
Verify that ignition power is available at the ignition coil 4
Check the ignition coil 4 primary resistance to verify that coil 4 is not damaged
Check connector at ignition coil 4
Check wiring between ignition coil 4 and ECM connector

SPN-FMI 1271-6	**P-Code** P2310
Ignition coil 4 current above threshold during dwell-on time	

The ECM monitors the ignition currents to detect a faulty ignition coil or a problem in the wiring between the coils and the ECM. If the ignition current in coil 1 reaches the threshold prior to the end of the calibrated dwell time for more than 20 times, the code will be set and the MIL is activated.

OBD II Definition: Ignition Coil D Primary Control Circuit High

Necessary conditions for fault:
Primary: Ignition coil 4 reached current of 9.5A prior to calibrated dwell-time end > 20 time
Secondary: No actuator power supply faults active
Actuator power relay actuated

ECM substitution or action:
MIL is activated
The dwell time for ignition coil 4 is reduced
Possible causes:
Coil 4 control signal short to power
Faulty ignition coil 4
Troubleshooting:
Check electrical connection to ignition coil 4
Check key power voltage (if lower than voltage on coil 4, code will be set)
Check wiring between ECM and ignition coil 4
If only one ignition coil 4 exhibits this fault, replace this ignition coil

SPN-FMI 1393-31	**P-Code** P2302
No spark detected in cylinder 1	

The ECM monitors the primary currents after dwell time to detect a faulty spark plug a wiring problem between the ignition coil and the spark plug on cylinder 1. If the ECM detects spark duration shorter than a calibrated value this code will be set and the MIL is activated. Note that only an open circuit spark plug can be diagnosed; a short circuited, cracked spark plug or degraded wire insulation is not detected by this diagnostic.

OBD II Definition: Ignition Coil A Secondary Circuit

Necessary conditions for fault:
Primary: Spark duration in ignition coil 1 < 0.23ms > 20 times
Secondary: No actuator power supply faults active
Actuator power relay commanded ON
ECM substitution or action:
MIL is activated
Possible causes:
Open circuit in spark plug wiring on cylinder 1
Faulty spark plug on cylinder 1
Troubleshooting:
Check the ignition secondary wiring and spark plug on cylinder 1 for open circuits
Check spark plug wire on cylinder 1 for continuity
Check the spark plugs for excessively worn electrodes

SPN-FMI 1394-31	**P-Code** P2305
No spark detected in cylinder 2	

The ECM monitors the primary currents after dwell time to detect a faulty spark plug a wiring problem between the ignition coil and the spark plug on cylinder 2. If the ECM detects spark duration shorter than a calibrated value this code will be set and the MIL is activated. Note that only an open circuit spark plug can be diagnosed; a short circuited, cracked spark plug or degraded wire insulation is not detected by this diagnostic.

OBD II Definition: Ignition Coil A Secondary Circuit

Necessary conditions for fault:
Primary: Spark duration in ignition coil 2 < 0.23ms > 20 times
Secondary: No actuator power supply faults active
Actuator power relay commanded ON

ECM substitution or action:
MIL is activated
Possible causes: Open circuit in spark plug wiring on cylinder 2
Faulty spark plug on cylinder 2
Troubleshooting: Check the ignition secondary wiring and spark plug on cylinder 2 for open circuits
Check spark plug wire on cylinder 2 for continuity
Check the spark plugs for excessively worn electrodes

SPN-FMI 1395-31	**P-Code** P2308
No spark detected in cylinder 3	

The ECM monitors the primary currents after dwell time to detect a faulty spark plug a wiring problem between the ignition coil and the spark plug on cylinder 3. If the
ECM detects spark duration shorter than a calibrated value this code will be set and the MIL is activated. Note that only an open circuit spark plug can be diagnosed; a short circuited, cracked spark plug or degraded wire insulation is not detected by this diagnostic.

OBD II Definition: Ignition Coil A Secondary Circuit

Necessary conditions for fault:
Primary: Spark duration in ignition coil 3 < 0.23ms > 20 times
Secondary: No actuator power supply faults active
Actuator power relay commanded ON

ECM substitution or action:
MIL is activated
Possible causes:
Open circuit in spark plug wiring on cylinder 3
Faulty spark plug on cylinder 3
Troubleshooting: Check the ignition secondary wiring and spark plug on cylinder 3 for open circuits
Check spark plug wire on cylinder 3 for continuity
Check the spark plugs for excessively worn electrodes

SPN-FMI 1396-31	**P-Code** P2311
No spark detected in cylinder 4	

The ECM monitors the primary currents after dwell time to detect a faulty spark plug a wiring problem between the ignition coil and the spark plug on cylinder 4. If the
ECM detects spark duration shorter than a calibrated value this code will be set and the MIL is activated. Note that only an open circuit spark plug can be diagnosed; a short circuited, cracked spark plug or degraded wire insulation is not detected by this diagnostic.

OBD II Definition: Ignition Coil A Secondary Circuit

Necessary conditions for fault:
Primary: Spark duration in ignition coil 4 < 0.23ms > 20 times
Secondary: No actuator power supply faults active
Actuator power relay commanded ON

ECM substitution or action:
MIL is activated
Possible causes:
Open circuit in spark plug wiring on cylinder 4
Faulty spark plug on cylinder 4
Troubleshooting:
Check the ignition secondary wiring and spark plug on cylinder 4 for open circuits
Check spark plug wire on cylinder 4 for continuity
Check the spark plugs for excessively worn electrodes

SPN-FMI 1485-3	**P-Code** P0687
Actuator power control relay circuit voltage high	

The ECM monitors the performance of the power relay to detect a faulty power control relay or a wiring problem between the relay and the ECM. If the voltage on the relay control signal line exceeds the threshold for longer than 0.3s, the code will set and the MIL is activated.

OBD II Definition: ECM/PCM Power Relay Control Circuit High

Necessary conditions for fault:
Primary: Relay control signal voltage > 3.5V for > 0.3s
Secondary: Actuator power control relay commanded on
Key power voltage > 6V

ECM substitution or action:
MIL is activated
Possible causes:
Relay control line short to power
Short circuit in wiring between relay and ECM
Faulty power relay
Troubleshooting:
Check wiring between relay and ECM
Check for pinched or bare wires

SPN-FMI 1485-4	**P-Code** P0686
Actuator power control relay circuit voltage low	

The ECM monitors the performance of the power relay to detect a faulty power control relay or a wiring problem between the relay and the ECM. If the voltage in the actuator relay control line drops below the threshold for longer than 0.3s, the code will set and the MIL is activated.

OBD II Definition: ECM/PCM Power Relay Control Circuit Low

Necessary conditions for fault:
Primary: Relay control signal voltage < 3.5V for > 0.3s
Secondary: Actuator power control relay commanded off
Key power voltage > 6V

ECM substitution or action:
MIL is activated
Possible causes:
Open circuit in relay control signal line
Relay control signal short to ground
Faulty power relay
No Battery power to relay
Troubleshooting:
Verify if relay is properly connected
Verify wiring between relay and ECM
Verify continuity and resistance of the relay coil
Check for pinched or bare wires
Check power to relay

SPN-FMI 1634-31	**P-Code** P1609
Programming error	

Calibration / Firmware Mismatch

OBD II Definition: Calibration / Firmware Mismatch

Necessary conditions for fault:
Primary: Firmware reprogrammed after calibration change
Secondary: secondary fault 1
secondary fault 2

ECM substitution or action:
n/a
SparroWatch Calibration Variables:
Variable 1
Variable 2
Possible causes:
Cause 1
Cause 2
Troubleshooting:
Check 1
Check 2

SPN-FMI 2623-3	**P-Code** P2128
APP2 sensor signal circuit voltage high	

The ECM monitors the APP2 sensor signal voltage. If the voltage exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch E Circuit High Input

Necessary conditions for fault:
Primary: Voltage on APP2 sensor signal line > 4.82V (VIC Pedal connector APP2 pin) for > 0.25s
Secondary: No 5V power supply faults present

ECM substitution or action:

MIL is activated

Backup APP Unless both APP1 & APP2 have failed in which case the throttle goes into Limp Home mode and will not respond to the pedal and will remain fixed.

Possible causes:

APP2 sensor signal line shorted to APP2 5V supply line

APP2 sensor signal line shorted to battery

Faulty APP assembly

Troubleshooting:

Check VIC Pedal connector for proper connection

Check voltage on APP2 pin

Check for pinched or bare wires

SPN-FMI 2623-4	**P-Code** P2127
APP2 sensor signal circuit voltage low	

The ECM monitors the APP2 sensor signal voltage. If the voltage drops below the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch E Circuit Low Input

Necessary conditions for fault:

Primary: Voltage on APP2 sensor signal line < 0.08V (VIC Pedal connector APP2 pin) for > 0.25s

Secondary: No 5V power supply faults present

ECM substitution or action:

MIL is activated

Backup APP Unless both APP1 & APP2 have failed in which case the throttle goes into. Limp Home mode and will not respond to the pedal and will remain fixed.

Possible causes: APP2 sensor signal line open circuit

APP2 sensor signal line shorted to ground

VIC Pedal connector disconnected

Faulty APP assembly

Troubleshooting: Check VIC Pedal connector for proper connection

Check voltage on APP2 pin

Check voltage on APP2 5V pin

Check for pinched or bare wires

SPN-FMI 2803-0	**P-Code** P0603
There is no saved EEPROM data	

There are two battery power lines going to the ECM main connector, B+ and Switched Ignition. To be able to save required data in EEPROM the B+ line must be connected to the ECM for at least 60 seconds after the Switched Ignition is turned off (preferably the B+ should always remained connected to the battery 12 Volt source). A new, never programmed ECM has no values in EEPROM, if the Switched Ignition line is turned off and the B+ line is also shut off in less than 60 seconds the EEPROM in the ECM may not be written completely or correctly and this code will be set.

OBD II Definition: Internal Control Module Keep Alive Memory (KAM) Error

Necessary conditions for fault:

Primary: EEPROM does not contain valid data

Secondary: n/a

ECM substitution or action:
Engine does not start
Possible causes:
Power supply to ECM is cut off at the same time Switched Ignition is shut off
Troubleshooting:
Assure that the B+ line power is supplied to the ECM for at least 60 seconds after. Switched Ignition power is shut off.

SPN-FMI 3217-3	**P-Code** P0132
O2 sensor (S1B1) signal circuit voltage high	

The ECM monitors the voltage of the front O2 sensors to determine the lambda value and with it the air-fuel ratio of the engine. For lowest emissions, the O2 sensor voltage oscillates approximately between 0.2V to 0.8V. If this voltage exceeds the calibrated threshold for longer than 1s, the code will set and the MIL is activated.

OBD II Definition: O2 Sensor Circuit High Voltage (Bank 1 Sensor 1)

Necessary conditions for fault:
Primary: O2 sensor voltage > 1.26V for > 1s

ECM substitution or action:
MIL is activated
Fueling goes Open loop (using existing learned Long Term Fuel Trim values).
Possible causes:
HEGO 11 + signal line shorted to HEGO 11 power line
HEGO 11 + signal line shorted to battery
Faulty HEGO 11 sensor assembly
Troubleshooting:
Check HEGO 11 connector for proper connection
Check voltage on HEGO 11 + pin
Check for pinched or bare wires

SPN-FMI 3217-4	**P-Code** P0131
O2 sensor (S1B1) signal circuit voltage low	

The ECM monitors the voltage of the front O2 sensors to determine the lambda value and with it the air-fuel ratio of the engine. For lowest emissions, the O2 sensor voltage oscillates approximately between 0.2 to 0.8 Volts. If this voltage is less than the calibrated threshold for longer than the calibrated time, the code will set and the MIL is activated.

OBD II Definition: O2 Sensor Circuit Low Voltage (Bank 1 Sensor 1)

Necessary conditions for fault:
Primary: O2 sensor voltage < 0.05V for > 5s
Secondary: Time after engine key-off > 600s
ECT < 50°C

ECM substitution or action:
MIL is activated
Fueling goes Open loop (using existing learned Long Term Fuel Trim values).

Possible causes:

HEGO 11 sensor signal lines shorted to ground
Faulty HEGO 11 sensor assembly

Troubleshooting:

Check HEGO 11 connector for proper connection
Disconnect sensor and verify the O2 sensor voltage readings
Check power circuit for continuity and fuse integrity
Check for pinched or bare wires

SPN-FMI 3217-5	**P-Code** P0134
O2 sensor (S1B1) not switching enough within detection period	

The ECM monitors the voltage of the front O2 sensors to determine the lambda value and with it the air-fuel ratio of the engine. For lowest emissions, lambda is controlled to oscillate around a value of approximately 0.985 and the O2 sensor voltage oscillates accordingly. If this voltage remains between 0.4V and 0.55V for longer than the calibrated time, the code will set and the MIL is activated.

OBD II Definition: O2 Sensor Circuit No Activity Detected (Bank 1 Sensor 1)

Necessary conditions for fault:

Primary: O2 sensor voltage between 0.4V and 0.55V for > 60s
Secondary: Engine speed > 400rpm
Engine load > 5%
ETC > 55°C
No O2 sensor heater fault has been logged this key cycle
OR
Primary: O2 sensor voltage between 0.4V and 0.55V for > 150s
Secondary: Engine speed > 400rpm
Engine load > 5%
ETC < 55°C
No O2 sensor heater fault has been logged this key cycle

ECM substitution or action:

MIL is activated
Fueling goes Open loop (using existing learned Long Term Fuel Trim values).

Possible causes:

HEGO 11 connector disconnected
HEGO 11 heater not operating properly
Faulty HEGO 11 sensor assembly

Troubleshooting:

Check HEGO 11 connector for proper connection
Troubleshoot other O2 sensor codes first
Verify O2 sensor heater for proper operation

SPN-FMI 3217-16	**P-Code** P2196
O2 sensor (S1B1) voltage continuously high. Problem with closed-loop control.	

The ECM monitors the voltage of the front O2 sensors to determine the lambda value and with it the air-fuel ratio of the engine. For lowest emissions, lambda is controlled to oscillate around a value of approximately 0.985 and the O2 sensor voltage oscillates accordingly. If the sensor voltage is continuously high within a valid range for longer than a calibrated time , the code will set and the MIL is activated.

OBD II Definition: O2 Sensor 1 Bank 1 Signal Stuck Rich

Necessary conditions for fault:
Primary: O2 sensor voltage > 0.55V for > 32s
Secondary: Engine operating in closed loop mode

ECM substitution or action:
MIL is activate
Fueling goes Open loop and Long Term Fuel Trim is disabled

Possible causes:
Faulty HEGO 11 sensor

Troubleshooting:
Verify that HEGO 11 is functioning properly
Check regulator outlet pressure

SPN-FMI 3217-18	**P-Code** P2195
O2 sensor (S1B1) voltage continuously low. Problem with closed-loop control.	

The ECM monitors the voltage of the front O2 sensors to determine the lambda value and with it the air-fuel ratio of the engine. For lowest emissions, lambda is controlled to oscillate around a value of approximately 0.985 and the O2 sensor voltage oscillates accordingly. If the sensor voltage is continuously low within a valid range for longer than a calibrated time , the code will set and the MIL is activated.

OBD II Definition: O2 Sensor 1 Bank 1 Signal Stuck Lean

Necessary conditions for fault:
Primary: O2 sensor voltage < 0.4V for > 32s
Secondary: Engine operating in closed loop mode

ECM substitution or action:
MIL is activated
Fueling goes Open loop and Long Term Fuel Trim is disabled

Possible causes:
Leak in the exhaust system
Misfires
Faulty HEGO 11 sensor

Troubleshooting:
Check exhaust system for leaks
Check for misfires introducing high oxygen levels
Check regulator outlet pressure

SPN-FMI 3223-3	**P-Code** P0032
O2 sensor (S1B1) heater control circuit voltage high	

The ECM monitors the voltage of the heater circuit of the front O2 sensors to detect a problem in the wiring between the HEGO 11 connector and the ECM. If the voltage in the heater driver IC exceeds a certain value for longer than 0.3s, the code will set and the MIL is activated.

OBD II Definition: HO2S Heater Control Circuit High (Bank 1 Sensor 1)

Necessary conditions for fault:
Primary: Voltage in O2 sensor heater driver IC above a certain value for > 0.3s

Secondary: No actuator power supply faults
Actuator power relay actuated
Key power voltage > 6V
Oxygen sensor heater duty cycle in on-time period

ECM substitution or action:
MIL is activated
Possible causes:
HEGO 11 heater control signal line shorted to HEGO 11 power line
HEGO 11 heater control signal line shorted to battery
Faulty HEGO 11 sensor assembly
Troubleshooting:
Check HEGO 11 connector for proper connection
Check voltage on HEGO 11 heater line
Check for pinched or bare wires

SPN-FMI 3223-4	**P-Code** P0031
O2 sensor (S1B1) heater control circuit voltage low	

The ECM monitors the voltage of the heater circuit of the front O2 sensors to detect a problem in the wiring between the HEGO 11 connector and the ECM. If the voltage in the heater driver IC drops below a certain value for longer than 0.3s, the code will set and the MIL is activated.

OBD II Definition: HO2S Heater Control Circuit Low (Bank 1 Sensor 1)

Necessary conditions for fault:
Primary: Voltage in O2 sensor heater driver IC below a certain value for > 0.3s
Secondary: No actuator power supply faults
Actuator power relay actuated
Key power voltage > 6V
Oxygen sensor heater duty cycle in on-time period

ECM substitution or action:
MIL is activated
Possible causes:
HEGO 11 sensor heater control line open circuit
HEGO 11 sensor heater control line shorted to ground
HEGO 11 connector disconnected
Faulty HEGO 11 sensor assembly
Troubleshooting:
Check HEGO 11 connector for proper connection
Check voltage on HEGO 11 heater control line
Check voltage on HEGO 11 heater power line
Check power circuit for continuity and fuse integrity
Check for pinched or bare wires

SPN-FMI 3227-3	**P-Code** P0138
Rear O2 sensor (S2B1) signal circuit voltage high	

The ECM monitors the voltage of the rear O2 sensors to determine the oxygen content of the exhaust gas after the catalytic converter. If this voltage exceeds the calibrated threshold for longer than the calibrated time, the code will set and the MIL is activated.

OBD II Definition: O2 Sensor Circuit High Voltage (Bank 1 Sensor 2)

Necessary conditions for fault:
Primary: O2 sensor voltage > 1.25V for > 5s
Secondary: n/a

ECM substitution or action:
MIL is activated
Possible causes:
HEGO 21 + signal line shorted to HEGO 21 power line
HEGO 21 + signal line shorted to battery
Faulty HEGO 21 sensor assembly
Troubleshooting:
Check HEGO 21 connector for proper connection
Check voltage on HEGO 21 + pin
Check for pinched or bare wires

SPN-FMI 3227-4	**P-Code** P0137
Rear O2 sensor (S2B1) signal circuit voltage low	

The ECM monitors the voltage of the rear O2 sensors to determine the oxygen content of the exhaust gas after the catalytic converter. If this voltage drops below the calibrated threshold for during engine cold-soak, the code will set and the MIL is activated.

OBD II Definition: O2 Sensor Circuit Low Voltage (Bank 1 Sensor 2)

Necessary conditions for fault:
Primary: O2 sensor voltage < 0.05V for > 5s
Secondary: ECT < 50°C

ECM substitution or action:
MIL is activated
Possible causes:
HEGO 21 sensor signal lines open circuit
HEGO 21 sensor signal lines shorted to ground
HEGO 21 connector disconnected
Faulty HEGO 21 sensor assembly
Troubleshooting:
Check HEGO 21 connector for proper connection
Disconnect sensor and verify the O2 sensor voltage readings
Check for pinched or bare wires

SPN-FMI 3233-3	**P-Code** P0038
Rear O2 sensor (S2B1) heater control circuit voltage high	

The ECM monitors the voltage of the heater circuit of the rear O2 sensors to detect a problem in the wiring between the HEGO 21 connector and the ECM. If the voltage in the heater driver IC exceeds a certain value for longer than 0.3s, the code will set and the MIL is activated.

OBD II Definition: HO2S Heater Control Circuit High (Bank 1 Sensor 2)

Necessary conditions for fault:
Primary: Voltage in O2 sensor heater driver IC above a certain value for > 0.3s

Secondary: No actuator power supply faults
Actuator power relay actuated
Key power voltage > 6V
Oxygen sensor heater duty cycle in on-time period

ECM substitution or action:
MIL is activated
Skip rear O2

Possible causes:
HEGO 21 heater control signal line shorted to HEGO 21 power line
HEGO 21 heater control signal line shorted to battery
Faulty HEGO 21 sensor assembly

Troubleshooting:
Check HEGO 21 connector for proper connection
Check voltage on HEGO 21 heater line
Check for pinched or bare wires

SPN-FMI 3233-4	**P-Code** P0037
Rear O2 sensor (S2B1) heater control circuit voltage low	

The ECM monitors the voltage of the heater circuit of the rear O2 sensors to detect a problem in the wiring between the HEGO 11 connector and the ECM. If the voltage in the heater driver IC drops below a certain value for longer than 0.3s, the code will set and the MIL is activated.

OBD II Definition: HO2S Heater Control Circuit Low (Bank 1 Sensor 2)

Necessary conditions for fault:
Primary: Voltage in O2 sensor heater driver IC below a certain value for > 0.3s
Secondary: No actuator power supply faults
Actuator power relay actuated
Key power voltage > 6V
Oxygen sensor heater duty cycle in on-time period

ECM substitution or action:
MIL is activated
Skip rear O2

Possible causes:
HEGO 21 sensor heater control line open circuit
HEGO 21 sensor heater control line shorted to ground
HEGO 21 connector disconnected
Faulty HEGO 21 sensor assembly

Troubleshooting:
Check HEGO 21 connector for proper connection
Check voltage on HEGO 21 heater control line
Check voltage on HEGO 21 heater power line
Check power circuit for continuity and fuse integrity
Check for pinched or bare wires

SPN-FMI 3464-7	**P-Code** P0638
Desired and actual throttle positions do not match	

The ECM monitors the difference between desired and actual throttle position to evaluate the quality of the electronic throttle control system and whether or not it is able to provide the required airflow. If the error between the two signals exceeds the calibration threshold for longer than the calibrated

time, the code will be set and the MIL activated. The throttle will be put in “Limp Home” mode. This no power mode will allow the engine to continue to run at a minimal speed and load.

OBD II Definition: Throttle Actuator Control Range/Performance

Necessary conditions for fault:
Primary: Error between commanded and actual throttle position > 5% for > 0.6s
Secondary: Engine running
Throttle not in limp home mode

ECM substitution or action:
MIL is activated
Disable ETC (Limp Home)
Possible causes:
ETC+ or ETC- supply lines not connected or short to GND
Debris or foreign material in throttle
Troubleshooting:
Check ETB connector for proper connection
Check ETB for blockage and if throttle is able to move freely
Check if ETB is supplied with power

SPN-FMI 3464-11	**P-Code** P1519
Only one copy of span data in EEPROM is found when there should be two	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are translated into a relative position value that the ECM requires for throttle position control and airflow estimation. This process generates two copies of the data in the EEPROM. If only one copy is found in the EEPROM, either this code or SPN-FMI 3464-13 (P1520) will set and the MIL is activated.

OBD II Definition: Throttle Actuator Backup Span Data Lost
Necessary conditions for fault:
Primary: No valid TPS zero position data found in the backup memory area of EEPROM
Secondary: Keyed on

ECM substitution or action:
MIL is activated
Disable ETC (Limp Home)
Possible causes:
Faulty battery backup power setup
New ECM installation
Wrong ECM power down procedure (do not cut power to ECM right after key-off)
Troubleshooting:
Check battery backup power for proper operation
Clear code and power cycle
ECM Review
ECM power down procedure

SPN-FMI 3464-13	**P-Code** P1520
Only one copy of span data in EEPROM is found when there should be two	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are trans-

lated into a relative position value that the ECM requires for throttle position control and airflow estimation. This process generates two copies of the data in the EEPROM. If only one copy is found in the EEPROM, either this code or SPN-FMI 3464-13 (P1519) will set and the MIL is activated.

OBD II Definition: Throttle Actuator Primary Span Data Lost

Necessary conditions for fault:
Primary: No valid TPS zero position data found in the primary memory area of EEPROM
Secondary: *Secondary:* n/a

ECM substitution or action:
MIL is activated
Disable ETC (Limp Home)
Possible causes:
Faulty battery backup power setup
New ECM installation
Wrong ECM power down procedure (do not cut power to ECM right after key-off)
Troubleshooting:
Check battery backup power for proper operation
Clear code and power cycle ECM
Review ECM power down procedure

SPN-FMI 3509-3	**P-Code** P0643
5V Sensor Power Supply 1 voltage high	

The ECM monitors sensor 5V power supply voltage to detect possible short circuits to ground or battery. If the voltage exceeds a hardcoded value of 5.35V for longer than the hardcoded time of 0.25s, the code will be set and the MIL is activated. When this DTC is set, SPN-FMI 3510-3 may also be active.

OBD II Definition: Sensor Reference Voltage A Circuit High
Necessary conditions for fault:
Primary: Sensor power supply 1 voltage > 5.35V (
ECM pin #40) for > 0.25s
Secondary: n/a

ECM substitution or action:
MIL is activated)
Backup TPS and exit cruise control
Possible causes:
Short to battery on sensors along the sensor power supply 1 line
Troubleshooting:
Check connection of power supply 1 circuit at ECM connector
Check for sensor power supply 1 line shorts to battery
Check all devices using the +5V power supply 1 line

SPN-FMI 3509-4	**P-Code** P0642
5V Sensor Power Supply 1 voltage low	

The ECM monitors sensor 5V power supply voltage to detect possible short circuits to ground or battery. If the voltage drops below a hardcoded value of 4.63V for longer than the hardcoded time of 0.25s, the code will be set and the MIL activated. When this DTC is set, SPN-FMI 3510-4 may also be active.

OBD II Definition: Sensor Reference Voltage A Circuit Low

Necessary conditions for fault:
Primary: Sensor power supply 1 voltage < 4.63V (ECM pin #40) for > 0.25s
Secondary: n/a

ECM substitution or action:
MIL is activated
Backup TPS and exit cruise control
Possible causes:
Short to ground on sensors along the sensor power supply 1 line
Troubleshooting:
Check connection of power supply 1 circuit at ECM connector
Check for sensor power supply 1 line shorts to ground or an open circuit
Check all devices using the +5V power supply 1 line

SPN-FMI 3510-3	**P-Code** P0653
5V Sensor Power Supply 2 voltage high	

The ECM monitors sensor power supply voltage to detect possible short circuits to ground or battery. If the voltage exceeds a hardcoded value of 5.35V for longer than the hardcoded time of 0.25s, the code will be set and the MIL is activated. When this DTC is set, SPN-FMI 3509-3 may also be active.

OBD II Definition: Sensor Reference Voltage B Circuit High

Necessary conditions for fault:
Primary: Sensor power supply 2 voltage > 5.35V (ECM pin #38) for > 0.25s
Secondary: n/a

ECM substitution or action:
MIL is activated
Backup TPS and exit cruise control
Possible causes:
Short to battery on sensors along the sensor power supply 2 line
Troubleshooting:
Check connection of power supply 2 circuit at ECM connector
Check for sensor power supply 2 line shorts to ground or an open circuit
Check all devices using the +5V power supply 2 line

SPN-FMI 3510-4	**P-Code** P0652
5V Sensor Power Supply 2 voltage low	

The ECM monitors sensor the 5V power supply voltage to detect possible short circuits to ground or battery. If the voltage drops below a hardcoded value of 4.63V for longer than the hardcoded time of 0.25s, the code will be set and the MIL is activated. When this DTC is set, SPN-FMI 3509-4 may also be active.

OBD II Definition: Sensor Reference Voltage B Circuit Low

Necessary conditions for fault:
Primary: Sensor power supply 2 voltage < 4.63V (ECM pin #38) for > 0.25s
Secondary: n/a

ECM substitution or action:
MIL is activated
Backup TPS and exit cruise control
Possible causes: Short to ground on sensors along the sensor power supply 2 line
Troubleshooting: Check connection of power supply 2 circuit at ECM connector
Check for sensor power supply 2 line shorts to battery
Check all devices using the +5V power supply 2 line

SPN-FMI 3563-3	**P-Code** P0108
MAP sensor signal circuit voltage high	

The ECM monitors MAP signal voltage and estimates engine airflow based on the MAP reading. If voltage exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The MAP will be estimated using a model based on either throttle position or MAF sensor readings.

OBD II Definition: Manifold Absolute Pressure/Barometric Pressure Circuit High Input

Necessary conditions for fault:
Primary: Voltage on MAP signal line > 4.94V (MAPMAT connector MAP Sig pin) for > 1s
Secondary: No 5V power supply faults present
Throttle position < 100%
Engine speed > 0 RPM
ECM substitution or action:
MIL is activated
MAP model based on throttle position replaces measured value
Possible causes: MAP signal line shorted to +5V power line
MAP signal line shorted to battery
Faulty MAPMAT assembly
Troubleshooting: Check MAPMAT connector for proper connection
Check voltage on MAP Sig pin
Check for pinched or bare wires

SPN-FMI 3563-4	**P-Code** P0107
MAP sensor signal circuit voltage low	

The ECM monitors MAP signal voltage and estimates engine airflow based on the MAP reading. If voltage drops below the calibrated threshold for longer than the calibrated time, the code will be set and the MIL is activated. The MAP will be estimated using a model based on either throttle position or MAF sensor readings.

OBD II Definition: Manifold Absolute Pressure/Barometric Pressure Circuit Low Input

Necessary conditions for fault:
Engine running:
Primary: Voltage on MAP signal line < 0.05V (MAPMAT connector MAP Sig pin) for > 0.25s
Secondary: No 5V power supply faults present
Throttle position > 8%
OR
Engine speed < 3000RPM
Engine stopped:
Primary: MAP < 70kPa

Secondary: No engine speed signal

ECM substitution or action:
MIL is activated
MAP model based on throttle position replaces measured value
Possible causes:
MAP signal line open circuit
MAP signal line shorted to ground
MAPMAT connector disconnected
Faulty MAPMAT assembly
Troubleshooting:
Check MAPMAT connector for proper connection
Check voltage on MAP Sig pin
Check voltage on +5V pin
Check for pinched or bare wires

SPN-FMI 3673-0	**P-Code** P2164
WOT position not found by TPS2 during electronic throttle self-span	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are translated into a relative position value that the ECM requires for throttle position control and airflow estimation. If the TPS2 voltage reading does not correspond to the expected throttle range during this self-span, the code will be set and the MIL is activated.

OBD II Definition: Throttle Position Sensor B Maximum Stop Performance
Necessary conditions for fault:
Primary: Voltage range on TPS2 recorded during throttle span < 3.5V
Secondary: n/a

ECM substitution or action:
MIL is activated
Disable ETC (Limp Home)
Possible causes: Short to battery or ground in TPS2 circuit
Short to ground in power supply line
Faulty ETB assembly
Troubleshooting: Troubleshoot active DTCs related to sensor power supply
Troubleshoot active DTCs related to TPS2
Check ETB for blockage and if throttle is able to move freely

SPN-FMI 3673-1	**P-Code** P2113
Zero throttle position not found by TPS2 during electronic throttle self-span	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are translated into a relative position value that the ECM requires for throttle position control and airflow estimation. If readings for the throttle rest position on TPS2 does not translate into a position between 5% and 35%, the code will be set and the MIL is activated.

OBD II Definition: Throttle Position Sensor B Minimum Stop Performance

Necessary conditions for fault:
Primary: TPS2 readings for throttle rest position are not between 5% and 35%
Secondary: n/a

ECM substitution or action:
MIL is activated
Disable ETC (Limp Home)
Possible causes: Short to battery or ground in TPS2 circuit
Short to ground in power supply line
Faulty ETB assembly
Troubleshooting: Troubleshoot active DTCs related to sensor power supply
Troubleshoot active DTCs related to TPS1 and/or TPS2
Check ETB for blockage and if throttle is able to move freely

SPN-FMI 3673-3	**P-Code** P0223
TPS2 signal circuit voltage high	

This code is actually referring to the second of two throttle position sensors (TPS2) in the electronic throttle body. The ECM monitors the TPS2 signal voltage. If the voltage exceeds the calibrated threshold for longer than the calibrated time, the code will be set and the MIL activated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch B Circuit High

Necessary conditions for fault:
Primary: Voltage on TPS2 signal line > 4.92V (ETB connector TPS2 pin) for > 0.016s
Secondary: No 5V power supply faults present

ECM substitution or action:
MIL is activated
Backup TPS and exit cruise control
Possible causes:
TPS2 signal line shorted to Supply +5V power line
TPS2 signal line shorted to battery
Faulty ETB assembly
Troubleshooting:
Check ETB connector for proper connection
Check voltage on TPS2 pin
Check for pinched or bare wires

SPN-FMI 3673-4	**P-Code** P0222
TPS2 signal circuit voltage low	

This code is actually referring to the second of two redundant throttle position sensors (TPS2) in the electronic throttle body. The
ECM monitors the TPS2 signal voltage. If the voltage drops below the calibrated threshold for longer than the calibrated time, the code will be set and the MIL activated.

OBD II Definition: Throttle/Pedal Position Sensor/Switch B Circuit Low

Necessary conditions for fault:
Primary: Voltage on TPS2 signal line < 0.1V (ETB connector TPS2 pin) for > 0.016s
Secondary: No 5V power supply faults present

ECM substitution or action:
MIL is activated
Backup TPS and exit cruise control
Possible causes: TPS2 signal line open circuit
TPS2 signal line shorted to ground
ETB connector disconnected
Faulty ETB assembly
Troubleshooting:
Check ETB connector for proper connection
Check voltage on TPS2 pin
Check voltage on Supply +5V pin
Check for pinched or bare wires

SPN-FMI 4237-0	**P-Code** P0171
Long term fuel trim above threshold, but still running lean (B1)	

The ECM monitors the performance of the fuel system to detect possible problems in the air intake or fuel system. In the long term fuel trim table, if the fuel compensation values exceed the calibrated threshold in more than the calibrated number of cells, the code will set.

OBD II Definition: System Too Lean, Bank 1

Necessary conditions for fault:
Primary: Long term fuel trim > 25% for > 3 long term fuel trim cells
Fueling Lean
Secondary: n/a

ECM substitution or action:
MIL is activated
Possible causes:
Fuel injector
Low Fuel Pressure
Air intake and exhaust system
Troubleshooting:
Check exhaust system for leaks (especially near O2 sensors)
Verify pressure regulator for proper operation
Check fuel system filters for restrictions
Verify fuel quality is within expected range

SPN-FMI 4237-1	**P-Code** P0172
Long term fuel trim below threshold, but still running rich (B1)	

The ECM monitors the performance of the fuel system to detect possible problems in the air intake or fuel system. In the long term fuel trim table, if the fuel compensation values drop below the calibrated threshold in more than the calibrated number of cells, the code will set.

OBD II Definition: System Too Rich, Bank 1

Necessary conditions for fault:
Primary: Long term fuel trim < -25% for > 3 long term fuel trim cells
Secondary: Fueling Rich

ECM substitution or action:
MIL is activated
Possible causes:
Fuel injectors
Fuel Pressure Too High
Air intake and exhaust system
Troubleshooting:
Check for leaky injectors (pressurize fuel rail)
Check exhaust for restrictions
Verify pressure regulator for proper operation
Check fuel system filters for restrictions
Verify fuel quality is within expected range

SPN-FMI 5099-31	**P-Code** P1524
Problem with oil pressure lamp circuit	

The ECM monitors the performance of the oil pressure lamp to detect a problem in the wiring in the lamp circuit. If the voltage in the circuit drops below the driver IC threshold for more than 2s, the code will set.

OBD II Definition: Low Oil Pressure Lamp Circuit Fault

Necessary conditions for fault:
Primary: Oil pressure lamp circuit voltage > IC threshold for > 2s
Secondary: Key power voltage > 6V

ECM substitution or action:
Activate MIL
Possible causes:
Oil pressure lamp bulb burnt out
Wiring fault between lamp and ECM
Troubleshooting:
Check if the rest of the instrument cluster is operational
Check wiring connection to lamp
Check for continuity between lamp and ECM
Check if lamp control signal line is shorted to ground

SPN-FMI 5374-0	**P-Code** P2172
Airflow increases suddenly without a torque command increase	

The ECM monitors the performance of the air intake system to detect possible problems with the throttle or leaks in the manifold. If the relative air mass flow suddenly increases by more than the calibrated threshold within the calibrated time, the code will set and the MIL is activated.

OBD II Definition: Throttle Actuator Control System - Sudden High Airflow Detected

Necessary conditions for fault:
Primary: Airflow jumps > 40% within < 0.15s
Secondary: Desired torque jumps < 5%

ECM substitution or action:
MIL is activated

Substitute default or modelled value
RPM limiter

Possible causes:
Faulty ETB assembly
Leak in manifold hose

Troubleshooting:
Check ETB for proper operation
Check for broken manifold hoses
Troubleshoot SPN-FMI 3464-7 first if active

SPN-FMI 5374-16	**P-Code** P2173
Airflow estimate into engine is higher than expected	

The ECM monitors the performance of the air intake system to detect possible problems with the throttle or leaks in the manifold. If the relative air mass flow exceeds the calibrated threshold for longer than the calibrated time, the code will set and the MIL is activated.

OBD II Definition: Throttle Actuator Control System - High Airflow Detected

Necessary conditions for fault:
Primary: Airflow > 40% above desired airflow for > 1.7s
Secondary: n/a

ECM substitution or action:
MIL is activated
Substitute default or modelled value
RPM limiter

Possible causes: Faulty ETB assembly
Leak in manifold hose

Troubleshooting:
Check ETB for proper operation
Check for broken manifold hose
Troubleshoot SPN-FMI 3464-7 first if active

SPN-FMI 5419-0	**P-Code** P2111
Throttle is stuck open and does not move as commanded	

The ECM monitors the TPS voltage and translates it into relative throttle position values between 0% and 100%. If this position value is greater than a calibrated threshold for longer than a calibrated time even though the throttle actuation is trying to close the throttle, the code will set and the MIL is activated. The throttle will be put in “Limp Home” mode. This throttle no power position will allow the engine to continue to run at a minimal speed and load without being actively actuated.

OBD II Definition: Throttle Actuator Control System - Stuck Open

Necessary conditions for fault:
Primary: Relative throttle position > 95% for > 1s
Secondary: Throttle duty cycle < -25%
No sensor power fault active

ECM substitution or action:
MIL is activated
Substitute default or modelled value
Disable ETC (Limp Home)

SparroWatch Calibration Variables:
Variable 1
Variable 2
Possible causes:
Blockage or ice in throttle body
Wiring fault between ETB and ECM
Troubleshooting: Check throttle for blockage and ice
Verify if throttle can move smoothly when disconnected from ECM

SPN-FMI 5419-1	**P-Code** P2112
Throttle is stuck close and does not move as commanded	

The ECM monitors the TPS voltage and translates it into relative throttle position values between 0% and 100%. If this position value is smaller than a calibrated threshold for longer than a calibrated time even though the throttle actuation is trying to open the throttle, the code will set and the MIL is activated. The throttle will be put in “Limp Home” mode. This throttle no power position will allow the engine to continue to run at a minimal speed and load without being actively actuated.

OBD II Definition: Throttle Actuator Control System - Stuck Close

Necessary conditions for fault:
Primary: Relative throttle position > 3.1% for > 1s
Secondary: Throttle duty cycle < 25%
No sensor power fault active

ECM substitution or action:
MIL is activated
SparroWatch Calibration Variables:
Variable 1
Variable 2
Possible causes:
Blockage or ice in throttle body
Wiring fault between ETB and ECM
Troubleshooting:
Check throttle for blockage and ice
Verify if throttle can move smoothly when disconnected from ECM

SPN-FMI 5419-4	**P-Code** P2100
Open circuit in ETC motor circuit	

The ECM monitors the performance of the ETC circuit to detect a faulty ETB or a problem in the wiring between the ETB and the ECM. If the current in the throttle driver drops below a certain threshold even though the throttle actuation command is greater than a certain threshold, the code will set and the MIL is activated.

OBD II Definition: Throttle Actuator Control Motor Circuit Open

Necessary conditions for fault:
Primary: Current in ETC motor control signal line < 130mA
Secondary: ETC duty cycle > 16.4%
Engine running

ECM substitution or action:
MIL is activated
Possible causes:
ETC + or ETC - signal line open circuit
ETC + or ETC - signal line shorted to ground
ETC + or ETC - signal line shorted to battery
ETB connector disconnected
Faulty ETB assembly
Troubleshooting:
Check ETB connector for proper connection
Check voltage on ETC + or ETC - pins
Check for pinched or bare wires
Check throttle motor for continuity

SPN-FMI 5419-5	**P-Code** P2102
ETC motor circuit shorted to ground	

The ECM monitors the performance of the ETC motor circuit to detect a faulty ETB assembly or a problem in the wiring between the ETB and the ECM.

OBD II Definition: Throttle Actuator Control Motor Circuit Low

Necessary conditions for fault:
Primary:
Secondary: Engine running

ECM substitution or action:
MIL is activated
Disable ETC (Limp Home)
SparroWatch Calibration Variables:
Variable 1
Variable 2
Possible causes:
ETC + or ETC - signal line shorted to ground
Faulty ETB assembly
Troubleshooting:
Check ETB connector for proper connection
Check voltage on ETC + or ETC - pins
Check for pinched or bare wires
Check throttle motor for continuity

SPN-FMI 5419-6	**P-Code** P2103
ETC motor circuit short to high	

The ECM monitors the performance of the ETC circuit to detect a faulty ETB or a problem in the wiring between the ETB and the ECM. If the current in the throttle driver exceeds a certain threshold, the code will set and the MIL is activated.

OBD II Definition: Throttle Actuator Control Motor Circuit High

Necessary conditions for fault:
Primary: Current in ETC motor control signal line > IC threshold
Secondary: Engine running

ECM substitution or action:

MIL is activated
Disable ETC (Limp Home)

Possible causes:

ETC + signal line shorted to ETC - signal line
ETC + or ETC - signal line shorted to ground
ETC + or ETC - signal line shorted to battery
Faulty ETB assembly

Troubleshooting:

Check ETB connector for proper connection
Check voltage on ETC + and ETC - pins
Check for pinched or bare wires

SPN-FMI 5419-7	**P-Code** P1521
Detected rest position of throttle does not match expected value	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are translated into a relative position value that the ECM requires for throttle position control and airflow estimation. This process generates two copies of the data in the EEPROM. If the EEPROM does not show a valid record of the zero throttle position, the code will set and the MIL is activated.
OBD II Definition: Throttle Zero Cycle Rest Value Incorrect

Necessary conditions for fault:
Primary: No valid zero throttle position found in span data on EEPROM
Secondary: Key-on position after
ECM power cycle

ECM substitution or action:

MIL is activated
Substitute default or modelled value

Possible causes:

Faulty actuator power supply
Blockage or debris in ETB
New ECM installation (clear code and power cycle ECM)

Troubleshooting:

Troubleshoot any power supply faults first
Troubleshoot any TPS faults first
Verify voltage readings of TPS1 and TPS2
Check throttle actuation for proper operation
Perform manual throttle zero process using scan tool

SPN-FMI 5419-13	**P-Code** P2176
ECM was not able to determine rest position during throttle span	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are translated into a relative position value that the ECM requires for throttle position control and airflow estimation. If readings for the throttle rest position on TPS1 and TPS2 do not translate into a position between 5% and 35%, the code will set and the MIL is activated at the next key-on event.

OBD II Definition: Throttle Actuator Control System - Idle Position Not Learned

Necessary conditions for fault:
Primary: TPS1 and TPS2 readings for throttle rest position are not between 5% and 35%
Secondary: Voltage range on TPS1 and TPS2 recorded during throttle span < 3.5V

ECM substitution or action:
MIL is activated
Possible causes:
Faulty sensor power supply
Blockage or debris in ETB
Troubleshooting:
Troubleshoot any power supply faults first
Troubleshoot any TPS faults first
Verify voltage readings of TPS1 and TPS2
Check throttle actuation for proper operation
Perform manual throttle zero process using scan tool

SPN-FMI 5419-14	**P-Code** P1522
After spanning, resting positions of redundant TPSs have failed to match	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are translated into a relative position value that the ECM requires for throttle position control and airflow estimation. If calculated throttle rest positions of TPS1 and TPS2 do not match within an error of 5%, the code will set and the MIL is activated at the next key-on event.

OBD II Definition: Throttle Zero Cycle Position Mismatch

Necessary conditions for fault:
Primary: Error between throttle rest positions from TPS1 and TPS2 > 5%
Secondary: n/a

ECM substitution or action:
MIL is activated
Disable ETC (LIMPHOME)
Possible causes:
Faulty sensor power supply
Sensor drift in TPS1 and TPS2 of ETB
Faulty wiring on ETB
Troubleshooting:
Troubleshoot any power supply faults first
Troubleshoot any TPS faults first
Verify voltage readings of TPS1 and TPS2
Check throttle actuation for proper operation
Perform manual throttle zero process using scan tool

SPN-FMI 5445-4	**P-Code** P2119
Electronic throttle could not complete its self-span	

After key-off, the electronic throttle body performs an automated self-span to find the TPS voltage levels corresponding to zero and wide open throttle (WOT) position. These voltage levels are translated into a relative position value that the ECM requires for throttle position control and airflow esti-

mation. If the throttle span after key-off could not be completed, the code will set and the MIL is activated at the next key-on event.

OBD II Definition: Throttle Actuator Control Throttle Body Range/Performance

Necessary conditions for fault:
Primary: Incomplete throttle span
Secondary: n/a

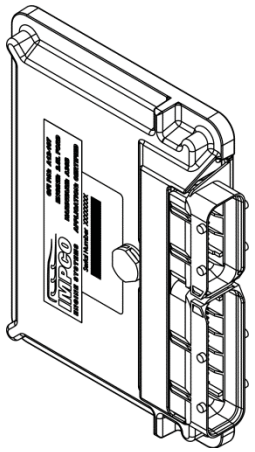
ECM substitution or action:
MIL is activated
Possible causes:
Faulty sensor power supply
Blockage or debris in ETB
Troubleshooting:
Troubleshoot any power supply faults first
Troubleshoot any TPS faults first
Verify voltage readings of TPS1 and TPS2
Check throttle actuation for proper operation
Perform manual throttle zero process using scan tool

SPN-FMI 524280-31	**P-Code** P0606
ECM did not pass functional test during manufacturing	

SPN-FMI 524284-31	**P-Code** P0604
Problem with ECM RAM	

Servicing the Fuel System

I. ENGINE CONTROL MODULE



A36 ECM

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

REMOVAL PROCEDURE

1. Disconnect Negative battery cable.
2. Remove screws mounting the controller.
3. Push connector lock back to unlock connector.
4. Remove ECM.

INSTALLATION PROCEDURE

IMPORTANT
The ECM is calibrated for each engine. Verify you have the correct controller by noting the part number on the ECM label. The calibration number can also be found by connecting the Spectrum Engine Monitor and locating the calibration number on the Gauge page.

1. Mount the ECM.
2. Plug connector into controller.
3. Push lock into place.
4. Reconnect the Negative battery cable.
5. Install Spectrum Engine Monitor.
6. Start engine.
7. Check for any DTC codes and clear.
8. Verify engine is in closed loop, operates normally in throttle ranges and no MIL light is present.

II. ENGINE WIRE HARNESS REPLACEMENT

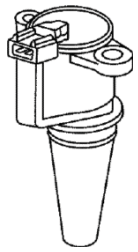
1. Disconnect Negative battery cable.
2. Lay out the new wire harness, noting the location, type of connectors, and identifying markings. Take special note of identical or similar connectors (such as the ignition coils or HEGO Sensors) to avoid crossing connections during installation. Note the routing of the existing wire harness in and around the engine and the vehicle. Refer the Electrical Schematic.

CAUTION

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

3. Remove all wire harness connectors on the vehicle.
4. Remove all clips and brackets holding the wire harness and remove harness from vehicle.
5. Lay the new wire harness over the engine and route each end to its connection. Verify that all connectors match prior to installation.
6. Connect all connectors and ring terminals.
7. Install all clips and brackets to hold down the harness.
8. Reconnect Negative battery cable.
9. Start the engine and verify it runs normally in all throttle ranges in closed loop and no MIL is present.

III. IGNITION COIL



Coil on Plug Ignition Coil

REMOVAL PROCEDURE

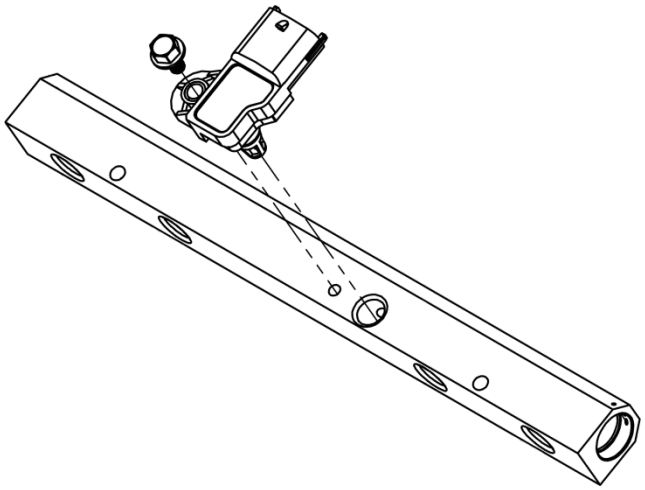
1. Disconnect Negative battery cable.
2. Remove electrical connector from the coil.
3. Remove bolt securing the ignition coil.
4. Gently remove the ignition coil by pulling

while lightly twisting back and forth.

INSTALLATION PROCEDURE

1. Insert Ignition coil into the opening on the cylinder head, ensuring the boot is properly placed on top of the spark plug and the top of coil is flush with top of the cylinder head.
2. Secure Ignition Coil with bolt. **Torque to 8.43 to 10.8 Nm (6.2 to 8.0 ft. lbs.).**
3. Reconnect electrical connector to the coil.
4. Reconnect Negative battery cable.
5. Start the engine and verify it runs normally in all throttle ranges in closed loop and no MIL is present

IV. FUEL RAIL PRESSURE/TEMPERATURE (FRT/FAP) SENSOR



Fuel Rail and Sensor

REMOVAL PROCEDURE

1. Disconnect the Negative battery cable.
2. Relieve the LPG fuel system pressure. Refer to *XIX. LPG Fuel System Pressure Relief.*
3. Locate the Fuel Temperature Sensor near the center of the fuel rail.
4. Remove the electrical connector from the sensor.
5. Remove the sensor from the fuel rail.

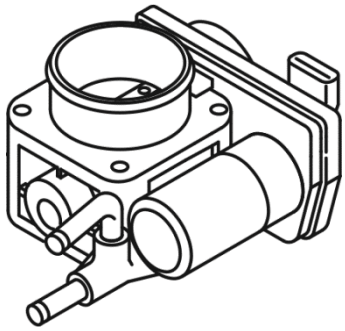
WARNING

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

INSTALLATION PROCEDURE

1. Lubricate O-ring on the sensor with petroleum jelly or Vaseline.
2. Install the sensor into the fuel rail. **Torque to 10 +/-1 Nm (7.4 +/- 0.7 ft.lbs.).**
3. Attach the electrical connector.
4. Reconnect the Negative battery cable.
5. Using the Spectrum Engine Monitor, clear DTC information from the ECM.
6. Turn the ignition OFF and wait 30 seconds. Check for leaks.
7. Start the engine and verify it runs normally in all throttle ranges in closed loop and no MIL is present.

V. THROTTLE BODY AND/OR GASKET



Throttle Body

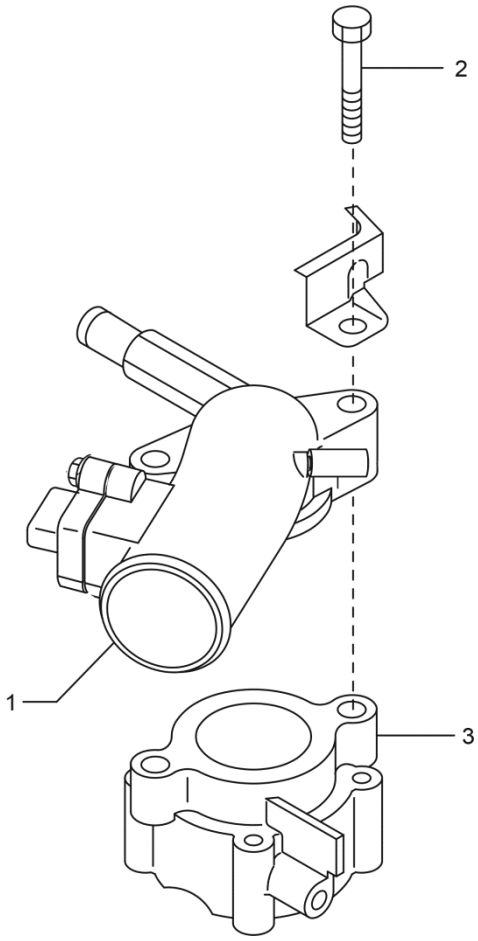
REMOVAL PROCEDURE

1. Disconnect the Negative battery cable.
2. Remove the Air Horn assembly. Refer to *VI Air Horn*.
3. Remove Throttle Body electrical connector.
4. Remove the Throttle Body and the Gasket.

INSTALLATION PROCEDURE

1. Inspect Throttle Body Gasket. Replace if necessary.
2. Place Throttle Body and Gasket on the Intake Manifold plenum and align holes.
3. Connect electrical connector.
4. Reattach the intake/gasket/adapter assembly with four screws. Refer to *VI Air Horn*.
5. Reconnect Negative battery cable.
6. Start the engine and verify it runs normally in all throttle ranges in closed loop and no MIL is present.

VI. AIR HORN



Air Horn Assembly

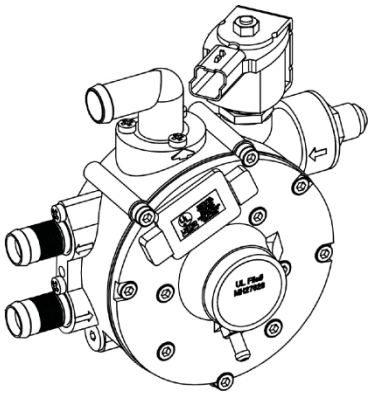
REMOVAL PROCEDURE

1. Disconnect Negative battery cable.
2. Remove air intake duct from Air Horn (1).
3. Remove MAF electrical Connector.
4. Remove Bolts (2).
5. Remove four Bolts (not shown) securing Adapter (3) and remove Adapter and Gasket (not shown).

INSTALLATION PROCEDURE

6. Place Gasket (not shown) Adapter (3) on Throttle Body and align holes.
7. Install four Bolts (not shown) securing Adapter (3) and **torque to 1.2-1.4 ft.lbs (11.8-13.7 Nm)**.
8. Place Air Horn (1) on Adapter (3). Align holes and secure with Bolts. **Torque to 2.0-2.3 ft.lbs (19.6-23.5 Nm)**.
9. Reconnect MAF electrical Connector.
10. Reconnect air intake duct from Air Horn (1).
11. Start the engine and verify it runs normally in all throttle ranges in closed loop and no MIL is present.

VII. REGULATOR



Regulator

REMOVAL PROCEDURE

12. Relieve the LPG fuel system pressure. Refer to *XIX. LPG FUEL SYSTEM PRESSURE RE-LIEF.*
13. Disconnect Negative battery cable.
14. Remove the electrical connector on the Shutoff Valve.
15. Remove the Fuel Hose between the regulator and Fuel Rail.
16. Remove the LPG Supply Fuel Line at the flare fitting attached to the Shutoff Valve.

CAUTION

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

17. Clamp both Coolant Hoses as close to the Regulator as possible.
18. Remove Coolant Hoses from Regulator.

CAUTION

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

19. Remove Balance Line Hose.
20. Remove the Bolts securing the Regulator and remove Regulator.

INSTALLATION PROCEDURE

1. Secure Regulator with Bolts. Refer to the OEM for torque specifications.
2. Attach the LPG Supply Fuel Line at the flare fitting attached to the Shutoff Valve.
3. Reconnect the Fuel Line from Fuel Rail to the top of the regulator.
4. Connect Coolant Lines. Remove clamps from Hoses (if used during removal).
5. Attach Balance Line Hose.
6. Slowly open LPG Tank Valve and check for leaks.

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

7. Reconnect Negative battery cable. Turn ignition key to ON and check for leaks at the inlet and outlet fittings using a commercial grade soapy solution or an electronic leak detector. If leaks are detected make repairs.
8. Start engine and check for fuel and coolant leaks. If leaks are detected make repairs.
9. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.
10. Check coolant level and add coolant if necessary.

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

During normal operation oil or “heavy ends” may build inside the secondary chamber of the Regulator. These oil and heavy ends may be a result of poor fuel quality, contamination of the fuel, or regional variation of the fuel make up and a significant build up of oil can affect the performance of the secondary diaphragm response. The *LPG CERTIFIED ENGINE MAINTENANCE REQUIREMENTS* found in the MAINTENANCE section of this manual recommends that the oil be drained periodically. This is the minimum requirement to maintain the emission warranty. More frequent draining of the Regulator is recommended for special situation where substandard fuel may be a problem. IMPCO recommends the Regulator be drained at every engine oil change (500 hours) if contaminated or substandard fuel is suspected or known to be have been used or in use with the emission complaint fuel system. This is known as special maintenance, and failure to follow this recommendation may be used to deny a warranty claim.

IMPORTANT:
Draining the Regulator when the engine is warm will help the oils to flow freely and permit easier removal from the Regulator.

To drain the Regulator, follow the steps below:

1. Move the equipment to a well ventilated area and ensure no external ignition sources are present.
2. Turn off LPG Valve and Relieve the LPG fuel system pressure. Refer to *XIX. LPG FUEL SYSTEM PRESSURE RELIEF.*
3. Disconnect Negative battery cable.

CAUTION

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

4. Using a hex key, remove the plug on the Regulator under the lower coolant port.
5. Place a small receptacle in the engine compartment to catch any liquid that may come out of the Regulator.
6. Inspect the Regulator for any large dried particles and remove. Use a safety solvent to remove any build up.

WARNING

Use only Safety Solvents for the cleaning of the regulator and its components. Solvents such as carburetor or brake cleaners may damage gaskets, seals, O-rings, diaphragms or other non-metal components.

7. Lubricate the O-ring with petroleum jelly of Vaseline and reinstall the Plug. **Torque until tight.**
8. Connect Negative battery cable.
9. Open Valve on LPG tank.

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

10. Turn Key ON. Check for leaks using a soapy solution or an electronic leak detector.
11. Start engine and check for leaks at all serviced fittings. If leaks are detected make repairs.
12. Dispose of any drained material in safe and proper manner.

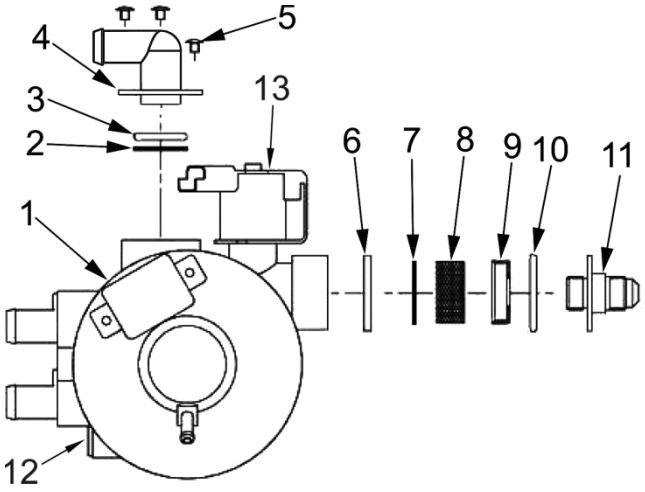
IX. REGULATOR FUEL FILTER ELEMENTS

REMOVAL PROCEDURE

1. Relieve the LPG fuel system pressure. Refer to *XIX. LPG FUEL SYSTEM PRESSURE RELIEF.*
2. Disconnect Negative battery cable.

CAUTION

A small amount of fuel may still be present in the fuel line. Use gloves and proper eye protection to prevent burns. Make sure the manual valve is fully closed.



Regulator, showing filter related components.

3. Disconnect the fuel inlet and outlet lines from the LPG Regulator.
4. Remove the fuel inlet fitting (11) and O-ring (10).
5. Remove the plastic body (9), foam filter (8), paper filter element (7), and filter gasket (6).
6. Remove the screws (5), fuel outlet fitting (4) O-ring (3), and filter (2). Discard O-ring and filter.

INSTALLATION PROCEDURE

1. Install new filter (2) in port for fuel outlet fitting. Install new O-ring (3) and fuel outlet fitting (4).
2. Install retaining screws (5) for fuel outlet fitting (4). **Tighten screws to 2 to 3 Nm (17.7 to 26.55 in.lb.).**
3. Install the filter gasket (6), new paper filter element (7), new foam filter (8), and plastic body (9).
4. Install the fuel inlet fitting (11) and O-ring (10). **Tighten to 18 to 20 Nm (13.3 to 14.75 ft.lbs.).**
5. Connect the fuel inlet line to the LPG Regulator.
6. Connect the Negative battery cable.
7. Slowly open the fuel valve on tank.

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

8. Turn the key to the ON position and back to the OFF position to pressurize the fuel system.
9. Check for leaks at connections by using a commercial grade soapy solution or electronic leak detector. If leaks are detected, make proper repairs.
10. Start the engine and verify it runs normally in all throttle ranges in closed loop and no MIL is present.

X. LOCK-OFF SOLENOID

1. Relieve the LPG fuel system pressure. Refer to *XIX. LPG FUEL SYSTEM PRESSURE RELIEF.*
2. Disconnect Negative battery cable.
3. Disconnect the electrical connector from the lock-off solenoid.
4. Remove the nut and solenoid from the cartridge

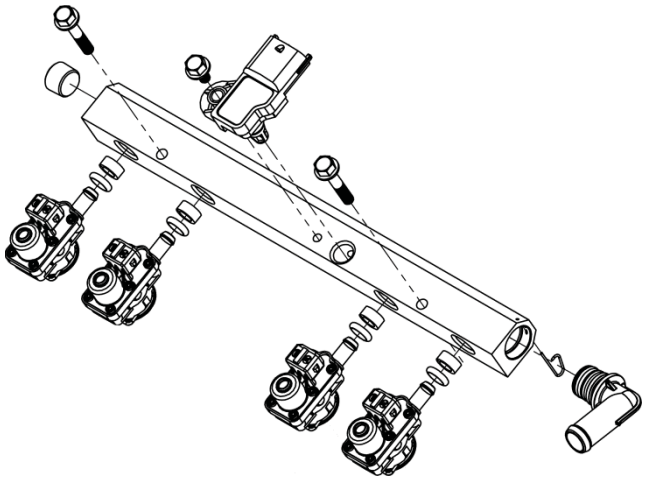
INSTALLATION PROCEDURE

1. Install solenoid and nut onto cartridge. **Tighten nut to 7.85 Nm (69.5 in.lbs.)**.
2. Connect electrical connector to solenoid.
3. Connect the Negative battery cable.
4. Slowly open the fuel valve on the LPG tank.

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

5. Turn the key to the ON position and back to the OFF position to pressurize the fuel system. Check for leaks.
6. Check for leaks at connections by using a commercial grade soapy solution or an electronic leak detector. If leaks are detected, make proper repairs.
7. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XI. FUEL RAIL



Fuel Rail, Injectors, Sensor and hardware

REMOVAL PROCEDURE

1. Relieve the LPG fuel system pressure. Refer to *XIX. LPG FUEL SYSTEM PRESSURE RELIEF.*
2. Disconnect the Negative battery cable.
3. Remove the pin securing the fuel inlet hose, then remove fitting from the fuel rail.

CAUTION

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

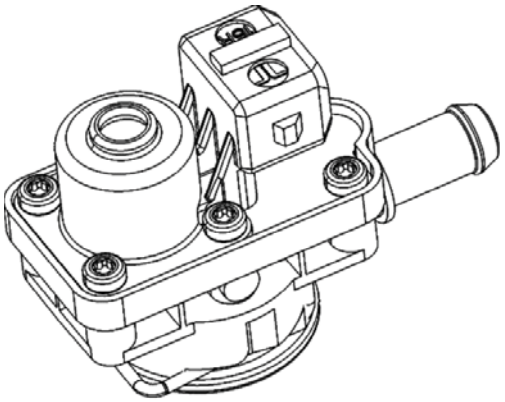
4. Remove Fuel Pressure Sensor electrical connection.
5. Remove two bolts securing the Fuel Rail.
6. Carefully pull the rail flush along the Fuel Rail and away from the Fuel Injectors.
7. If rail is to be replaced, remove the Fuel Pressure Sensor *and the end plug*. Refer to *IV. FUEL RAIL PRESSURE/TEMPERATURE (FRT/FAP) SENSOR.*

INSTALLATION PROCEDURE

1. If the Fuel Pressure Sensor, was removed Refer to *IV. FUEL RAIL PRESSURE/ TEMPERA-TURE (FRT/FAP) SENSOR.* If the end plug was removed, reinstall using Loctite

567 (or equivalent high-temp thread locker/sealer) to the threads.
2. Lubricate Fuel Injector O-rings with petroleum jelly or Vaseline.
3. Ensure all Injectors are properly aligned to mate to the Fuel Rail. Carefully place the Injector Ports into the Fuel Rail. Ensure the Fuel Injectors and O-rings are properly seated.
4. Align holes on Fuel Rail with holes in the bracket. **Torque to 9 to 11 Nm (6.6 to 8.1 ft. lbs.)**.
5. Connect Fuel Pressure Sensor electrical connection.
6. Lubricate Port Fitting O-rings with petroleum jelly or Vaseline.
7. Insert fuel inlet port fitting and secure with pin.
8. Reconnect Negative battery cable. Turn ignition key to ON and check for leaks at the inlet and outlet fittings using a commercial grade soapy solution or an electronic leak detector. If leaks are detected make repairs.
9. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XII. FUEL INJECTOR



Fuel Injector

REMOVAL PROCEDURE

1. Relieve the LPG fuel system pressure. Refer to *XIX. LPG FUEL SYSTEM PRESSURE RELIEF.*
2. Disconnect the Negative battery cable.
3. Remove the Fuel Rail. Refer to *XI. FUEL RAIL.*
4. Remove Injector electrical connector.
5. Remove Clip Retaining Fuel Injector (connecting it to the Injector Adapter).

CAUTION

When removing the fuel injectors, pull the injectors straight out. Do not pry the injectors with a screwdriver or pry bar, as this can damage the injectors or injector adapters.

6. Remove Injector.
7. Remove Spacer and O-ring from Injector.

INSTALLATION PROCEDURE

1. Inspect the O-rings on the Injector and Injector Adapter and replace if necessary. Lubricate with Vaseline or petroleum jelly.
2. Install the Fuel Injector into the Fuel Injector Adapter. Push the Injectors into the Adapters using hand pressure only.
3. Install the Clip Retaining Fuel Injector (connecting it to the Injector Adapter).
4. Ensure all Injectors are properly aligned to mate to the Fuel Rail.
5. Install Fuel Rail. Refer to *X. FUEL RAIL*
6. Connect the electrical connector(s) to the fuel injector(s). Verify that the connectors click/lock into place.
7. Connect the Negative battery cable.
8. Slowly open the fuel valve on the LPG tank.

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

8. Turn the key to the ON position and back to the OFF position to pressurize the fuel system. Check for leaks.
9. Check for leaks at connections by using a commercial grade soapy solution or an electronic leak detector. If leaks are detected, make proper repairs.
10. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XIII. FUEL INJECTOR ADAPTERS

REMOVAL PROCEDURE

Fuel Injector Adapter

1. Relieve the LPG fuel system pressure. Refer to *XX. LPG FUEL SYSTEM PRESSURE RELIEF.*
2. Disconnect the Negative battery cable.
3. Remove the Fuel Rail. Refer to *X. FUEL RAIL.*
4. Remove the Injector(s). Refer to *XI. FUEL INJECTOR*.
5. Remove the Fuel Injector Adaptor(s) from the Intake Manifold.
6. Place tape or a clean rag over the opening in the Intake Manifold to prevent dirt or debris from entering the engine, possibly causing permanent engine damage.
7.

INSTALLATION PROCEDURE

1. Lubricate the O-rings on the Fuel Injector Adapter with Vaseline or petroleum jelly and place back on the Intake Manifold, ensuring it is properly seated.

WARNING

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

2. Install Injectors on top of Adapters. Refer to *XI. FUEL INJECTOR.*
3. Install Fuel Rail. Refer to *X. FUEL RAIL.*
4. Connect the Negative battery cable.
5. Slowly open the fuel valve on the LPG tank.

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

6. Turn the key to the ON position and back to the OFF position to pressurize the fuel system. Check for leaks.
7. Check for leaks at connections by using a commercial grade soapy solution or an electronic leak detector. If leaks are detected, make proper repairs.
8. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XIV. INTAKE & EXHAUST MANIFOLDS /GASKET

CAUTION

To reduce the risk of burns when tightening manifold, always wait until manifold has cooled to the touch.

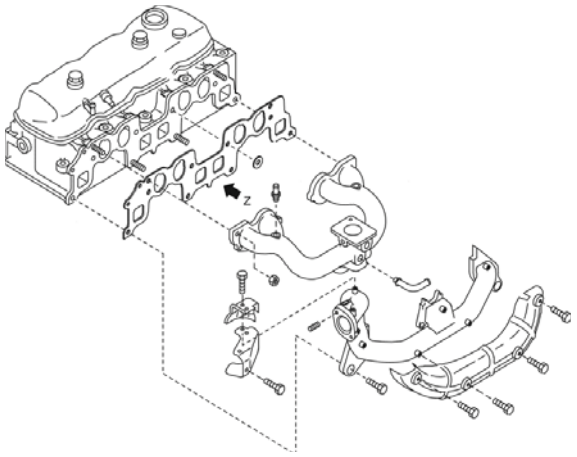
REMOVAL PROCEDURE

1. Relieve the Fuel Pressure refer to *XIX. LPG FUEL PRESSURE RELIEF.*
2. Disconnect Negative battery cable.
3. Remove Air Horn. Refer to *VI. AIR HORN*.
4. Remove Throttle body. Refer to *V. THROTTLE BODY AND/OR GASKET.*
5. Remove Fuel Rail. Refer to *XI. FUEL RAIL*.
6. If necessary, remove Injectors. Refer to *XII. FUEL INJECTOR.*
7. Remove two screws securing Fuel Rail Bracket and remove Bracket.

WARNING

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

8. Remove hoses (PCV and balance) from hose barbs on the Intake Manifold.
9. Remove the four bolts securing the Exhaust Manifold cover.
10. Remove exhaust pipe connection to the Exhaust Manifold.
11. Remove the six bolts securing the Intake and Exhaust Manifold and remove the four nuts from the studs.
12. Remove Intake and Exhaust Manifolds, plus the Gasket. Keep studs threaded into the block, unless they were unscrewed during the removal process or were damaged.

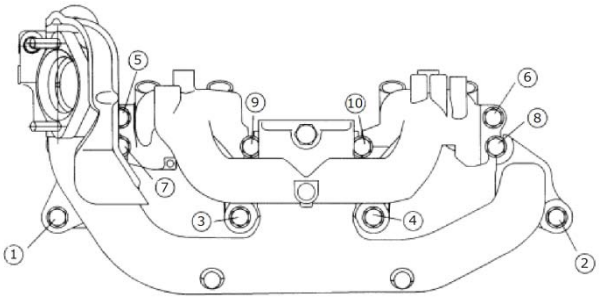


Cylinder Head, Gasket Manifolds & Hardware

13. If the Exhaust Manifold is to be replaced, remove the two cover pieces. If the Intake Manifold is to be replaced, remove the hose barbs/connectors from the Intake Manifold.

INSTALLATION PROCEDURE

1. Ensure the mating surfaces of the intake ports on the engine and manifold are clean and free of any gasket material.
2. If installing a new Intake Manifold reinstall using Loctite 567 (or equivalent high-temp thread locker/sealer) to the threads (small for the TMAP and larger for PCV). **Torque both until tight**.
3. Insert hose stem into the Intake Manifold, using Apply Loctite 567 (or equivalent high-temp thread locker/sealer).
4. Hang the Manifold Gasket on the studs and position the Gasket and Exhaust Manifold in place and finger tighten Bolts and Nuts. Hang the Intake Manifold on the studs and position and finger tighten Bolts and Nuts.
5. **Torque Bolts and nuts to 41.2 to 48.1 Nm (30.4 to 35.5 ft.lbs)** in the following order: middle, two upper, two outer/lower in the order shown:



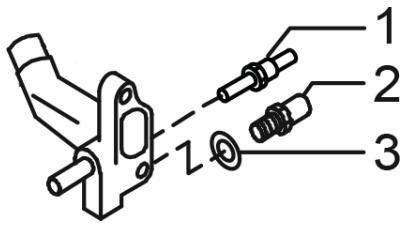
Intake Manifold footprint showing bolt tightening sequence.

6. Connect hoses to the hose barbs.
7. If Fuel Rail Bracket was removed, reinstall and **torque bolts to (13.2-16.2) 18-22 Nm.**
8. If Injectors were removed, reinstall. Refer to *XII. FUEL INJECTOR.*
9. Install Fuel Rail. Refer to Refer to *XI. FUEL RAIL*.
10. Install Throttle body. Refer to *V. THROTTLE BODY AND/OR GASKET.*
11. Install Air Horn assembly. Refer to *VI. AIR HORN.*
12. Attach the Exhaust Manifold to the Exhaust Pipes. Refer to OEM instructions for instructions and torque specification.
13. Attach cover to Exhaust Manifold. **Torque bolts until tight.**
14. Connect the Negative battery cable.
15. Slowly open the fuel valve on the LPG tank.

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

16. Turn the key to the ON position and back to the OFF position to pressurize the fuel system. Check for leaks.
17. Check for leaks at connections by using a commercial grade soapy solution or an electronic leak detector. If leaks are detected, make proper repairs.
18. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XV. ENGINE COOLANT TEMPERATURE SENSORS (ECT)



Coolant Temperature Sensors & Gasket

REMOVAL PROCEDURE

1. Disconnect the Negative battery cable.
2. Locate the Engine Coolant Temperature Sensors on the right side of the water pump.
3. Remove electrical connector.
4. Using an extra deep socket or open end wrench, remove the sensor.

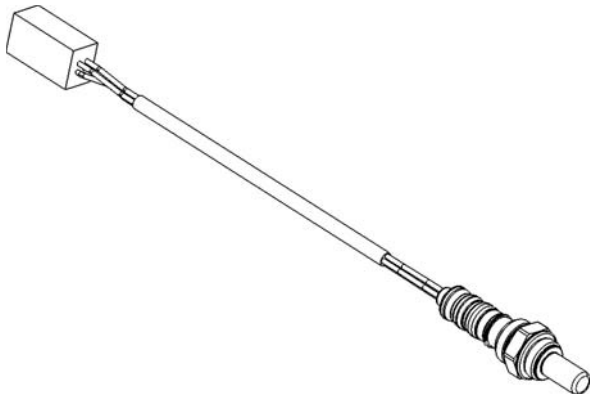
CAUTION

The coolant may be hot. Use caution when to prevent contact with coolant or related components.

INSTALLATION PROCEDURE

1. Apply a minimal amount of pipe thread sealer to threads on the Engine Coolant Temperature Sensor. Remove any excess sealer on threads or the sensor.
2. Install Engine Coolant Temperature Sensor. **Torque until tight.** Note that the lower sensor (2) requires Gasket (3).
3. Reconnect electrical connector.
4. Reconnect the Negative battery cable.
5. Using the Spectrum Engine Monitor, clear DTC information from the ECM.
6. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XVI. HEATED EXHAUST GAS OXYGEN SENSOR (HEGO)



Heated Exhaust Gas Oxygen (HEGO) Sensor

REMOVAL PROCEDURE

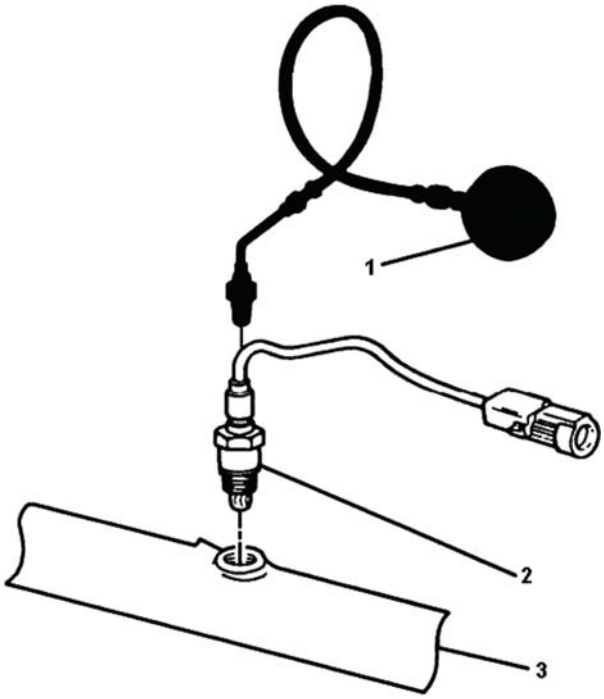
1. Disconnect Negative battery cable.
2. Locate the Oxygen Sensor on the exhaust pipe disconnect the Oxygen sensor electrical connector.
3. Using an Oxygen Sensor socket or open end wrench, remove the Oxygen Sensor.

INSTALLATION PROCEDURE

IMPORTANT
Before installing the Oxygen Sensor lubricate threads with a high temperature anti-seize compound. Avoid contaminating sensor tip with compound.

1. Install Oxygen Sensor. **Torque to 50 Nm (37 ft. lbs.)**.
2. Reconnect electrical connector to the Oxygen Sensor.
3. Reconnect the Negative battery cable.
4. Using the Spectrum Engine Monitor, clear DTC information from the ECM.
5. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XVII. RESTRICTED EXHAUST SYSTEM DIAGNOSIS



1. Back Pressure Gauge
2. Heated Exhaust Gas Oxygen (HEGO) Sensor.
3. Exhaust Manifold

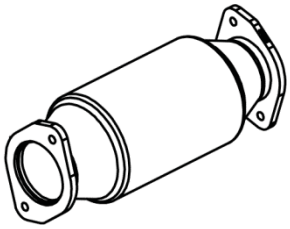
Exhaust Back Pressure Test

PROCEDURE:

1. Carefully remove the HEGO. Refer to *XVI. HEATED EXHAUST GAS OXYGEN SENSOR (HEGO).*
2. Install Exhaust Back Pressure Test Gauge (J35314-A) in place of the HEGO.
3. With the engine idling at normal operating temperature, observe the exhaust system back pressure reading on the gauge. Reading should not exceed 8.6 kPa (1.25 psi).
4. Increase engine speed to 2000 RPM and observe gauge. Reading should not exceed 20.7 kPa (3 psi).
5. If the back pressure at either speed exceeds specification, a restricted exhaust system is indicated.
6. Inspect the entire exhaust system for a collapsed pipe, heat distress or possible internal catalytic converter failure. Repair as necessary.

7. If there are no obvious reasons for the excessive back pressure, the catalytic converter is likely damaged and should be replaced.

XVIII. CATALYTIC CONVERTER



Catalytic Converter

REMOVAL PROCEDURE

1. Remove the Catalytic Converter using the OEM end product processes

INSTALLATION PROCEDURE

IMPORTANT
The Catalytic converter is specifically designed to meet the emission control of the certified engine. Use only the OEM specified part and install the Catalytic Converter using the OEM end product processes.

1. Start engine
2. Check for any DTC codes and clear
3. Verify engine is in closed loop and no MIL lights are present.

XIX. LPG FUEL PRESSURE RELIEF

CAUTION

The LPG fuel system operates at pressure up to 21.5 bar (312 psi). To minimize personal injury, relieve the LPG fuel system pressure before servicing the LPG fuel system components.

1. Close the manual shut-off valve (MSV) on the LPG fuel tank.
2. Start and run the vehicle until the engine stalls from lack of fuel.
3. Turn the ignition switch to OFF.
4. Disconnect the Negative battery cable.

WARNING

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

CAUTION

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

Always inspect the LPG 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.

XX. LPG FUEL SYSTEM PRESSURE CHECK

1. Turn ignition to OFF.
2. Connect the Spectrum Monitor and view the fuel pressure on the Gauge Page.
3. In the event the pressure reading and Fuel Rail Pressure Sensor are suspect, the pressure can be manually read by removing the plug on the end of the rail (opposite the fuel inlet port). Prior to removing the plug, relieve the Fuel Pressure refer to *XIX. LPG FUEL PRESSURE RELIEF.* Next, remove the plug on the end of the Fuel Rail and install a fitting, hose and pressure gauge. Reconnect the Negative battery cable and turn the key to ON. Note the fuel pressure, then start the engine and note the pressure when the engine is running.
4. Apply a minimal amount of pipe thread sealer, then replace Plug. **Torque until tight**.

XXI. LPG FUEL CONTROL SYSTEM CHECK

The fuel system can be thoroughly diagnosed by use of the Spectrum Engine Monitor tool. See section *Spectrum Engine Monitor.*

XXII. LPG FUEL SYSTEM LEAK TEST

There are two leak checks that can done on this fuel system:

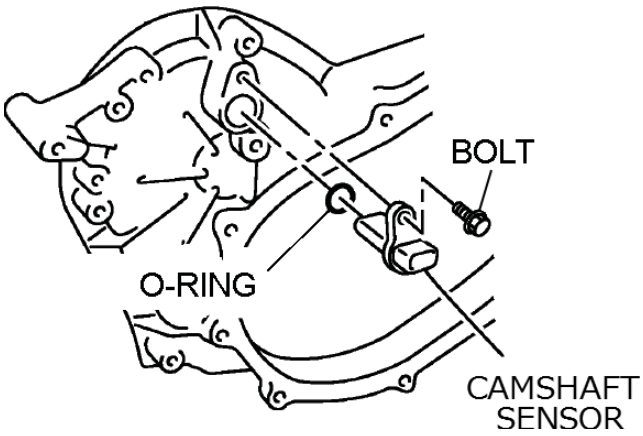
1. A commercially available liquid leak detector or an electronic leak detector can be used to detect leaks. Be sure to follow the manufacturers' instructions.

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

2. The injectors can be tested for an internal leak (excess fuel flow or leakage into the cylinders) and all of the fuel passages downstream of the regulator can be tested as follows:

   - Key ON, engine OFF.
   - Using the Spectrum Engine Monitor, plot the fuel pressure on the Plot page or note the pressure on the Monitor page.
   - Note the fuel pressure (as measured in the fuel rail by the FRT/FRT sensor) for 25 seconds.
   - After an additional 25 seconds, note any drop in fuel rail pressure. A drop of more than 3 kPa in 25 seconds is excessive and indicates a leaking injector(s), fuel hose, fitting, etc., downstream of the regulator. Use a leak detector to determine if the fuel is leaking outside of the fuel system. If no leak is found, an injector is leaking and should be replaced. Refer to *XII. Fuel Injector.*

XXIII. CAMSHAFT POSITION SENSOR



Camshaft Sensor

REMOVAL PROCEDURE

1. Disconnect Negative battery cable.
2. Remove the fan belt and the Crankshaft Pulley. Refer to *XXVIII. CRANKSHAFT PULLEY.*
3. Remove the electrical connector on the sensor.
4. Remove the Bolts securing the front Engine Cover and remove Cover.
5. Remove the bolt securing the Camshaft Sensor and remove the Sensor.

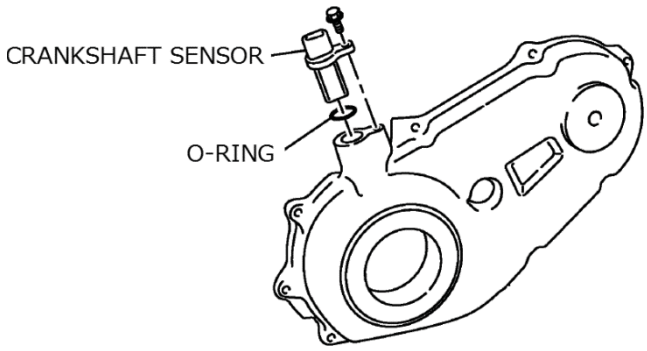
INSTALLATION PROCEDURE

1. Mount Camshaft Sensor. Secure with Bolt and **torque to 5.4 to 7.4 Nm (4.0 to 5.5 ft.lbs.).**

NOTE: Spacing is important for the sensor to properly read the wheel. Make sure the sensor is properly positioned and seated.

2. Remove any old sealant material and verify sealant surfaces are clean and free of old sealant and any foreign material.
3. Apply a light coat of oil to the Crankshaft Seal.
4. Apply liquid sealant (Refer to Parts Section).
5. Replace front Engine Cover. Secure with bolts and torque to 15-20 ft.lb. (20.6-26.5 Nm).
6. Connect electrical connector to the Camshaft Sensor.
7. Replace the fan belt and the Crankshaft Pulley. Refer to *XXVIII. CRANKSHAFT PULLEY.*
8. Reconnect Negative battery cable.
9. Start engine.
10. Using the Spectrum Engine Monitor, clear DTC information from the ECM.
11. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XXIV. CRANKSHAFT POSITION SENSOR



Crankshaft Position Sensor

REMOVAL PROCEDURE

1. Disconnect Negative battery cable.
2. Remove the electrical connector.
3. Remove the Bolt and the Crankshaft Sensor from the front engine cover.

INSTALLATION PROCEDURE

1. Lubricate the O-ring with petroleum jelly or Vaseline.
2. Mount Camshaft Sensor with Bolt and **torque to 5.4 to 7.4 Nm (4.0 to 5.5 ft.lbs.).**

NOTE: Proper spacing is crucial to ensure the sensor can accurately read the wheel. Verify that the sensor is properly seated and the screws securing it are not cross threaded.

3. Connect electrical connector.
4. Reconnect Negative battery cable.
5. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XXV. VACUUM LINE

REMOVAL PROCEDURE

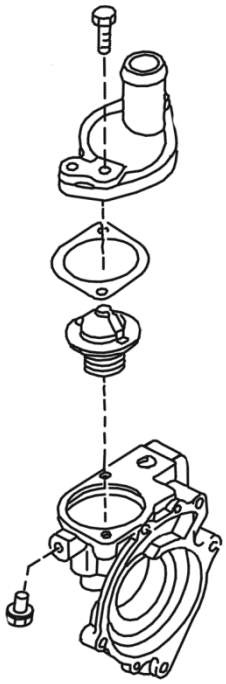
1. Remove the Vacuum Line from each fitting.
2. Inspect for rotting, deterioration, holes and tears and replace if necessary.

INSTALLATION PROCEDURE

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

1. Reinstall the Fuel Vapor Hose to each fitting.
2. Reconnect to fittings using petroleum jelly or Vaseline if necessary.
3. Start engine and check for leaks using an electronic leak detector. If leaks are detected make repairs or replace the hose.

XXVI. THERMOSTAT AND/OR HOUSING



Coolant Housing

REMOVAL PROCEDURE

1. Disconnect Negative battery cable.
2. Drain coolant.

CAUTION

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

3. Remove clamps from Hoses connecting to the Thermostat Housing and remove Hoses.
4. Remove two Bolts securing Thermostat Housing
5. Remove Thermostat Housing, Thermostat and Gasket.

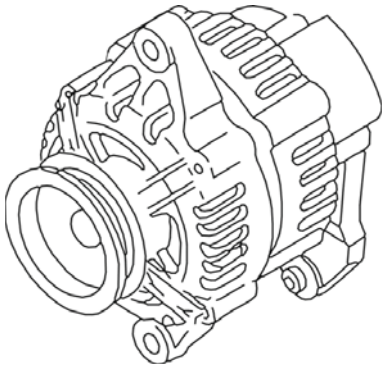
INSTALLATION PROCEDURE

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

1. Ensure the mating surfaces are clean and

free of any debris.
2. Insert Thermostat and Gasket into Housing.
3. Place Bolts into Housing and thread into engine. **Torque to 15.7 to 17.7 Nm (11.6 to 13.1 ft.lbs)**.
4. Connect Hoses to Housing and secure with clamps.
5. Refill with coolant.
6. Reconnect battery cable.
7. Start engine and let run until it reaches operating temperature.
8. Check for leaks. If leaks are detected, make repairs.
9. Stop engine and allow to cool. Check coolant level and add coolant as necessary.

XXVII. ALTERNATOR & FAN BELT



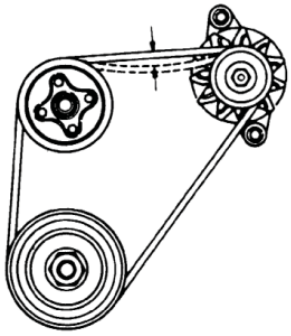
Alternator

REMOVAL PROCEDURE

1. Disconnect Negative battery cable.
2. Disconnect wires to the Alternator.
3. Remove top Bolt securing Alternator.
4. Loosen lower Bolts.
5. Remove Belt.
6. Remove Bolts securing the Alternator and remove Alternator.

INSTALLATION

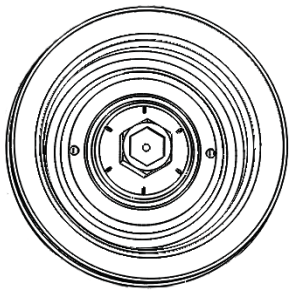
1. Place Alternator so the side with two mounting ears mate up with the two tabs of the lower Alternator Bracket.
2. Insert Bolts through the lower tabs and finger tighten nuts.
3. Place Belt over the Alternator pulley
4. Insert top Bolt and finger tighten.
5. Rotate the Alternator outward until it the holes in the upper tab and alternator bracket meet and install Bolt. **Torque all three Bolts to tight.**



Fan Belt Deflection

6. Test belt deflection by placing approximately 22 lbs (10 kg) of pressure between to of the pulleys and note deflection. If the belt is deflected more than half an inch (11-13mm), loosen bolts and repeat step 5.
7. Attach the wires to the Alternator.
8. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

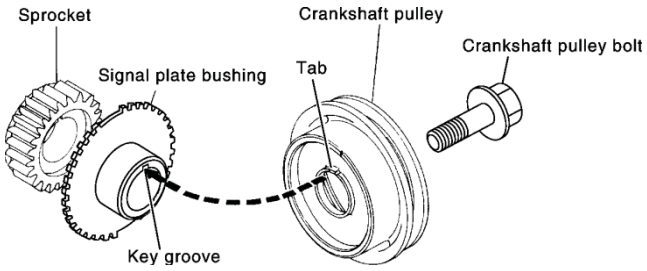
XXVIII. CRANKSHAFT PULLEY



Crankshaft Pulley, Front View

1. Remove the Belt from the Alternator. Refer to *XXVII. ALTERNATOR*.
2. Remove the Crankshaft Pulley Bolt.
3. Remove Crankshaft Pulley.

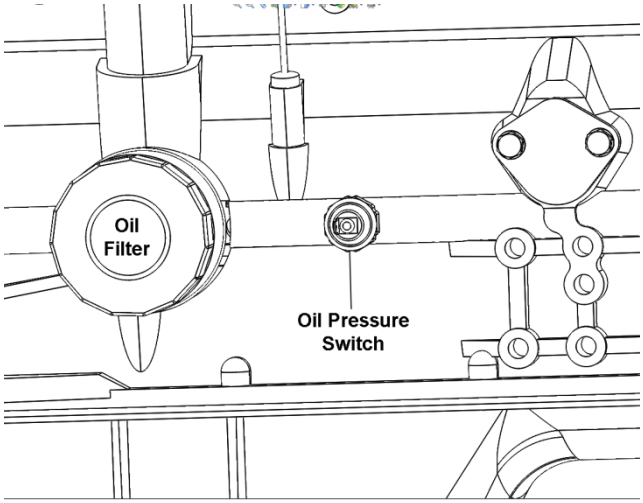
INSTALLATION



Crankshaft Pulley Installation

1. Align the tab inside the Crankshaft Pulley (as shown above) and set on the Signal Plate Bushing.
2. Insert bolt and **torque to 163 to 177 ft.lbs (220.5 to 240.1 Nm).**
3. Replace Belt. Refer to *XXVII. ALTERNATOR*.
4. Connect Negative battery terminal.
5. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XXIX. OIL PRESSURE SWITCH



Oil Pressure Switch

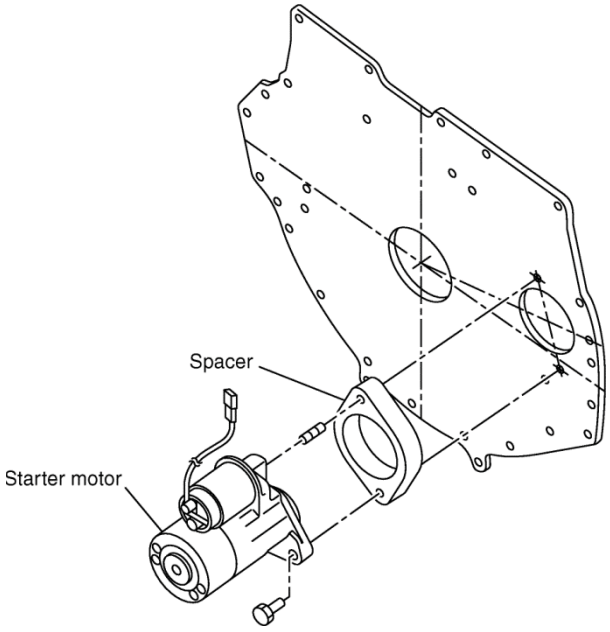
REMOVAL PROCEDURE

1. Disconnect the Negative battery cable.
2. Locate the Oil Pressure Sender on the side of the engine block near the Oil Filter.
3. Remove electrical connection from the Switch.
4. Remove the Switch using a 1 inch open end wrench.

INSTALLATION PROCEDURE

1. Apply Loctite 567 (or equivalent high-temp thread locker/sealer) to the threads on the Oil Pressure Sender.
2. Install Oil Pressure Sender. **Torque until tight.**
3. Plug in electrical connector.
4. Reconnect Negative battery cable.
5. Start the vehicle and verify engine is in closed loop, operates normally in all throttle ranges and no MIL light is present.

XXX. STARTER



Starter, Spacer and Plate

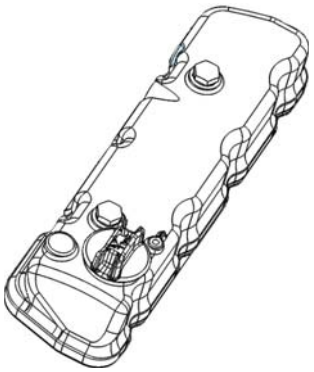
REMOVAL PROCEDURE

1. Disconnect Negative battery cable.
2. Disconnect positive wire from starter solenoid.
3. Disconnect electrical connector.
4. Remove two Bolt and Nut securing starter to the engine plate, remove starter and adapter spacer.
5.

INSTALLATION PROCEDURE

1. Secure Starter to Engine with Bolt and Nut. **Torque each until tight**.
2. Connect Negative battery cable.
3. Start the vehicle and verify the starter engages the flywheel correctly.

XXXI. VALVE COVER



Valve Cover

REMOVAL PROCEDURE

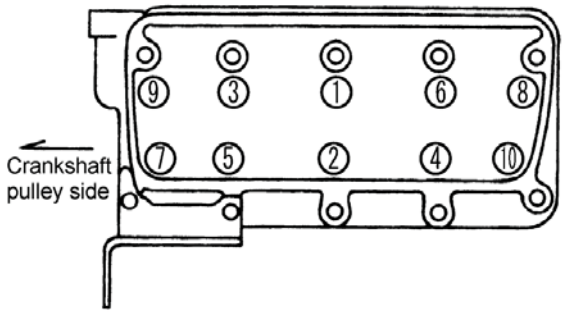
1. Disconnect Negative battery cable.
2. Remove two bolts securing Valve Cover.
3. Remove Valve Cover.

INSTALLATION PROCEDURE

1. Ensure all mating surfaces on the valve cover and engine block are clean and free of any debris.
2. Place a bead gasket sealer, on the mating surfaces on bottom of the bottom of the valve cover.
3. Finger tighten stud screws, then torque Screws to **1.4 to 1.6 ft.lbs. (13.7 to 15.7 Nm)**.
4. Clean any excess sealant and dispose of properly.

XXXII. CYLINDER HEAD BOLTS

1. Remove Valve Cover Refer to *XXXI Valve Cover*. Retighten the cylinder head bolts in order shown in the figure while the engine is cold.



Top View of Cylinder Head, Showing Cylinder Head Bolt Tightening Sequence

2. **Torque cylinder head bolts to 51 ft.lbs. (68.6 Nm).**

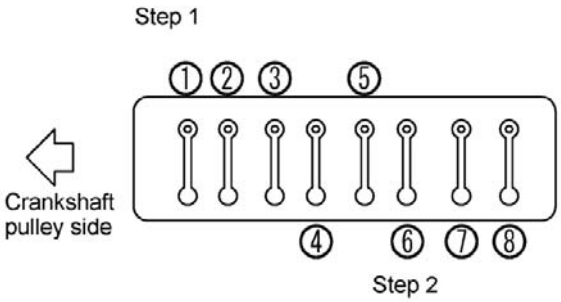
XXXIII. INTAKE & EXHAUST VALVE CLEARANCE

Note: Adjust when the engine is hot.

CAUTION

The engine will be hot. Use caution when removing parts to prevent contact.

1. Warm up engine until it reaches normal operating temperature then stop it.
2. Disconnect Negative battery cable.
3. Remove Valve Cover. *Refer to XXXI Valve Cover*.
4. Using a large breaker bar and a 1 3/16" socket mounted on the crankshaft bolt, turn the crankshaft (and the engine) until the piston of the No.1 cylinder in the compression TDC and adjust the valves of (1), (2), (3) and (5). Remove cylinder 1 Spark Plug if necessary to determine TDC. Refer to *XXXIV Spark Plug.*
5. Set the piston for the No.4 cylinder to the compression TDC by rotating crank again and adjust the valves of (4), (6), (7) and (8). Remove cylinder 1 Spark Plug if necessary to determine TDC. Refer to *XXXIV Spark Plug.*

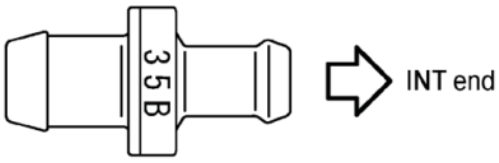


Valve Adjustment Order

- Intake/exhaust valve clearance (Hot)
- Intake: 0.015 in (0.38 mm)
- Exhaust: 0.015 in (0.38 mm)

5. Replace Spark Plug(s) if removed. *Refer to XXXIV Spark Plug*.
6. Remove Valve Cover. *Refer to XXXI Valve Cover*.

XXXIV. CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS
RESULTS OF INCORRECT OPERATION



PCV Valve

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

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

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

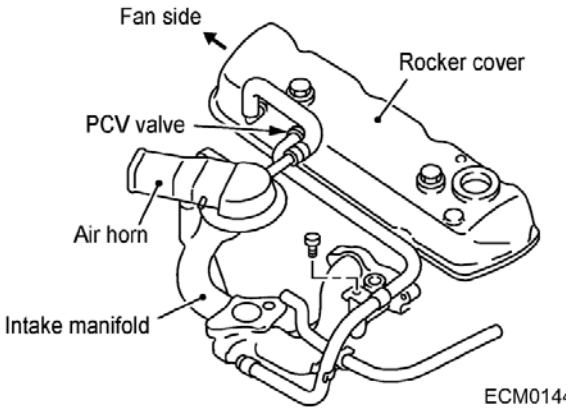
- Rough or unstable engine speed.
- Stalling
- High idle speed

Functional check:

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

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

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



Top of Engine Showing PCV Valve

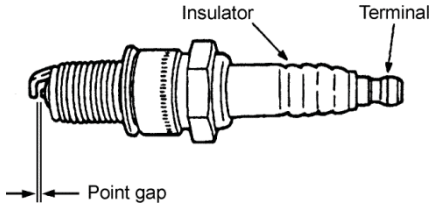
1. Remove the PCV hose (positive side) from the valve cover.
2. Operate the engine at idle.
3. Place your thumb over the end of the hose in order to check for vacuum. If there is no vacuum at the hose end, inspect for plugged hoses or a blockage at the manifold vacuum port.

If a problem is found:

- Turn the engine OFF.
- Inspect the PCV orifice in the valve cover for debris or blockage.
- Clean as necessary. If PCV is suspected, clean or replace.

XXXIV. SPARK PLUG

REMOVAL PROCEDURE



Spark Plug

1. Disconnect Negative battery cable.
2. Remove Spark Plug Wire
3. Using a ¾" Spark Plug Socket, remove Spark Plug.

INSTALLATION PROCEDURE

1. If replacing spark plug, inspect for cracks in the insulator, burned electrode or fouled plug. Replace if necessary.
2. Spark plugs should be gapped 0.034 to 0.035 inches (0.8 to 0.9 mm).

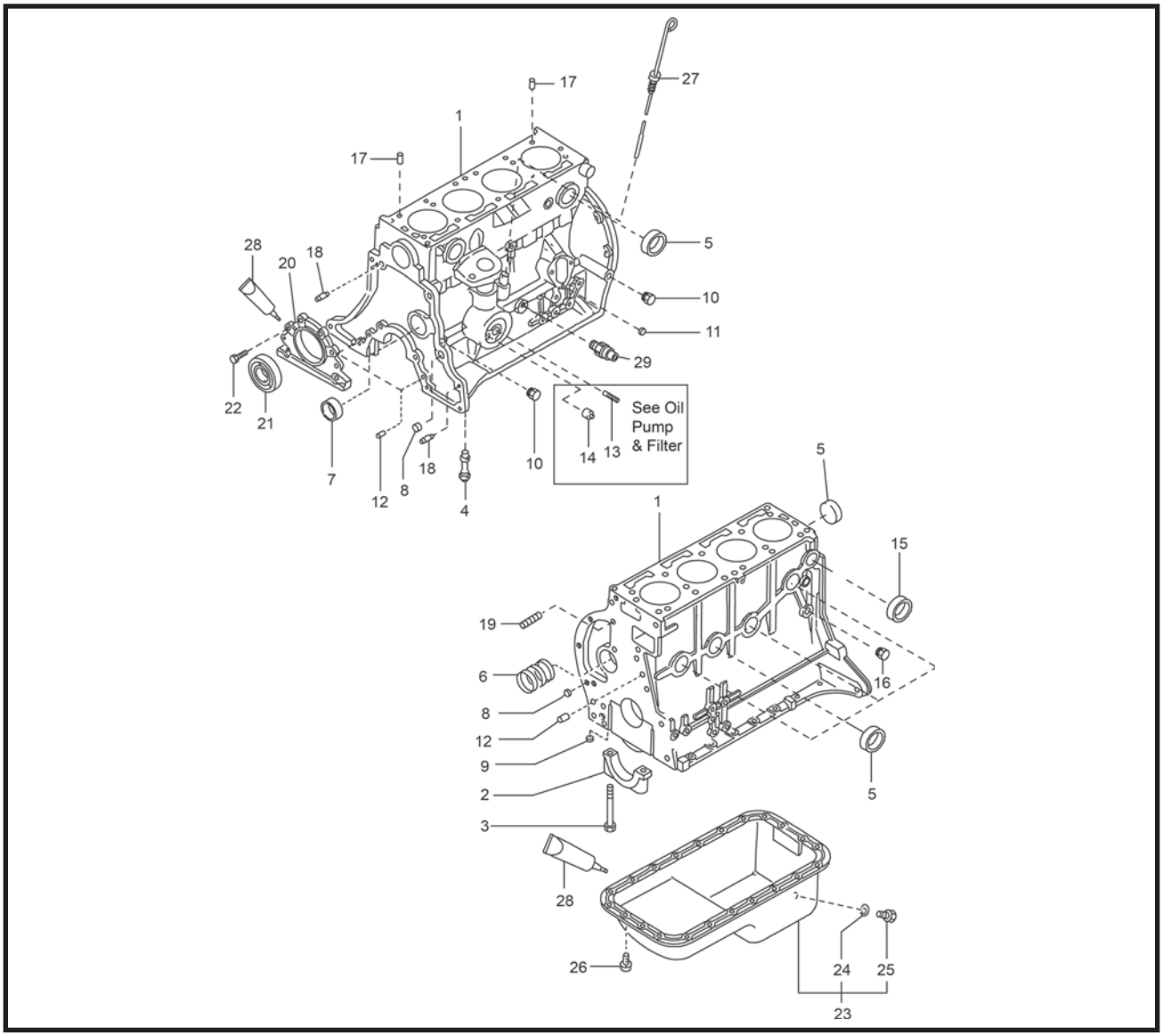
NOTE: When gapping plug, use care as to not damage the electrode.

3. Place anti-seize on threads of Spark Plug.
4. Replace spark plugs and torque to 14-22 ft.lbs (19.6-29.4 Nm).

Part Diagrams

NOTE: The part numbers listed in **BOLD** typeface are OEM Nissan K25 part numbers and are not available through IMPCO. Those parts listed in *ITALICS* are available through Unicarrier America in the USA. All others that appear in NORMAL typeface are available through IMPCO.

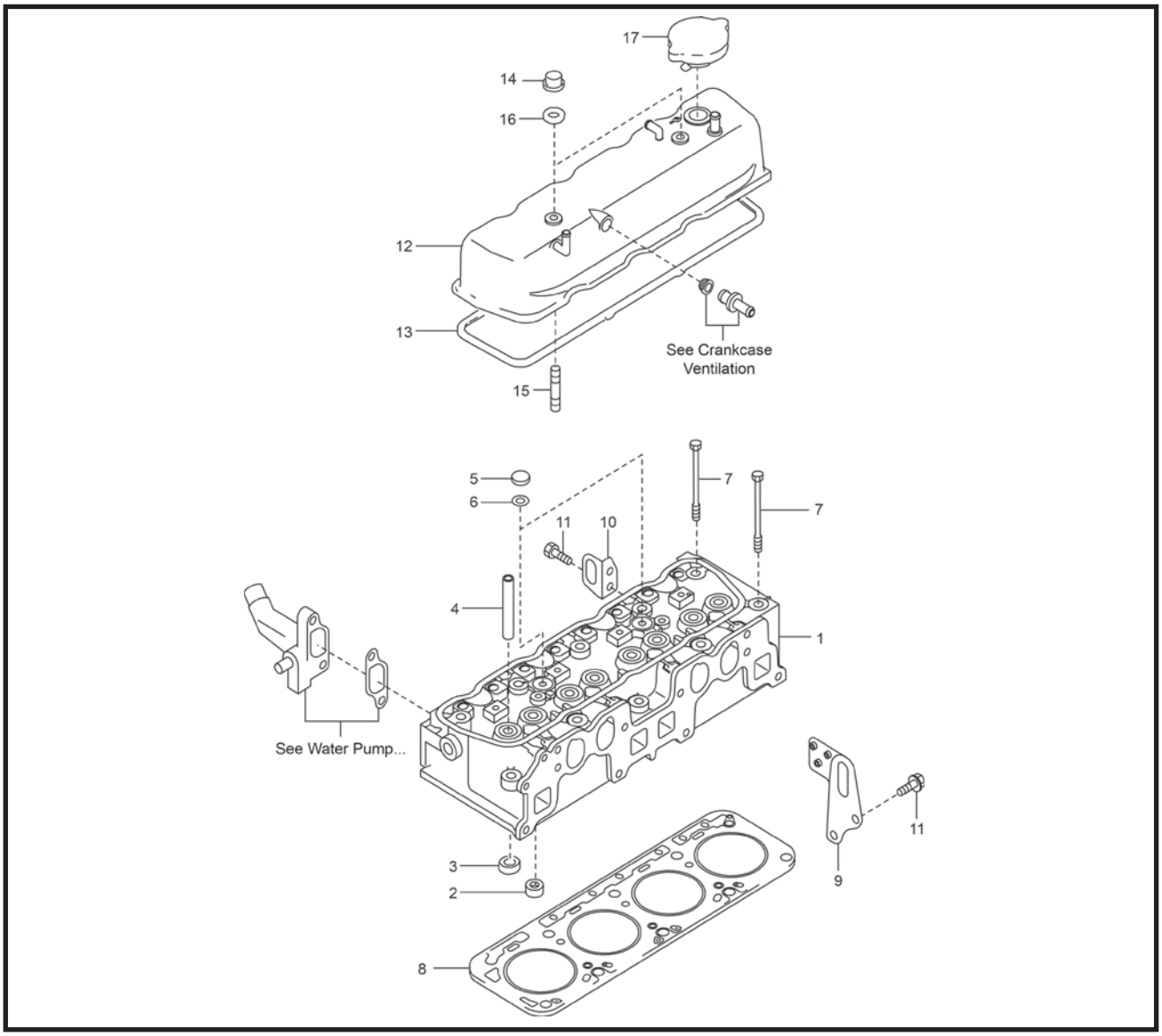
Engine (Internal)



ITEM	PART#	DESCRIPTION	QTY
1		BLOCK ASSY, INC. 2-15	1
2		NO PART NO. # CAP-MAIN BEARING	5
3	12293GJ01A	BOLT-MAIN BEARING CAP	10
4		NO PART NO. # BUSH	1
5	009331351A	PLUG-WELCH	7
6	1300271200	SET-BUSH CAMSHAFT	1
7	11019GJ00A	PLUG	1
8	11024GJ11A	PLUG-TAPER	2
9	1102478200	PLUG-BLIND	1
10	11024GJ01A	PLUG-TAPER	2
11	1102378200	PLUG-TAPER	1
12	11022GJ00A	PIN-DOWEL	4
13	NO PART NO.	STUD-OIL FILTER	1
14	NO PART NO.	VALVE ASSY-RELIEF	1
15	009331301A	PLUG-WELCH	1

ITEM	PART#	DESCRIPTION	QTY
16	11024GJ10A	PLUG-TAPER	1
17	11053GJ00A	DOWEL	2
18	30412GJ01A/ 30412GJ00A	DOWEL	2
19	1139250K00	STUD	2
20	12297FU41A	RETAINER	1
21	12279FJ10B	SEAL-OIL	1
22	081208201E	BOLT	4
23	11110FU400	PAN ASSY-OIL INC.24,25 24	1
24	1102601M02	WASHER	1
25	1112801M00	PLUG-DRAIN	1
26	0812061228	BOLT	12
27	11140FT86A	GAUGE ASSY-OIL LEVEL	1
28	NFL1000250	GASKET-LIQUID	AR
29	25240FJ10A	SWITCH ASSY-OIL PRESS	1

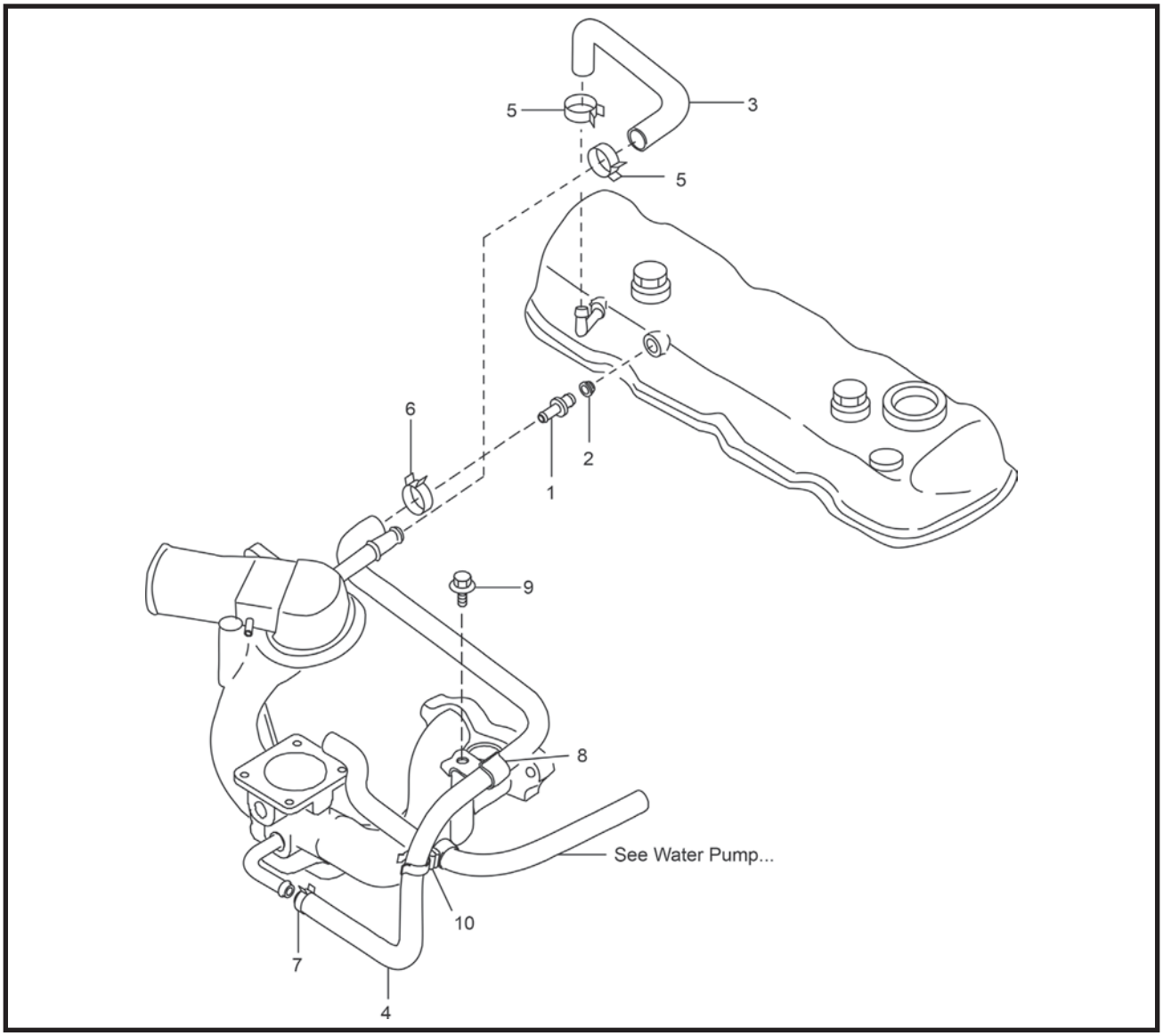
Cylinder Hear & Rocker Cover



ITEM	PART#	DESCRIPTION	QTY
1	11040FY501	HEAD ASSY-CYLINDER INC.2-6	1
2	NO PART NO. #	SEAT-VALVE,INTAKE	4
3	NO PART NO. #	SEAT-VALVE,EXHAUST	4
4	NO PART NO. #	GUIDE-VALVE	8
5	089317181A	PLUG	2
6	11026GJ00A	GASKET	2
7	11056FY50A	BOLT	10
8	11044FU400	GASKET	1
9	10005GS00A	SLINGER,FR	1
10	10006FU41A	SLINGER,RR	1
11	0112105351	BOLT	4
12	13264FU40A	COVER ASSY-VALVE ROCKER	1
13	13270FY50A	GASKET	1
14	13274B110A	NUT-CAP	2

ITEM	PART#	DESCRIPTION	QTY
15	0822388010	STUD	2
16	1326888V62	WASHER	2
17	15255FJ10A	CAP ASSY-OIL FILLER	1

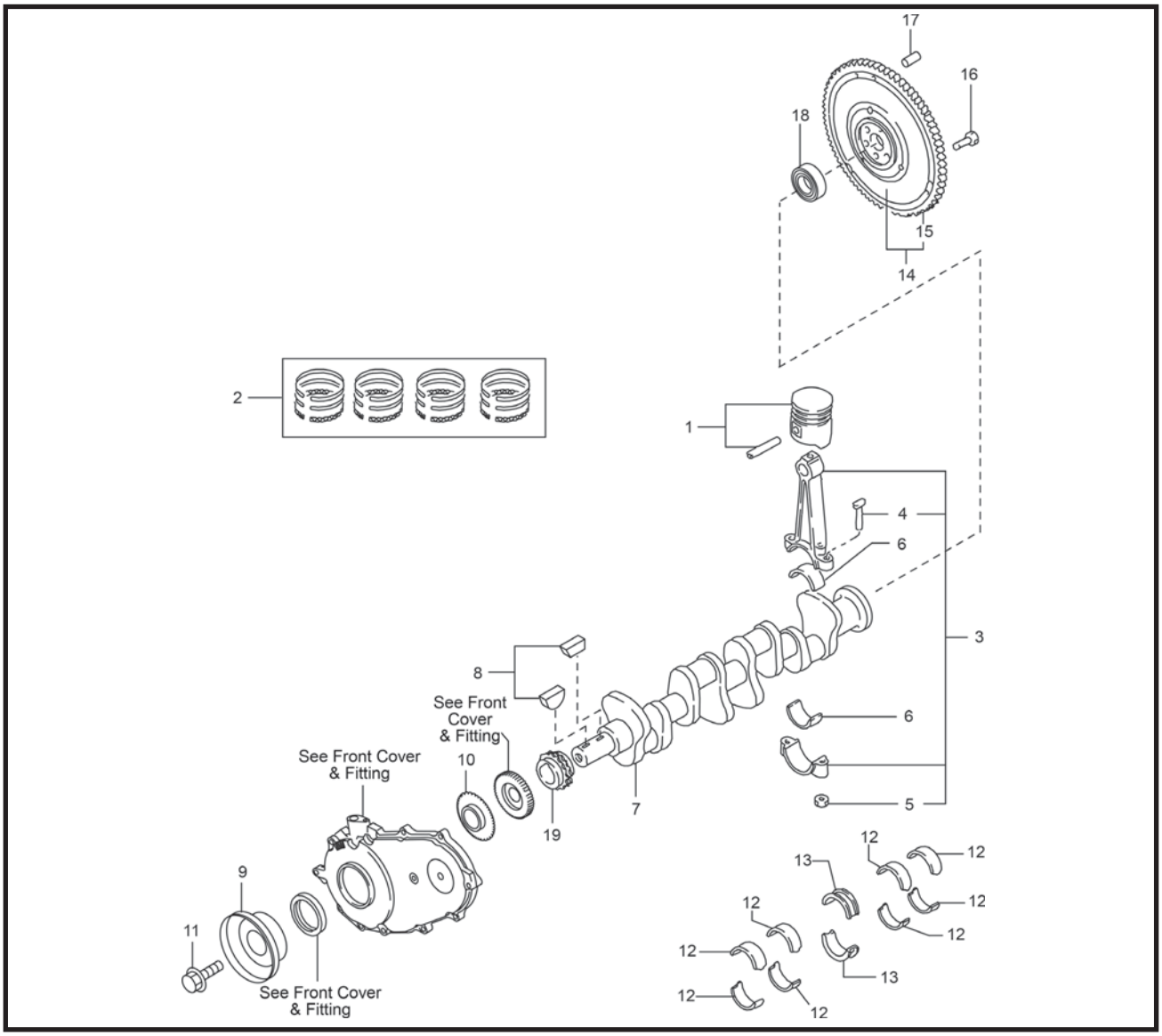
Crankcase Ventilation



ITEM	PART#	DESCRIPTION	QTY
1	11810FJ10A	VALVE ASSY-CTRL, BLOWBY	1
2	11812GJ00A	INSULATOR-PCV VALVE	1
3	11828FU400	HOSE-BLOWBY GAS	1
4	11823GS00A	HOSE ASSY-BLOWBY	1
5	16439GJ00A	CLIP-HOSE	2
6	16439GJ01A	CLIP-HOSE	1
7	164397S01C	CLIP-HOSE	1
8	24220FU400	CLIP	1
9	0812061228	BOLT	1
10	2422055Y00	CLIP	1

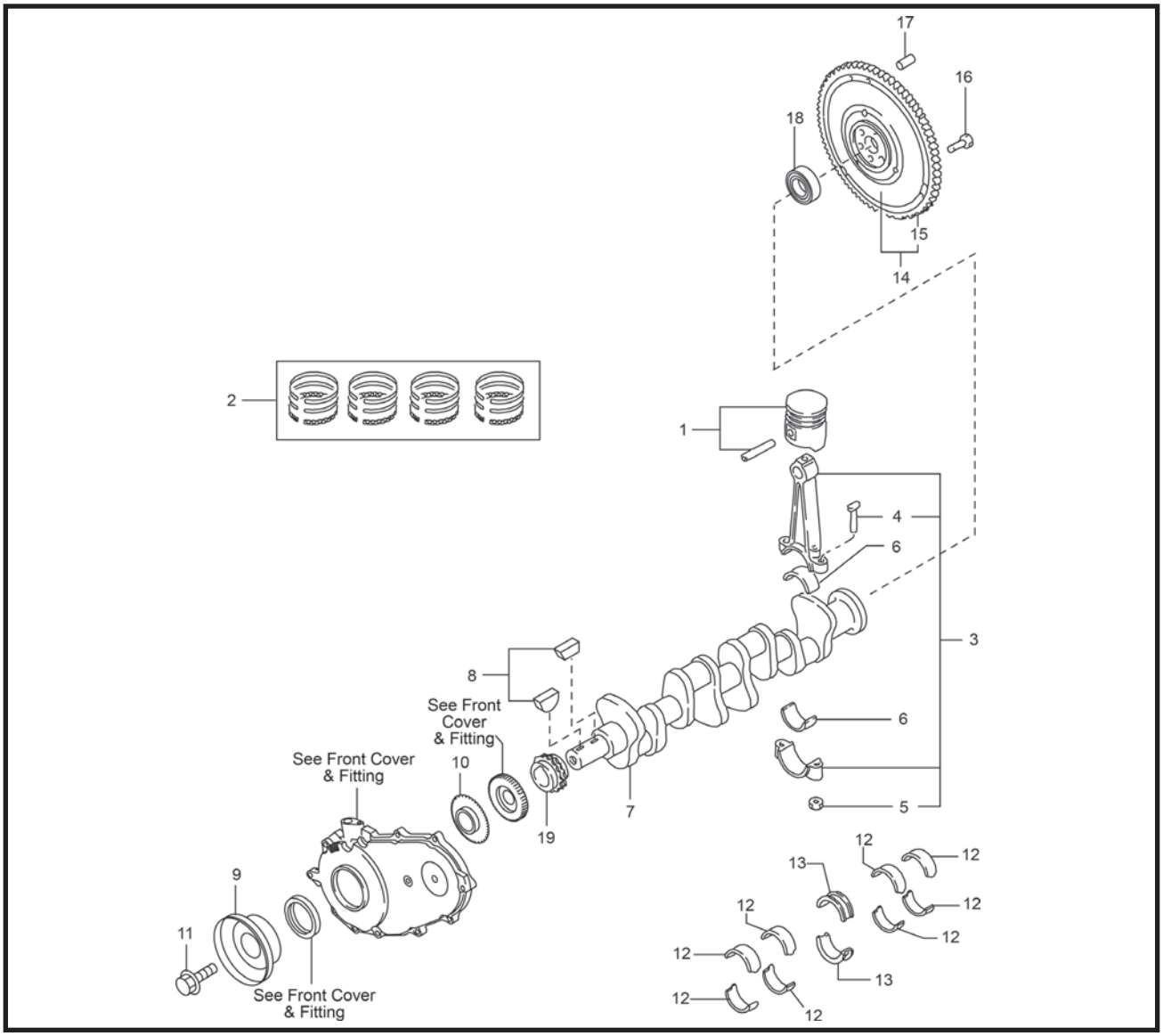
ITEM	PART#	DESCRIPTION	QTY

Piston, Crankshaft & Flywheel



ITEM	PART#	DESCRIPTION	QTY
1	12010GS10A	PISTON SET, W/PIN STD GRD1	4
	12010GS10B	PISTON SET, W/PIN STD GRD2	4
	12010GS10C	PISTON SET, W/PIN STD GRD3	4
	12010GS10D	PISTON SET, W/PIN STD GRD4	4
	12010GS10E	PISTON SET, W/PIN STD GRD5	4
	12010GS17A	PISTON SET, W/PIN OS=0.50	4
	12010GS17B	PISTON SET, W/PIN OS=1.00	4
2	12033AE003	RING SET-PISTON STD	1
	12036GS00A	RING SET-PISTON OS=0.50	1
	12038GS00B	RING SET-PISTON OS=1.00	1
3	12100FY50A	ROD ASSY-CONNECTING INC.4, 5	4
4	12109GQ70A	BOLT	8
5	12112H1000	NUT	8
6	12111FY500	BEARING-CNCTNG ROD STD	8

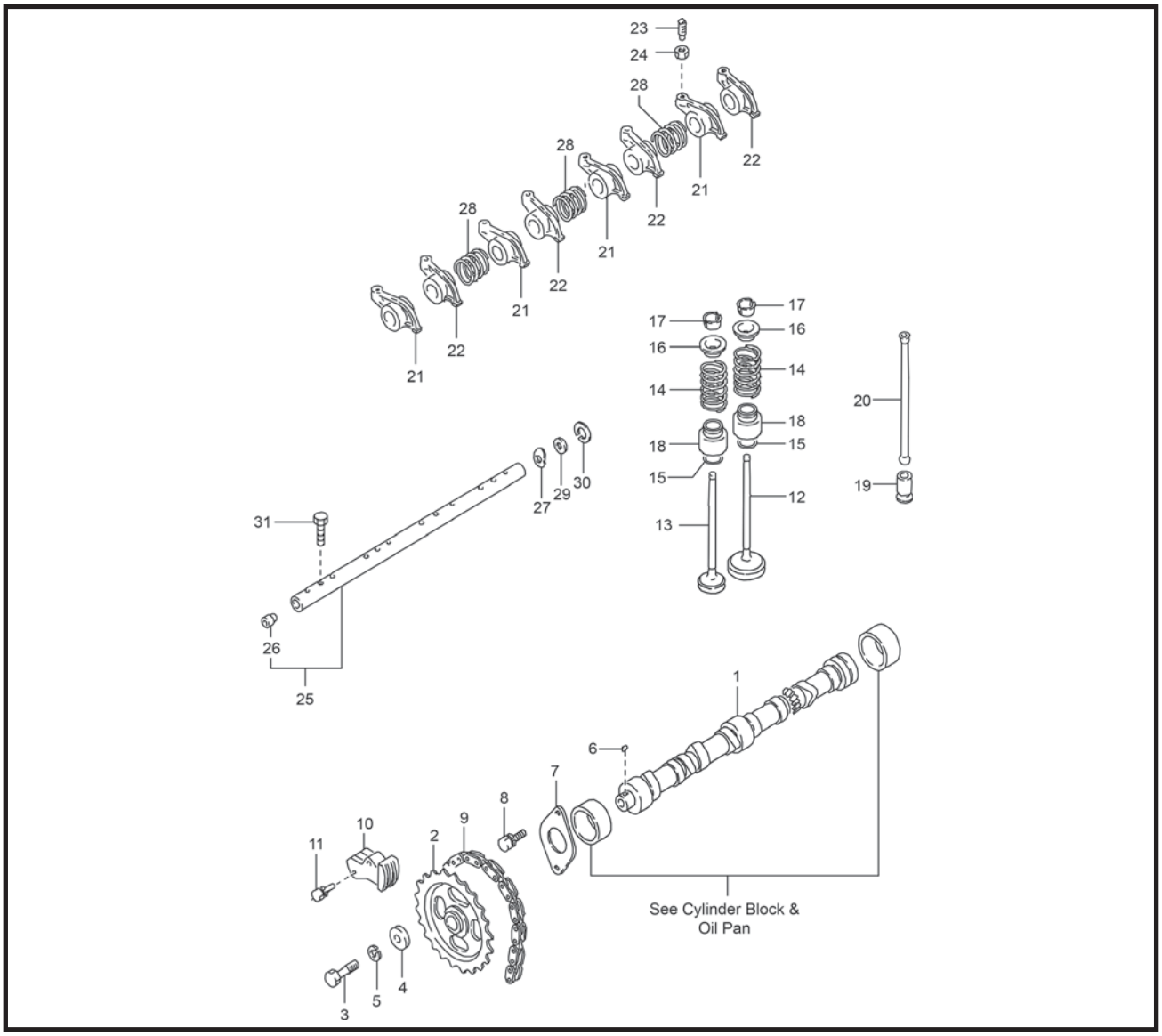
ITEM	PART#	DESCRIPTION	QTY
6	12117FY500	BEARING-CNCTNG ROD 0.08	8
	12118FY500	BEARING-CNCTNG ROD 0.12	8
	12119FY500	BEARING-CNCTNG ROD 0.25	8
7	12201GW90A	CRANKSHAFT	1
8	0092651600	KEY	2
9	12303FU400	PULLEY ASSY-CRANKSHAFT	1
10	12307GX10A	BUSH	1
11	12309FU400	BOLT	1
12	12231FY500	BEARING-MAIN,INTER STD	8
	12232FY500	BEARING-MAIN,INTER 0.02	8
	12233FY500	BEARING-MAIN,INTER 0.25	8
	12234FY500	BEARING-MAIN,INTER 0.50	8
	12235FY500	BEARING-MAIN,INTER 0.75	8
	12236FY500	BEARING-MAIN,INTER 1.00	8
13	1224750K00	BEARING-MAIN,CTR STD	2



ITEM	PART#	DESCRIPTION	QTY
13	1224850K00	BEARING-MAIN,CENTER 0.02	2
	1224950K00	BEARING-MAIN,CENTER 0.25	2
	1225050K00	BEARING-MAIN,CENTER 0.50	2
	1225150K00	BEARING-MAIN,CENTER 0.75	2
	1225250K00	BEARING-MAIN,CENTER 1.00	2
14	1231050K00	FLYWHEEL ASSY INC.15	1
15	1231250K00	GEAR-RING	1
16	12315GJ00A	BOLT	6
17	12313GJ00A	DOWEL-PIN	3
18	32203FU400	BEARING	1
19	13021FY50A	SPROCKET	1

ITEM	PART#	DESCRIPTION	QTY

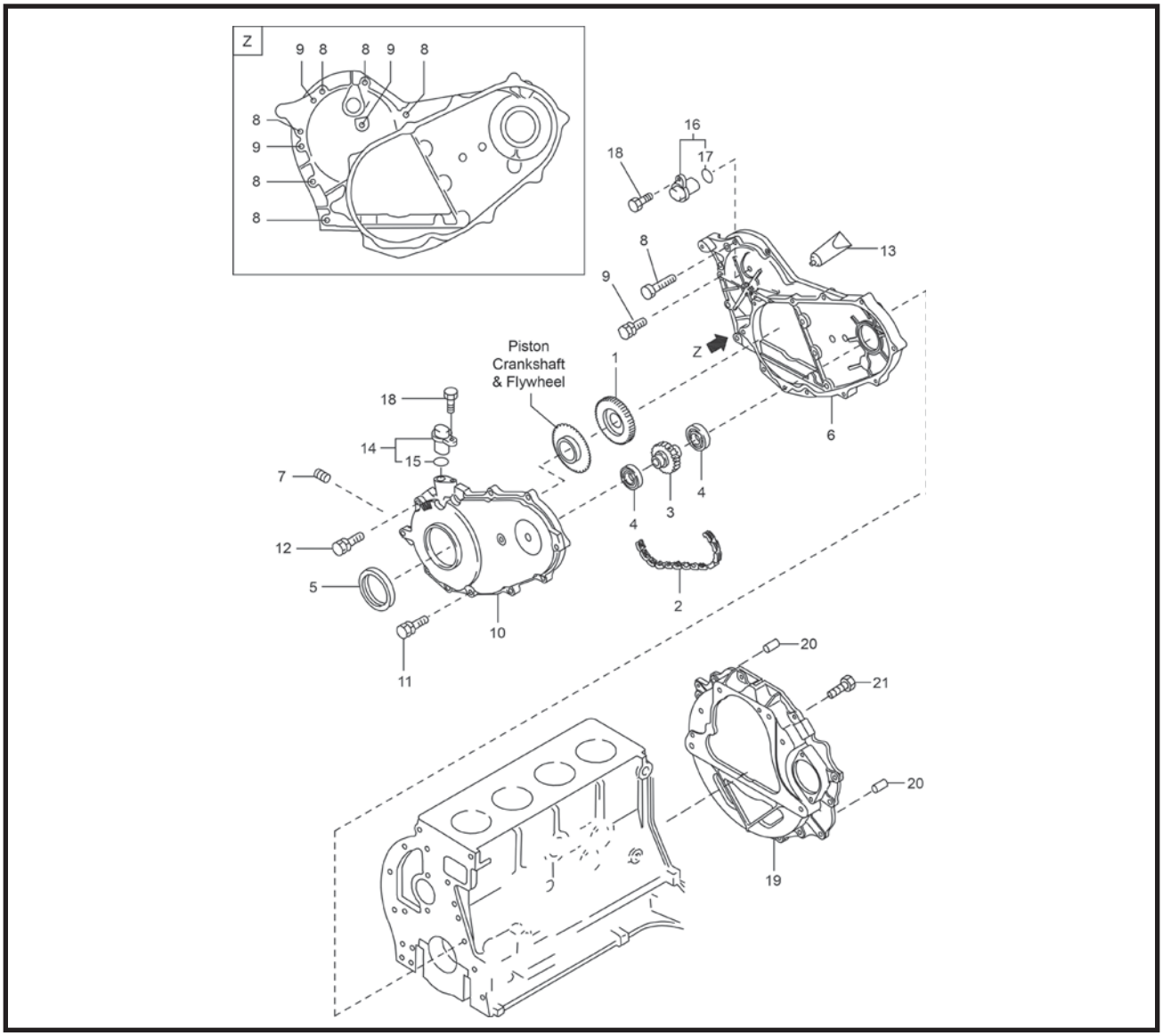
Camshaft & Valve Mechanism



ITEM	PART#	DESCRIPTION	QTY
1	13001GS00A	CAMSHAFT	1
2	13024FY50A	SPROCKET	1
3	081710401A	BOLT	1
4	1301378200	WASHER	1
5	089151401A	WASHER	1
6	0092641610	KEY	1
7	13010GJ01A	PLATE	1
8	0812061628	BOLT	2
9	13028FU400/1302887V00	CHAIN	1
10	1307050K00	TENSIONER	1
11	0812063528	BOLT	2
12	13201FY50A	VALVE-INTAKE	4
13	13202FU40A	VALVE-EXHAUST	4
14	13203FY50A	SPRING	8
15	13205GJ00A	SEAT-VALVE	8

ITEM	PART#	DESCRIPTION	QTY
16	13209GJ00A	RETAINER	8
17	13210GJ00A	COLLET	16
18	13207GJ01A/13207GJ00A	SEAL-OIL	8
19	13231GJ01A	VALVE LIFTER	8
20	13238FY500	PUSHROD	8
21	13258FY500	ARM-VALVE ROCKER,R H	4
22	13258FY510	ARM-VALVE ROCKER,LH	4
23	13234GJ01A	ADUST-SCREW	8
24	1323578200	NUT	8
25	13252FY500	SHAFT, INCL.26	1
26	13254GJ00A	PLUG	2
27	13255GJ00A	SPRING	2
28	13256GJ00A	SPRING	3
29	14686GJ00A	WASHER	2
30	0092212010	RING-SNAP	2
31	081A08251A	BOLT	4

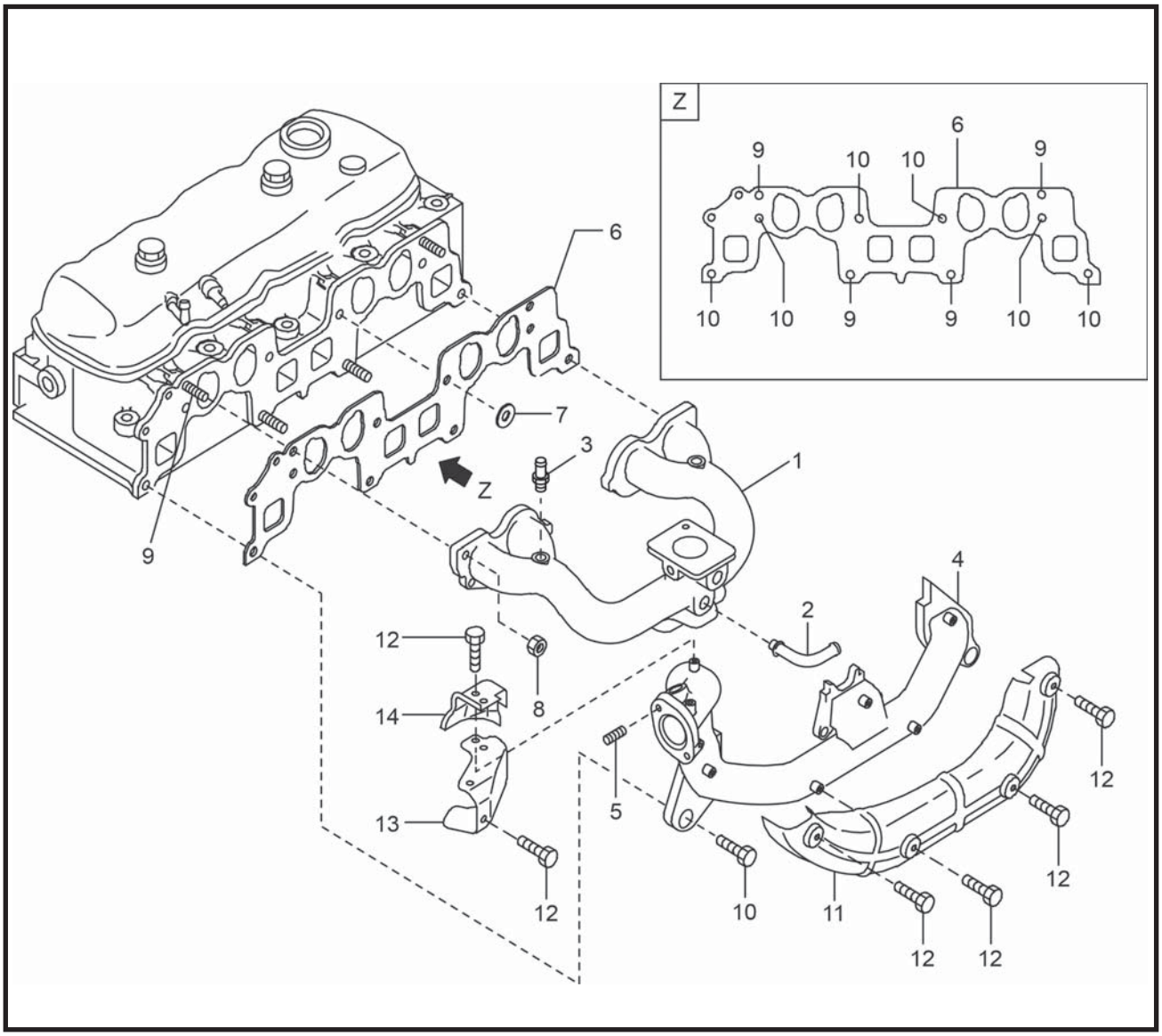
Front Cover & Fitting



ITEM	PART#	DESCRIPTION	QTY
1	12351FU400	SPROCKET-DRIVE	1
2	12352FU400	CHAIN	1
3	12353FU400	SPROCKET-DRIVEN	1
4	1235450K00	BEARING	2
5	13510FF200	SEAL-OIL	1
6	13034FU41A	CASE-GEAR	1
7	11022GJ00A	PIN-DOWEL	1
8	081208451E	BOLT	6
9	081208251E	BOLT	3
10	13501FU42A	COVER	1
11	081208251E	BOLT	10
12	0812062533	BOLT	1
13	NFL1000250	GASKET	AR
14	23731GJ00A	SENSOR-CRNK ANGLE INC.15	1

ITEM	PART#	DESCRIPTION	QTY
15	221314M505	SEAL-O RING	1
16	23731GJ01A	SENSOR-CRANK ANGLE INC.17	1
17	221314M505	SEAL-O RING	1
18	0812062033	BOLT	2
19	1232050K00	HOUSING-FLYWHEEL	1
20	3041361700	DOWEL	2
21	0112503311	BOLT	4

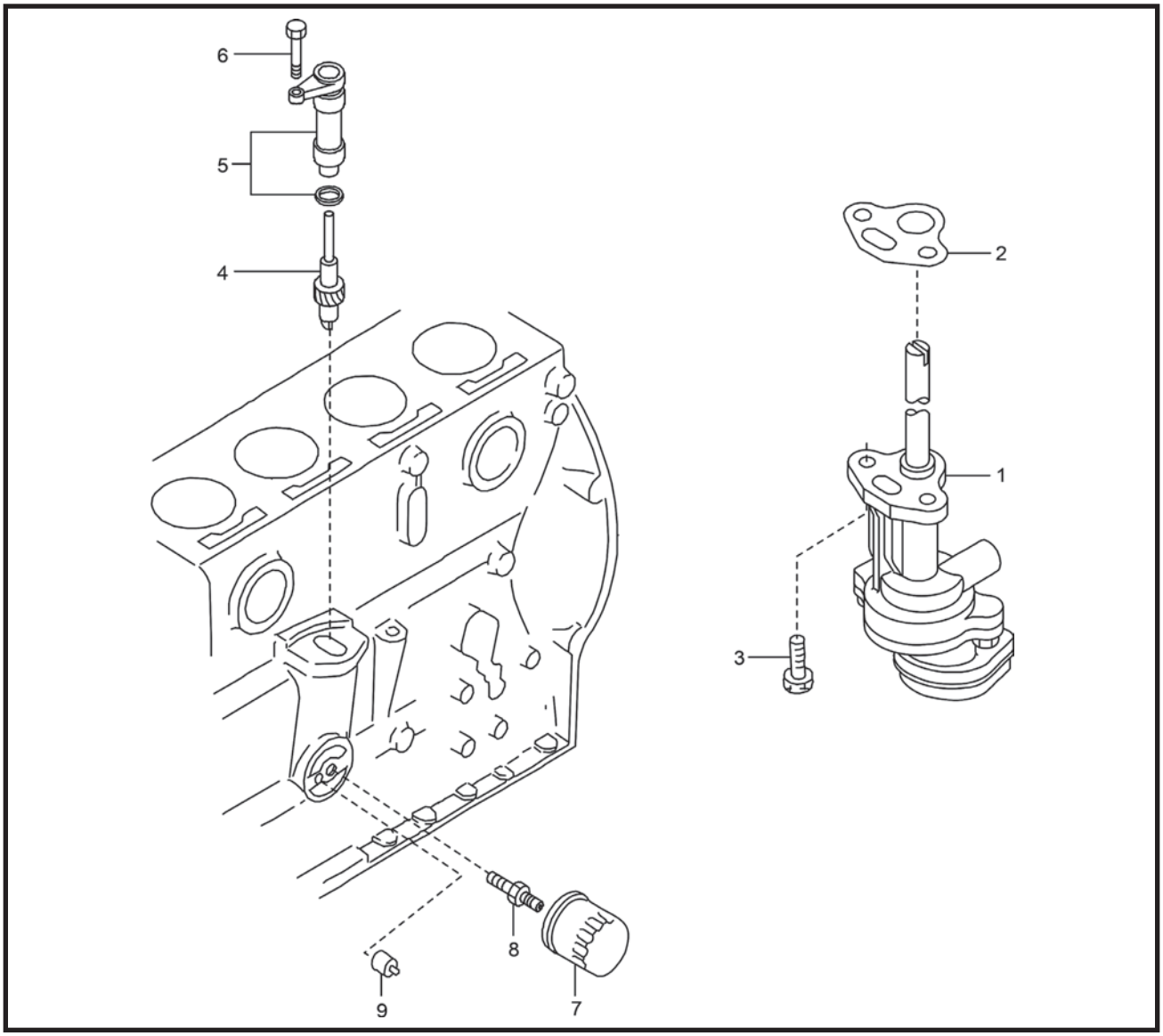
Manifolds



ITEM	PART#	DESCRIPTION	QTY
1	14003GS01A	MANIFOLD-INTAKE	1
2	14875FU46A	CONNECTOR-HOSE	1
3	14875GJ00A	CONNECTOR-VACUUM	1
4	14004GS00A	MANIFOLD-EXHAUST	1
5	0822383210	STUD	2
6	14035FY500	GASKET	1
7	14037GJ00A	YOKE	6
8	14094GJ00A	NUT	4
9	0826703510	STUD	4
10	081240351A	BOLT	6
11	16590GS00A	COVER	1
12	14069GJ00A	BOLT	7
13	16590GS00B	COVER	1
14	16590GS00C	COVER	1

ITEM	PART#	DESCRIPTION	QTY

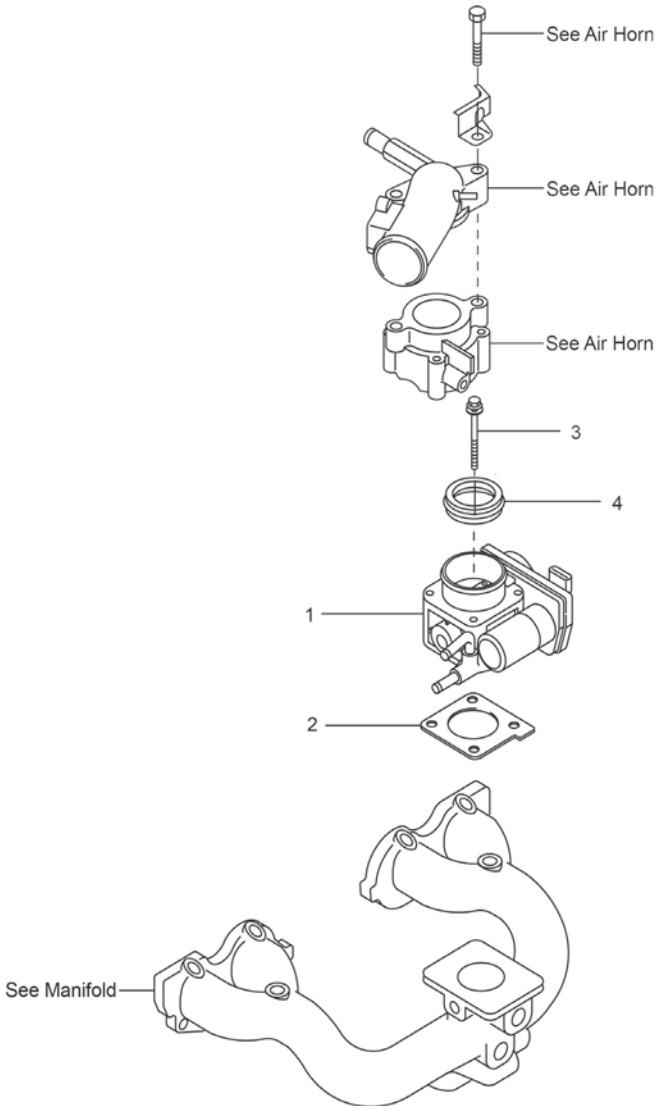
Oil Pump & Filter



ITEM	PART#	DESCRIPTION	QTY
1	15010GQ70B	PUMP ASSY-OIL	1
2	1506678200	GASKET	1
3	081208201E	BOLT	2
4	15040FU46A	SPINDLE	1
5	221774K40A	SUPPORT	1
6	081208351E	BOLT	1
7	15208FJ10B	ELEMENT-OIL FILTER	1
8	15213GJ00A	STUD	1
9	15241GJ00A	VALVE ASSY-RELIEF	1

ITEM	PART#	DESCRIPTION	QTY

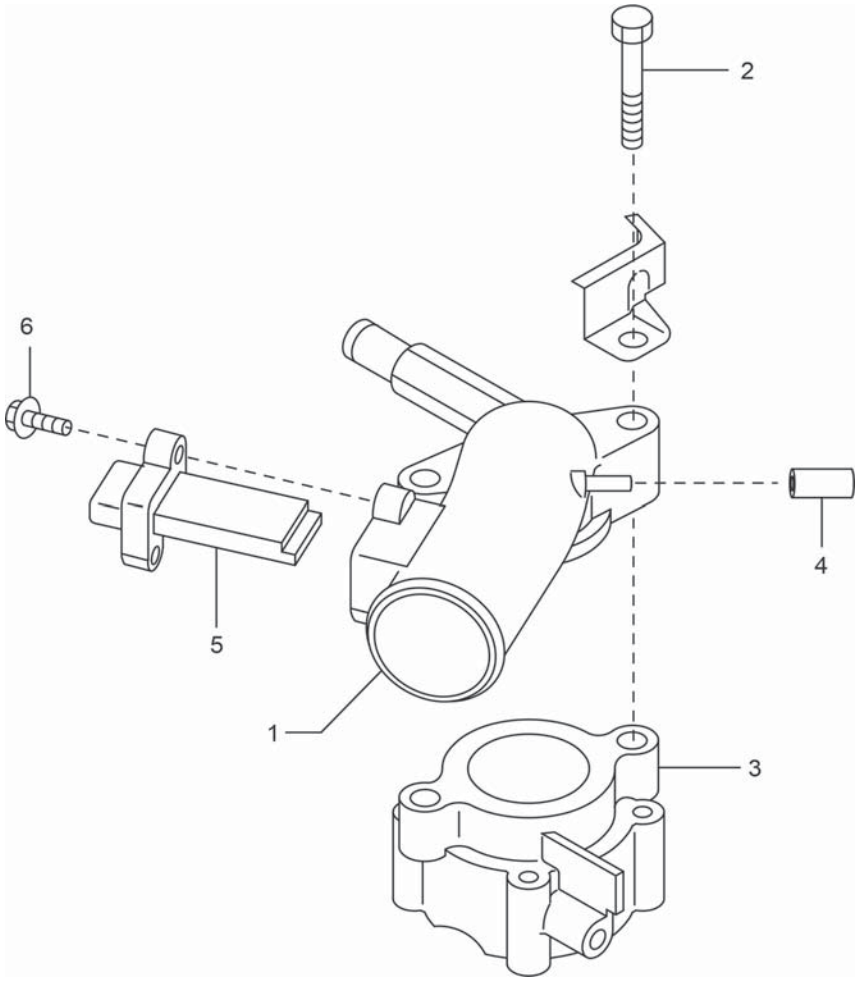
Throttle Body



ITEM	PART#	DESCRIPTION	QTY
1	16119GS00A	CHAMBER-THROTTLE	1
2	16175GS00A	GASKET	1
3	16185GS00A	BOLT	4
4	16175GS00B	GASKET	1

ITEM	PART#	DESCRIPTION	QTY

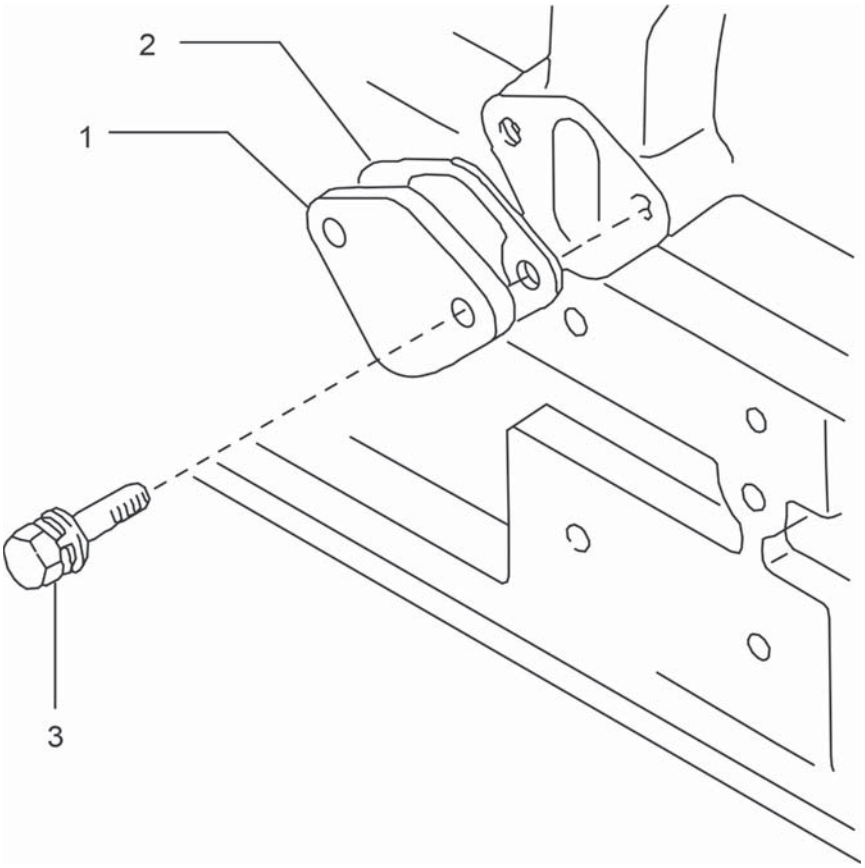
Air Horn



ITEM	PART#	DESCRIPTION	QTY
1	16267GS00A	HORN ASSY-AIR	1
2	16185GS10B	BOLT	2
3	16270GS01A	SPACER	1
4	16599GJ00A	CAP	1
5	226807S000	METER ASSY-AIR FLOW	1
6	083404082A	SCREW	2

ITEM	PART#	DESCRIPTION	QTY

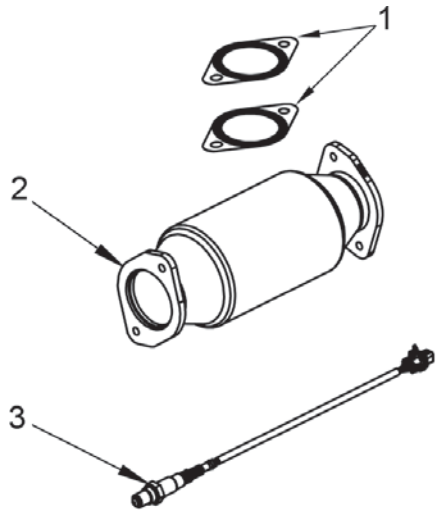
Fuel Pump Spacer



ITEM	PART#	DESCRIPTION	QTY
1	17099GJ02A	SPACER	1
2	17099GJ00A	GASKET	1
3	081208201E	BOLT	2

ITEM	PART#	DESCRIPTION	QTY

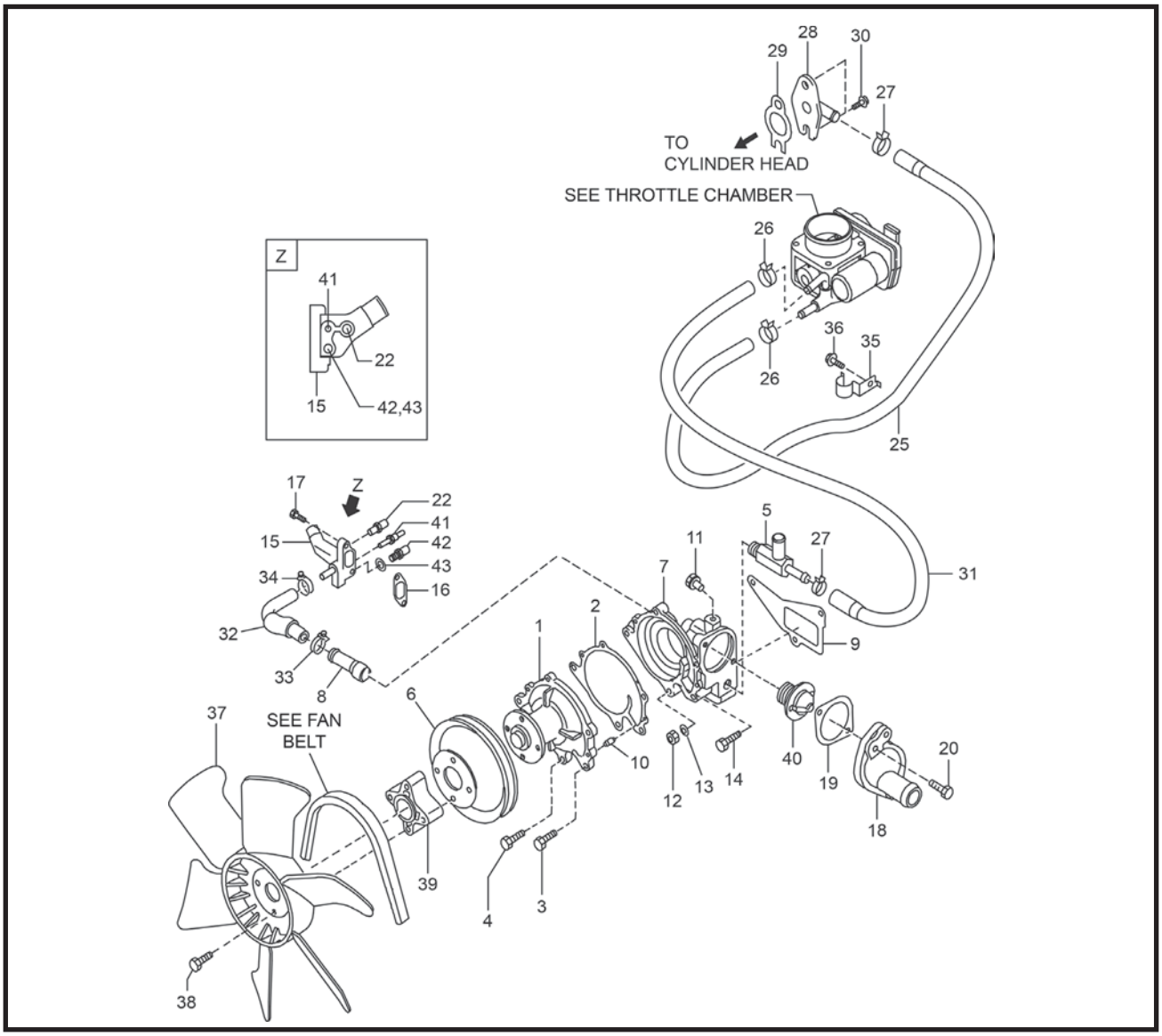
Catalyst Converter & HEGO



ITEM	PART#	DESCRIPTION	QTY
1	*20692 GJ02A*	*GASKET*	2
2	*20800 FJ10C*	*CATALYTIC CONVERTER*	1
3	S8-50234-001	SENSOR, OXY, BOSCH	1

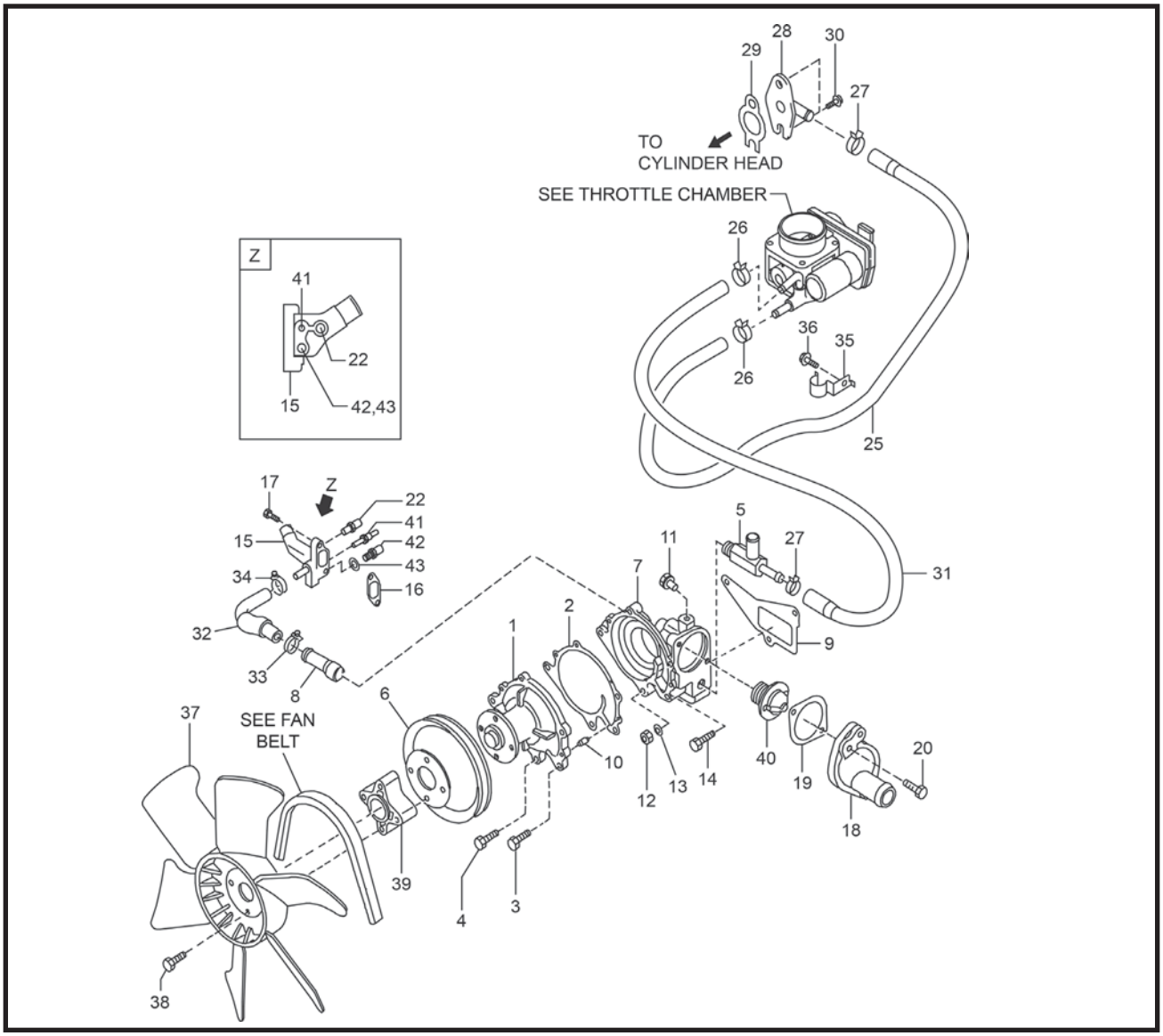
ITEM	PART#	DESCRIPTION	QTY

Water Pump, Cooling Fan & Thermostat



ITEM	PART#	DESCRIPTION	QTY
1	21010FU40A	PUMP ASSY-WATER	1
2	21014GJ00A	GASKET	1
3	081208201E	BOLT	2
4	0812062028	BOLT	3
5	14075FU46A	CONNECTOR-WATER	1
6	21051GY360	PULLEY-WATER PUMP	1
7	11061FU400	HOUSING	1
8	14075GJ00A	CONNECTOR-WATER	1
9	1107250K01	GASKET	1
10	11022GJ00A	PIN-DOWEL	2
11	14053GJ01A	PLUG-WATER	1
12	089111081A	NUT	2
13	089153381A	WASHER	2
14	21079K9760	BOLT	1
15	11060FU40A/11060FU40B	OUTLET-WATER	1
16	11062FY500	GASKET	1

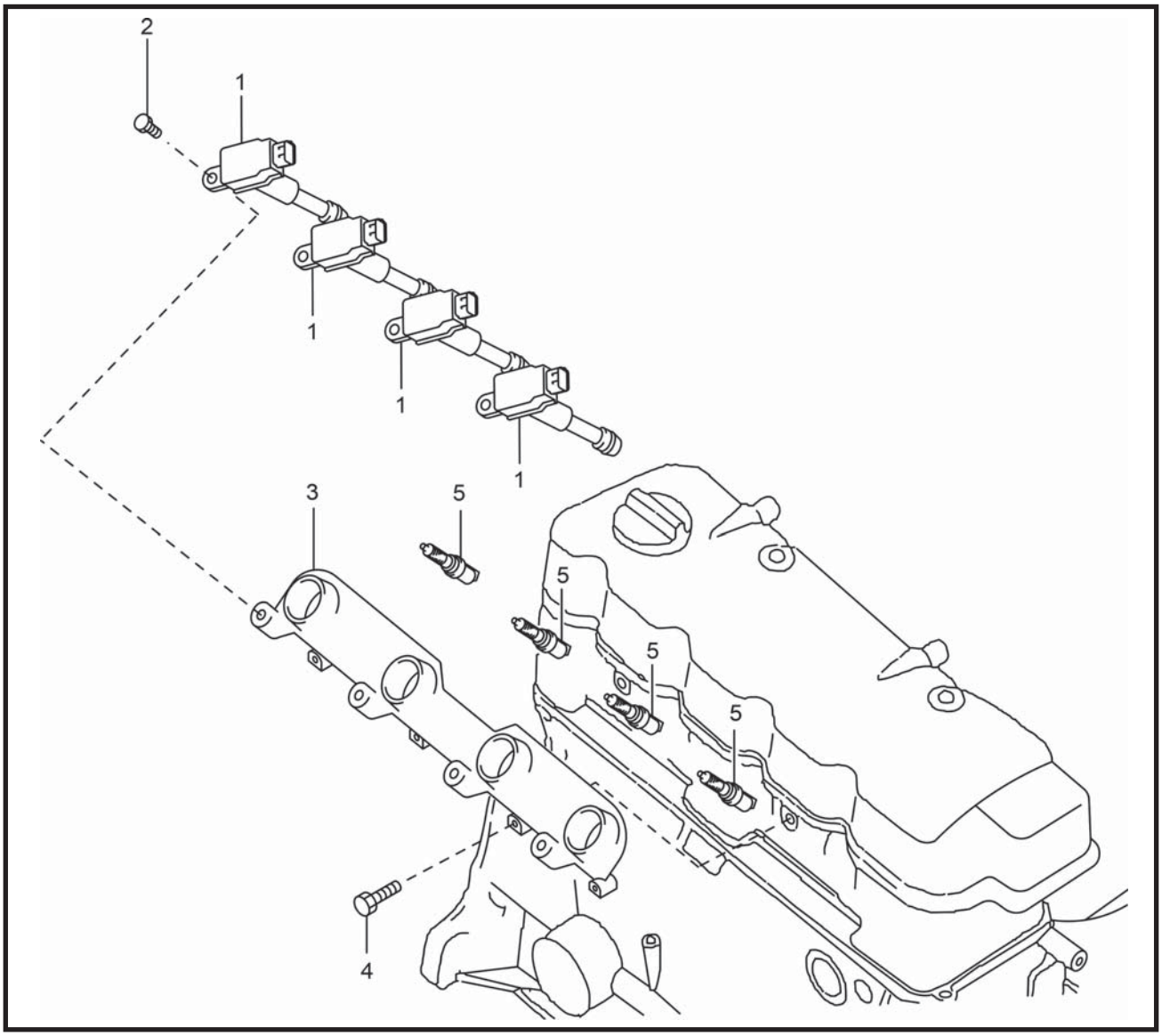
ITEM	PART#	DESCRIPTION	QTY
17	081208301E	BOLT	2
18	11060GJ00A	OUTLET-WATER	1
19	11062GJ00A	GASKET	1
20	081208301E	BOLT	2
22	016910005A	CONNECTOR-HOSE	1
25	14056GS01A	HOSE-WATER	1
26	1643956S0A	CLIP-HOSE	2
27	16439GJ02A	CLIP-HOSE	2
28	14053FU40A	PIPE ASSY-HEATER,FEED	1
29	13050FU400	GASKET	1
30	081A08161A	BOLT	2
31	14056GS01C	HOSE-WATER	1
32	1408050K0A	HOSE-WATER	1
33	0155500891/1643926E0A	CLAMP-HOSE	1
34	1643926E0A	CLIP-HOSE	1
35	14165GS00A	BRACKET	1



ITEM	PART#	DESCRIPTION	QTY
36	0812061228	BOLT	1
37	21060FU40A	FAN-COOLING	1
38	0812065028	BOLT	4
39	21064FU30A	SPACER	1
40	2120050K0A/2120050K0B	THERMO ASSY	1
41	25080FJ10A	SENSOR-TEMP	1
42	22630GN00B	SENSOR-WATER TEMP	1
43	22636GJ00A	GASKET	1

ITEM	PART#	DESCRIPTION	QTY

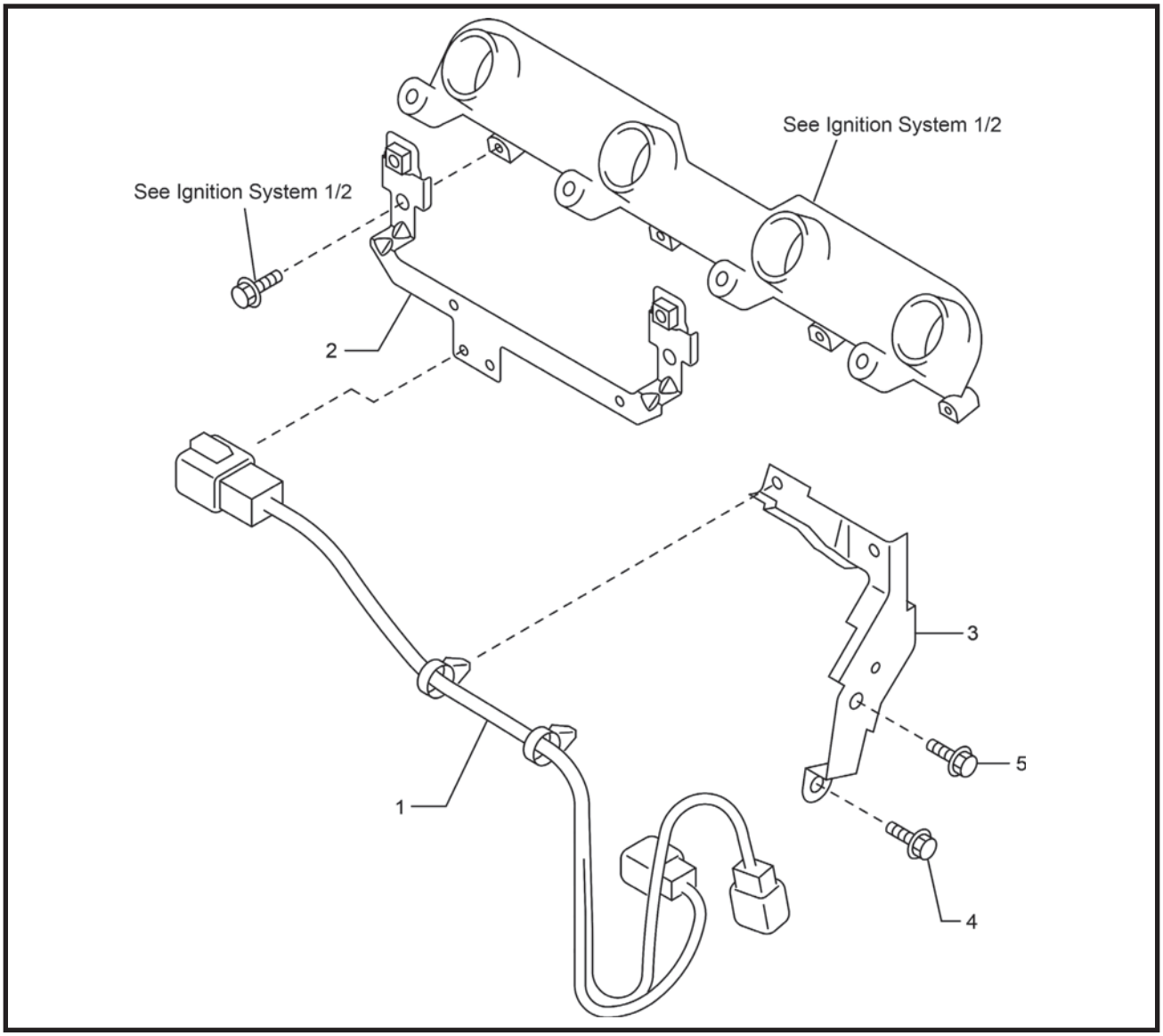
Ignition System 1/2



ITEM	PART#	DESCRIPTION	QTY
1	22448AR215	COIL ASSY-IGNITION	4
2	0812062028	BOLT	4
3	224355K60A/224355K60B	BRACKET	1
4	081208501E	BOLT	2
5	22401FU42A	PLUG	4

ITEM	PART#	DESCRIPTION	QTY

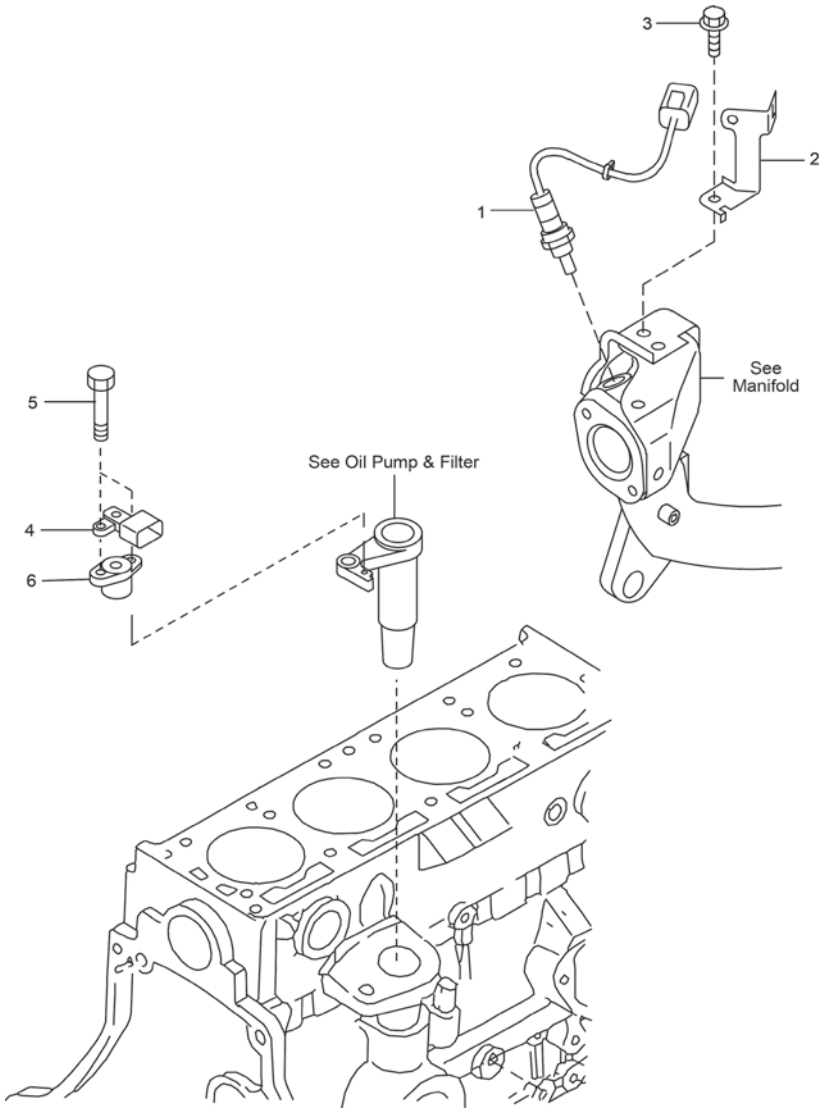
Ignition System 2/2



ITEM	PART#	DESCRIPTION	QTY
1	24075GY360	HARNESS	1
2	24136FU460	BRACKET	1
3	24136GY36A	BRACKET	1
4	081208161E	BOLT	1
5	081208301E	BOLT	1

ITEM	PART#	DESCRIPTION	QTY

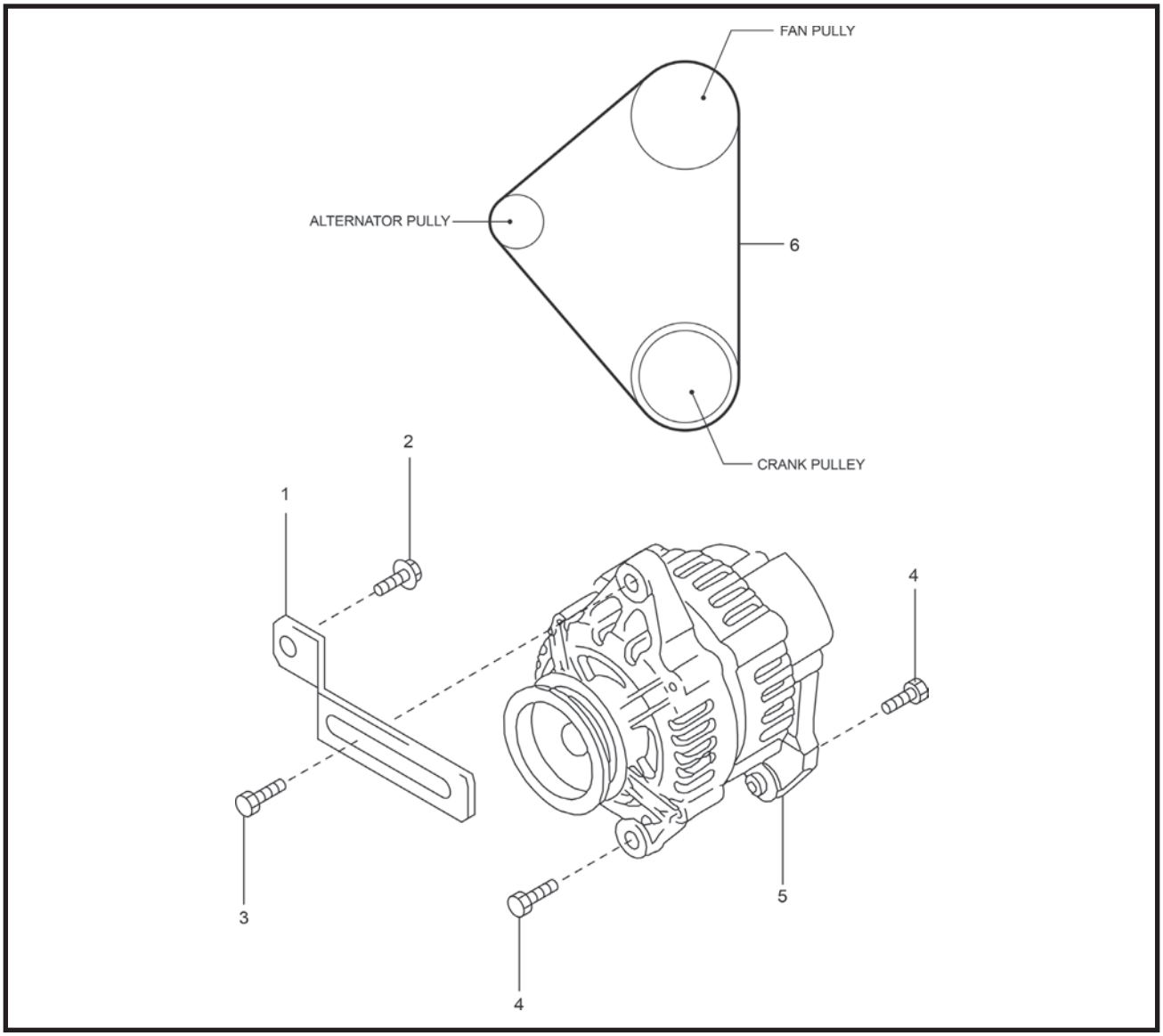
Ignition System 1/2



ITEM	PART#	DESCRIPTION	QTY
1	22690 GS00B	SENSOR ASSY-O2	1
2	24210GS00A	CLIP	1
3	14069GJ00A	BOLT	1
4	22365GJ00A	SENSOR ASSY-PRESS	1
5	081466162G	BOLT	2
6	165634K40A	CASE	1

ITEM	PART#	DESCRIPTION	QTY

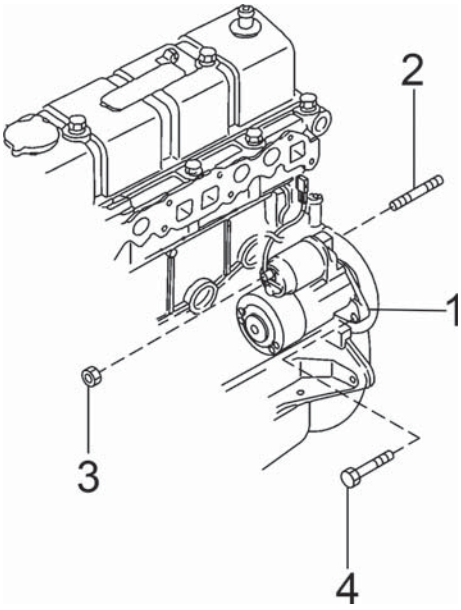
Alternator



ITEM	PART#	DESCRIPTION	QTY
1	11715 FU40A	BAR-ADJUSTING	1
2	081240201F	BOLT	1
3	081208201F	BOLT	1
4	081208301F	BOLT	2
5	23100FU41A	ALTERNATOR	1
6	21067FJ10A	BELT-FAN	1

ITEM	PART#	DESCRIPTION	QTY

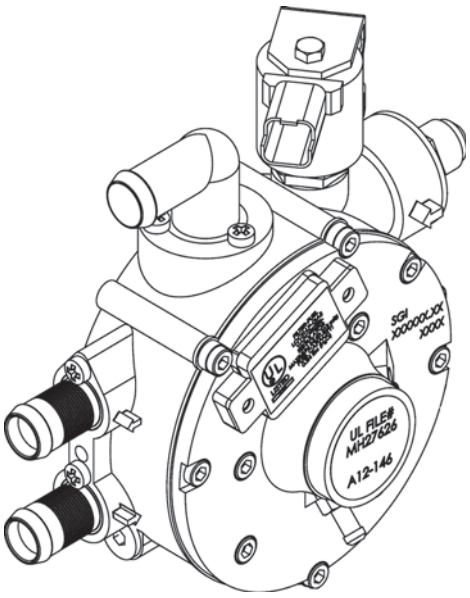
Starter

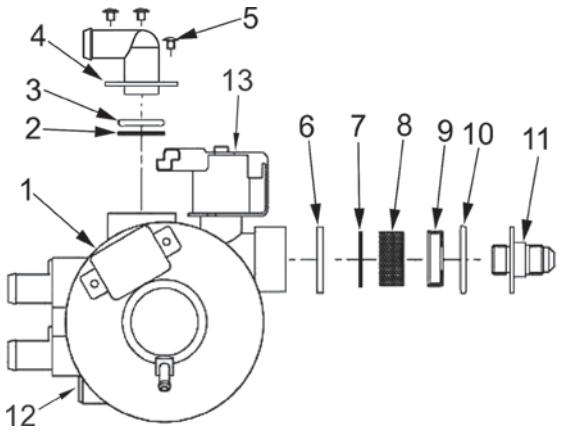


ITEM	PART#	DESCRIPTION	QTY
1	23300GS20C	STARTER MOTOR	1
2	0822703510	STUD	1
3	089111401G	NUT	1
4	081210401F	BOLT	1

ITEM	PART#	DESCRIPTION	QTY

Regulator & Repair Kit

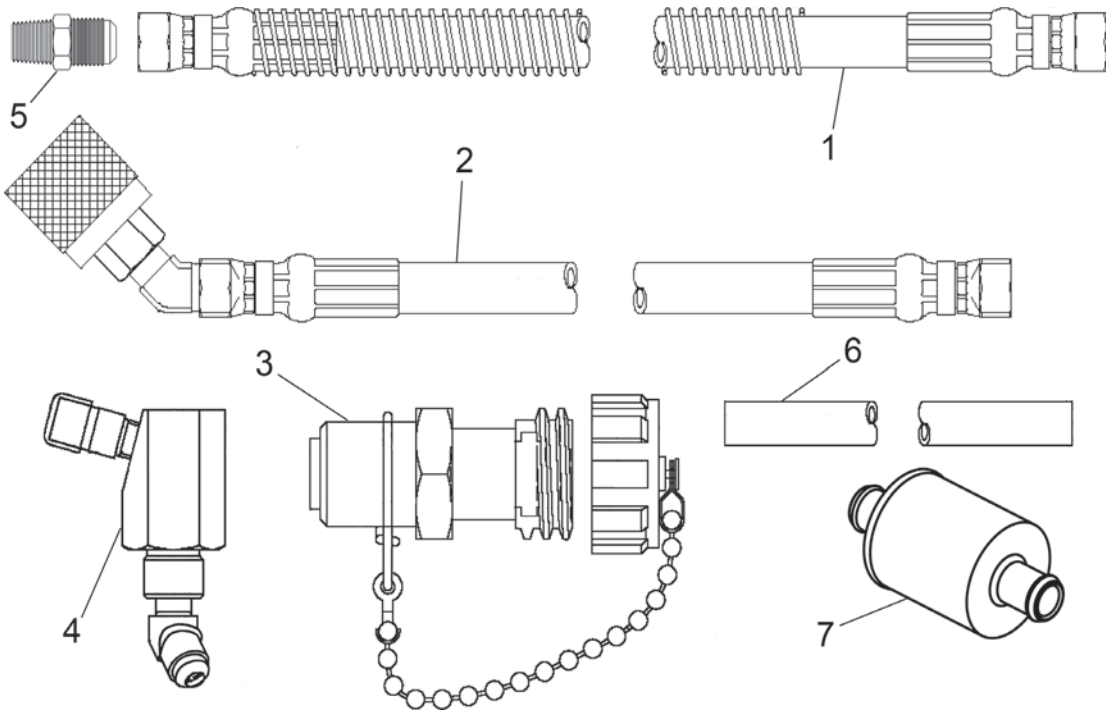




ITEM	PART#	DESCRIPTION	QTY
1	A12-146	Regulator Assy (Assembled)	1
	A7-170	Filter Kit (Includes 2, 6, 7, 8, 9)	1
	A12-421	Outlet Fitting Kit (Includes 3 & 4)	1
5	A7-176	Screw Kit (Includes 3 screws)	1
	A7-171	Inlet Fitting w/O-Ring (Incs 10 & 11)	1
12	A7-173	Drain Plug & O-ring Kit	1
13	A7-175	Lock-Off Assembly	1
14	A7-182	Rebuild Kit, Vaporizer (not shown)	1

ITEM	PART#	DESCRIPTION	QTY

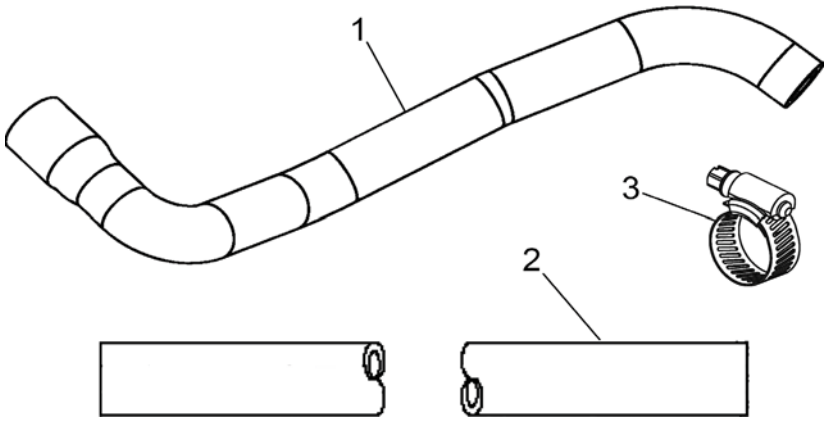
Hoses-Fuel



ITEM	PART#	DESCRIPTION	QTY
1	A10-154	HOSE ASSEMBLY (INCL NO.5)	1
2	A10-153	HOSE ASSEMBLY,MAIN FUEL LINE	1
3	A10-156	FUEL HOSE HOLDER ASSY	1
4	A10-155	BULKHEAD ASSEMBLY	1
5	A11-516	ADAPTER 1/4 MNPT X SAE 45 DEG	1
6	H1-19231-006	HOSE, 5/8" ID FUEL/OIL BULK	1
7	A8-367	FILTER,LPG VAPOR	1

ITEM	PART#	DESCRIPTION	QTY

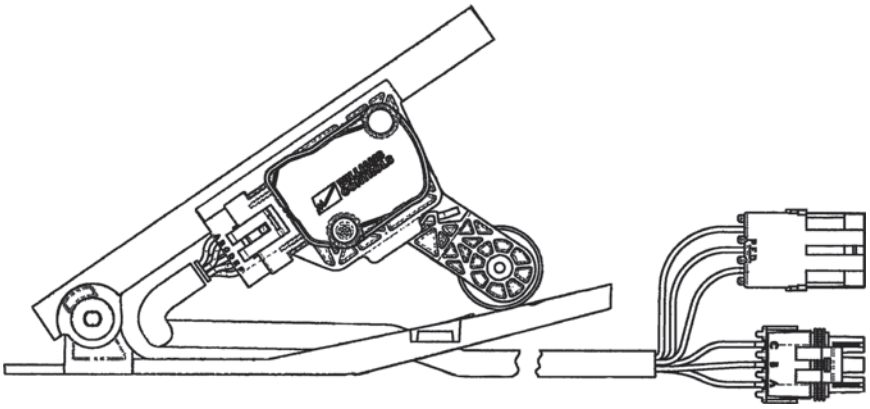
Hoses-Coolant



ITEM	PART#	DESCRIPTION	QTY
1	H1-50599-001	HOSE, FORMED GATE 18770	1
2	H1-50716-003	HOSE, COOLANT 5/8 DIA	1
3	0130845	HCE-636 CLAMP SAE 12	1

ITEM	PART#	DESCRIPTION	QTY

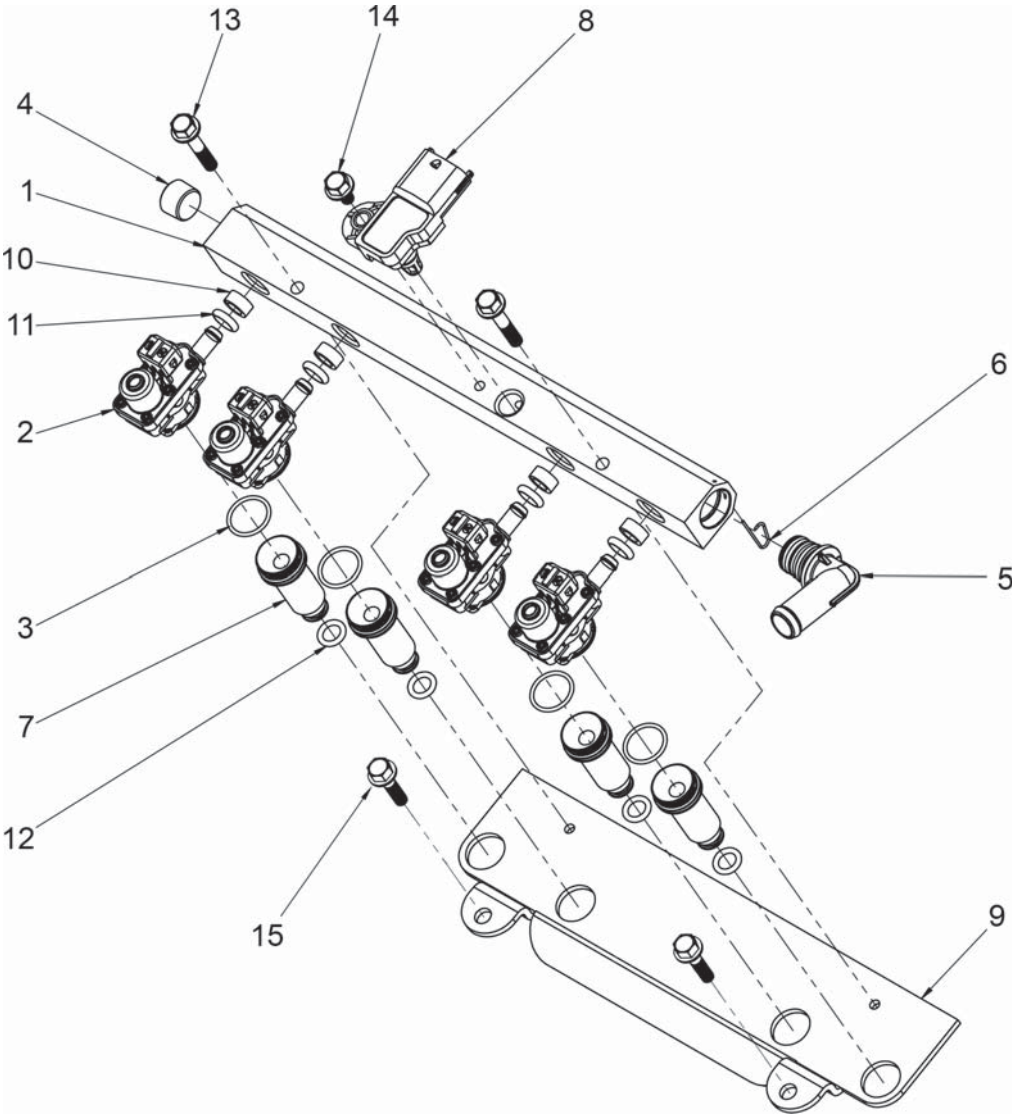
Foot Pedal



ITEM	PART#	DESCRIPTION	QTY
1	A10-195	ELECTRONIC FOOT PEDAL	1

ITEM	PART#	DESCRIPTION	QTY

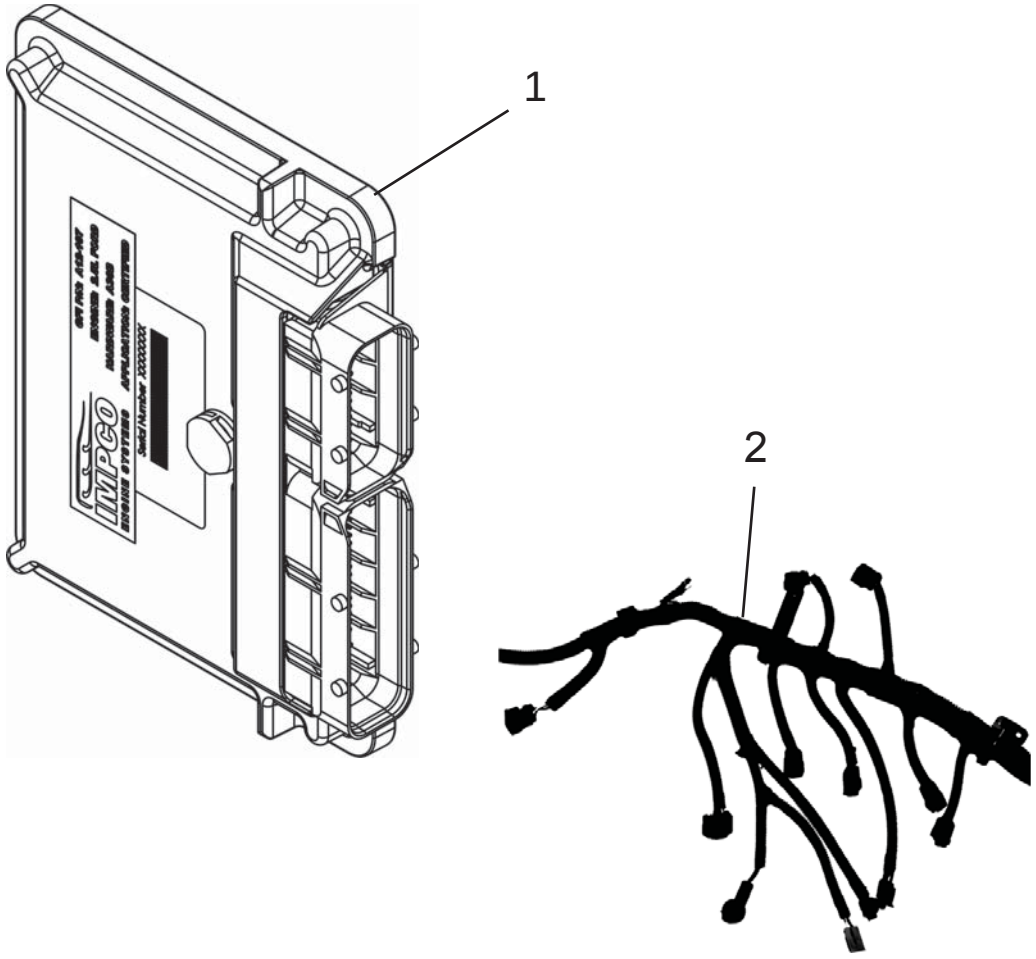
Fuel Rail & Injectors



ITEM	PART#	DESCRIPTION	QTY
1	A12-259	FUEL RAIL, NISSAN 2.5L, LPG	1
2	300000-023	INJECTOR GFI, 2.25 LPG/CNG	4
3	300200-005	ADAPTER, O-RING	4
4	P3-47	PLUG, 1/4" NPT, SOCKET HD BRASS	1
5	AF4-50733-001	FTG ASSY, 5/8X90X78 PORT	1
6	P1-30559	PIN, RETAINER	1
7	A4-51981-001	ADAPTER, FUEL INJECTOR	4
8	281002456	SENSOR, TMAP BOSCH	1
9	A12-262	BRACKET, FUEL RAIL, K25 2.5L	1
10	242100-807	SPACER, O-RING	4
11	270090-109	O-RING, INLET	4
12	GMN-033	O-RING, FKM-75 2-110, .362 ID	4
13	A7-283	HEX CAP SCREW M6X1.0X35	2
14	1534417	HCE-1047 CPSCR M6X1.0X12	1
15	1527879	HCE-1047 CPSCR, M8X1.25X16	2

ITEM	PART#	DESCRIPTION	QTY

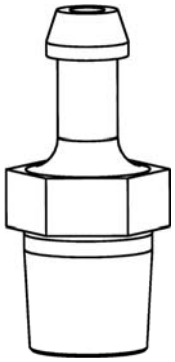
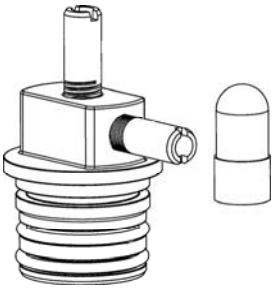
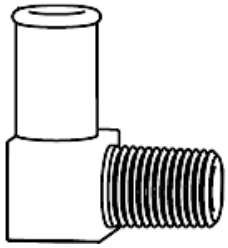
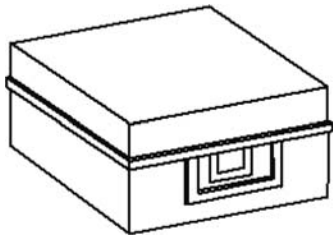
Wire Harness & Electronic Control Module



ITEM	PART#	DESCRIPTION	QTY
1	EC-0101-01	ECM	1
2	IJAW-0101-001	ENGINE WIRE HARNESS	3

ITEM	PART#	DESCRIPTION	QTY

IMPCO TOOLS

				
1	2	3	4	5
				
6	7			

IMPCO TOOLS

Item #	Description	Qty. Used	IMPCO Part Number
1	Test Kit Gauge 0-30 PSI	1	TG-030
2	Hose, 3/16" Id Vacuum, Bulk	1.5’	H1-11
3	Fitting, 1/8 NPT 3/16Hs Nip Brass	2	F4-4
4	Fitting Assembly, Test Cap	1	AF4-31105
5	Fitting, 1/8 NPT 1/4Hs El Nylon	2	F4-8
6	Case, Metal, 14.25 x 9 x 4.25	1	C9-50724-001
7	Pin, Retainer	10	P1-30559

Labor Time Guide

INTRODUCTION

This Guide provides the labor times for repairs and service operations covered under warranty for IMPCO Technologies Engine Systems Division fuel systems. It applies to 2015 model year 2.5L K25 Emission Certified Engines

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

LABOR TIME STUDY DEVELOPMENT

GENERAL

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

TOOLS

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

TIME ALLOWANCES

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

GLOSSARY OF TERMS

OPERATION DESCRIPTION

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

FAILED PART / CAUSAL PART

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

TROUBLE CODES / CONDITION CODING

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

ADD CONDITIONS

Add Conditions may be required to complete or supplement a labor operation and are included in the Add sections under the Labor Operation Description. If an ADD is performed, the allowed

labor time for the ADD must be recorded on the shop repair order under the Operation Number.

REPLACE

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

R&R OR REPLACE

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

INCLUDES

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

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

Use the Request for Review Form to question and/or recommend changes.

CUSTOMER PROBLEM ANALYSIS

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

SYMPTOM DIAGNOSIS

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

REPAIR DIAGNOSIS

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

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

Repair Diagnosis is the responsibility of the technician.

LABOR OPERATION NUMBER

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

OVERLAPPING LABOR

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

DUPLICATE LABOR

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

STRAIGHT TIME

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

approval may be obtained by contacting IMPCO Technical Assistance 1-866-473-2851.

ADDITIONAL OR OTHER LABOR

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

POLICY CODES

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

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

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

NORMAL & ADDITIONAL DIAGNOSTICS

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

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

TECHNICAL ASSISTANCE

Service technicians must call the OEM Technical Assistance whenever extensive diagnosis or repair advice is required, or to verify a vehicle's warranty.

OEM Technical Assistance personnel must contact IMPCO Technical Service personnel to obtain authorization for those repairs or additional labor that require prior authorization for warranty compensation. IMPCO Technical Assistance may be contacted at (1-714-656-1200) between the hours of 8:00 a.m. and 5:00 p.m. Pacific Time Monday through Friday except holidays.

COMPLETED WARRANTY CLAIMS

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

IMPCO LABOR OPERATIONS FOR K25

Engine-Electrical

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
DISCONNECT NEGATIVE BATTERY TERMINAL	**EE001**	0.1
ENGINE CONTROL MODULE (ECM)–REPLACEMENT	**EE002**	0.5
ENGINE CONTROL MODULE (ECM)–REFLASH	**EE003**	0.2
ENGINE WIRE HARNESS–REPAIR	**EE004**	0.9
ENGINE WIRE HARNESS–REPLACEMENT	**EE005**	0.8
PLUGS, SPARK–REPLACE ONE	**EE006**	0.1
PLUGS, SPARK–REPLACE ALL	**EE007**	0.5
COIL, IGNITION–REPLACEMENT (EACH)	**EE008**	0.1
ALTERNATOR (See Engine-Exterior Components for belts)	**EE009**	0.8
ALTERNATOR BRACKET	**EE010**	0.1
LPG FUEL CONTROL SYSTEM CHECK **INCLUDES:** Connect scan tool or test equipment. Check for trouble codes (DTCs), check HEGO operation, disconnect scan tool or test equipment.	**EE011**	0.1
ELECTRONIC THROTTLE BODY–REPLACEMENT	**EE012**	0.6
THROTTLE BODY/GASKET–REPLACEMENT	**EE013**	0.6

IMPCO LABOR OPERATIONS FOR K25

Engine-Sensors

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
ENGINE OIL PRESSURE SENSOR–REPLACEMENT	**ES001**	0.2
ENGINE COOLANT TEMP SENSOR–REPLACE	**ES002**	0.2
CAMSHAFT SENSOR-REPLACEMENT	**ES003**	0.3
CRANK POSITION SENSOR –REPLACEMENT	**ES004**	0.4
TEMP MANIFOLD PRESSURE SENSOR (TMAP)–REPLACEMENT	**ES005**	0.1
FUEL TEMPERATURE/PRESSURE SENSOR–REPLACEMENT	**ES006**	0.1
HEATED EXHAUST GAS OXYGEN SENSOR (HEGO)–REPLACEMENT	**ES007**	0.3

IMPCO LABOR OPERATIONS FOR K25

Fuel Delivery

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
LPG FUEL PRESSURE RELIEF & DRAIN	**FD001**	0.1
PRESSURE REGULATOR-REPLACEMENT **INCLUDES:** Transfer of all fittings	**FD002**	0.2
PRESSURE REGULATOR REPAIR (SEE M1001 FOR REPLACEMENT) **INCLUDES:** Replacement of fuel filters	**FD003**	0.9
BRACKET, LOW PRESSURE VAPOR LPG FILTER-REPLACE	**FD004**	0.3
BRACKET, REGULATOR MOUNTING–REPLACEMENT	**FD005**	0.5
FUEL INJECTOR, ADAPTER AND/OR FUEL RAIL-REPLACE **ADD:** Each Additional Fuel Injector **ADD:** Fuel Injector Hose **ADD:** Fuel Injector Adapter (each)	**FD006**	0.1 0.1 0.1 0.1
FUEL RAIL	**FD007**	0.1
FUEL RAIL BRACKET-REPLACE	**FD008**	0.2
FUEL INJECTOR (SINGLE)	**FD009**	0.15
LEAK CHECK LPG SYSTEM	**FD010**	0.2
LPG FUEL SYSTEM PRESSURE CHECK **INCLUDES:** Connect fuel pressure gauges. Check regulator primary and secondary pressure. Disconnect gauges.	**FD011**	0.3
AIR BOX—REPLACE	**FD012**	0.2
SHUT-OFF VALVE–REPLACEMENT	**FD013**	0.2

IMPCO LABOR OPERATIONS FOR K25

Exhaust

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
CATALYTIC CONVERTER–REPLACEMENT	**EX001**	1.0
RESTRICTED EXHAUST SYSTEM DIAGNOSIS	**EX002**	0.3

IMPCO LABOR OPERATIONS FOR K25

Coolant System & Hoses

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
DRAIN COOLANT	**CS001**	0.2
REFILL COOLANT	**CS002**	0.3
THERMOSTAT	**CS003**	0.3
WATER PUMP/GASKET—REPLACE	**CS004**	1.0
HOSE, COOLANT BYPASS TO VAPORIZOR	**CS005**	0.1
COOLANT HOSES–REPLACE ALL **INCLUDES:** Drain & Fill Radiator	**CS006**	0.7
COOLANT HOSE PORT FITTING-REPLACE	**CS008**	0.3
FUEL VAPOR HOSE—REGULATOR TO FUEL RAIL	**CS009**	0.1
FUEL VAPOR HOSE—REPLACE ALL **INCLUDES**: Replacement of Vapor Hose Port Fittings	**CS010**	0.4
FUEL VAPOR HOSE PORT-FITTING-REPLACE	**CS011**	0.1
VACUUM LINE-REPLACE ONE **ADD:** Additional Line Replace Allowances. Diagnosis Time: 0.1	**CS012**	0.1 0.1
PCV-INSPECT OR REPLACE	**CS013**	0.3

IMPCO LABOR OPERATIONS FOR K25

Engine-Exterior Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
WATER PUMP AND/OR GASKET-REPLACE	**EC001**	1.0
STARTER–REPLACEMENT	**EC002**	0.2
ALTERNATOR–REPLACEMENT	**EC003**	0.8
DRIVE BELT, FAN PULLEY–REPLACEMENT	**EC004**	0.2
THERMOSTAT, AND/OR GASKET–REPLACEMENT	**EC006**	0.3
CRANKSHAFT FLYWHEEL/FLEXPLATE–REPLACEMENT	**EC007**	1.5

IMPCO LABOR OPERATIONS FOR K25

Engine-Manifolds & Cylinder Head Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
INTAKE AND/OR EXHAUST MANIFOLD AND/OR GASKET-REPLACEMENT	**MC001**	0.6
VALVE COVER AND/OR GASKET-REPLACEMENT	**MC003**	0.3
ROCKER ARM–REPLACEMENT **ADD**: Replace all rocker arms:	**MC004**	0.4 0.3
CYLINDER HEAD-REPLACEMENT *Includes: R&R intake & exhaust manifolds, valve cover(s), gasket and compression test*.	**MC006**	3.0
VALVE–RECONDITION OR REPLACEMENT **ADD**: Each additional cylinder **ADD**: To recondition all valves **ADD**: To ream and fit guides for oversize stems	**MC007**	2.9 0.4 0.9 0.2
VALVE SPRING, CAP AND/OR SEALS–REPLACEMENT *Includes: R&R valve cover(s)* **ADD**: Each additional cylinder **ADD**: All springs, caps and/or seals	**MC008**	2.5 0.3 0.9
LIFTER, VALVE–REPLACEMENT, ONE CYLINDER *Includes: R&R valve cover(s)* **ADD:** To replace all lifters:	**MC009**	0.9 0.3

IMPCO LABOR OPERATIONS FOR K25

Engine–Internal Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
FRONT ENGINE COVER OIL SEAL–REPLACEMENT	**EI001**	0.7
FRONT ENGINE COVER AND/OR GASKET–REPLACEMENT	**EI002**	2.0
TIMING CHAIN–REPLACEMENT **ADD**: Replace crankshaft gear	**EI003**	1.6 0.2
CAMSHAFT TIMING GEAR–REPLACEMENT **ADD:** Replace crankshaft gear	**EI004**	3.9 0.2
CAMSHAFT–REPLACEMENT	**EI005**	6.0
OIL PAN AND/OR GASKET–REPLACEMENT *Includes: Fluid replacement*	**EI006**	2.2
PUMP, ENGINE OIL–REPLACEMENT *Includes: R&R engine oil pan and fluid replacement*	**EI008**	1.8
SEAL, REAR MAIN BEARING–REPLACEMENT *Includes: R&R engine oil pan and fluid, replace lower seal and repack upper seal*	**EI009**	2.8
BEARING, CRANKSHAFT MAIN–REPLACE ONE *Includes: R&R engine oil pan and fluid, and use* of *plastic type gauge* **ADD:** Replace main bearings Each additional (NOT to equal or exceed ALL) All main bearings **ADD:** Replace connecting rod bearings Each additional (NOT to equal or exceed ALL) All rod bearings	**EI010**	4.1 0.5 1.2 0.3 1.2

IMPCO LABOR OPERATIONS FOR K25

Engine–Internal Components

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
BEARING, CONNECTING ROD–REPLACE ONE *Includes: R&R engine oil pan and fluid, and use* of *plastic type gauge* **ADD:** Replace connecting rod bearings Each additional (NOT to equal or exceed ALL) All rod bearings	**EI011**	2.9 0.4 2.0
PISTON, ROD AND/OR RINGS–REPLACEMENT *Includes: R&R all necessary components and use of plastic type gauge* **ADD:** Replace rings only Each piston (NOT to exceed ALL) All pistons **ADD:** To replace connecting rods only Each rod (NOT to exceed ALL) All rods **ADD:** To replace pistons only Each piston (NOT to exceed ALL) All pistons	**EI012**	3.3 0.4 2.2 0.3 1.2 0.4 2.4
PLUG, EXPANSION–REPLACEMENT *Note: Use appropriate labor operation(s) for removal of necessary component(s) to gain access to plug*	**EI013**	0.3
PLUG, OIL GALLERY–REPLACEMENT *Note: Use appropriate labor operation(s) for removal of necessary component(s)*	**EI014**	0.3

IMPCO LABOR OPERATIONS FOR K25

Engine–Replacement

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
BLOCK, ENGINE FITTED–REPLACEMENT *Includes: R& R all components, fluids and accessories* **ADD:** To recondition all valves and guides	**ER001**	9.0 2.6
ENGINE, PARTIAL–REPLACEMENT *Includes: R& R all components, fluids and accessories* **ADD**: To recondition all valves and guides	**ER002**	7.2 2.6
ENGINE, ASSEMBLY–REPLACEMENT *Includes: R&R all components, fluids and accessories*	**ER003**	5.0
ENGINE, MOUNTS, FRONT–REPLACEMENT	**ER004**	0.3

MISCELLANEOUS

LABOR OPERATION DESCRIPTION	OPERATION NUMBER	TIME ALLOWED
DRAIN ENGINE OIL	**MI001**	0.2
ENGINE OIL LEAKS, DIAGNOSIS	**MI002**	0.6
CYLINDER HEAD GASKET, LEAKAGE DIAGNOSIS	**MI003**	0.2
COMPRESSION CHECK	**MI004**	0.5
OIL PRESSURE DIAGNOSIS	**MI005**	0.5
ADDITIONAL DIAGNOSTIC TIME Policy "B" Subject to review by IMPCO Technical Support	**MI006**	0.6
FASTENER OR FITTING TIGHTENING	**MI007**	0.1
DRIVE TESTS	**MI008**	0.2

REQUEST FOR REVIEW OF LABOR TIMES

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

Definitions

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

ADP: Adaptive Digital Processor.

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

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

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

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

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

Bi-Fueled: A vehicle equipped to run on two fuels.

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

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

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

CAFE: Corporate Average Fuel Economy.

CARB: California Air Resources Board.

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

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

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

Circuit: A path of conductors through which electricity flows.

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

CNG: Compressed Natural Gas.

CKP: Crankshaft Position Sensor

CMP: Camshaft Position Sensor

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

Contaminants: Impurities or foreign material present in fuel.

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

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

Cryogen: A refrigerant used to obtain very low temperatures.

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

DBW: Drive By Wire

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

DLC: Data Link Connector.

DTC: Diagnostic Trouble Code

Spectrum Engine Monitor : Diagnostic Scan Tool.

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

ECT: Engine Coolant Temperature.

ECM: Electronic Control Module

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

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

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

EGR: Exhaust Gas Recirculation.

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

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

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

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

FTV: Fuel Trim Valve.

FFV: Flexible Fuel Vehicle.

Firing Line: The portion of an oscilloscope pattern that represents the total amount of voltage being

expended through the secondary circuit.

FMVSS: Federal Motor Vehicle Safety Standards.

FPP: Foot Pedal Position Sensor

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

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

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

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

GCP: Spectrum III (90-pin) ECM.

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

HC: Hydrocarbon. An organic chemical compound.

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

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

HDV: Heavy Duty Vehicle.

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

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

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

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

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

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

IAT: Intake Air Temperature. Also known as “MAT” (Manifold Air Temperature).

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

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

ILEV: Inherently Low Emission Vehicle.

IMPCO: Imperial Machine Products Company.

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

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

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

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

ITK: IMPCO Test Kit

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

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

LDV: Light Duty Vehicle.

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

LEV: Low Emission Vehicle.

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

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

LPG: Liquified Petroleum Gas.

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

MAF: Mass Air Flow

MAT: Manifold Air Temperature. Also known as “IAT” (Intake Air Temperature).

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

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

MIL: Malfunction Indicator Lamp.

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

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

MFI: Multiport Fuel Injection. A fuel injection system that uses one injector per cylinder mounted on the

engine to spray fuel near the intake valve area of combustion chamber.

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

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

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

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

NGV: Natural Gas Vehicle.

NOX: See Oxides of Nitrogen.

OBD: On Board Diagnostic

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

OEM: Original Equipment Manufacturer, the vehicle manufacturer.

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

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

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

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

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

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

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

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

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

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

Pressure Differential: The differential between atmospheric pressure and intake manifold (referred to as vacuum) pressure.

Pressure Regulator: A device to control the pressure of fuel delivered to the fuel injector(s).

Primary Circuit: The low-voltage or input side of the ignition coil.

Propane: An odorless and colorless gas, C_3H_8, found in natural gas and petroleum.

Psia: pounds per square inch absolute

PTV: Pressure Trim Valve

Reactivity: Refers to the tendency of an HC in the presence of NOX and sunlight to cause a smog-forming reaction. The lighter the HC, the lower reactivity tends to be.

Regulator: An assembly used to reduce and control the pressure of a liquid or vapor.

Resistance: The opposition to the flow of current in an electrical circuit. Measured in ohms.

Rest Pressure: Fuel pressure maintained within the system after engine shutdown.

Rich Mixture: An air to fuel ratio below the stoichiometric ratio; too much fuel.

SAE: Society of Automotive Engineers.

Secondary Circuit: The high-voltage output side of the ignition coil.

SEFI or SFI: Sequential Electronic Fuel Injection or Sequential Fuel Injection.

Sensors: Devices that provide the control module with engine information as needed to properly control engine function.

Spark Line: The portion of an oscilloscope pattern that represents the time during which the air/fuel mixture is being burned in the combustion chamber.

Splice: An electrical term for the joining of two or more conductors at a single point.

Stoichiometric Ratio: An ideal fuel/air ratio for combustion in which all of the fuel and most of the oxygen will be burned.

Sulfur Oxides: Chemical compounds where sulfur is bonded to oxygen produced by the combustion of gasoline or any other fuel that contains sulfur. As sulfur oxides combine with water in the atmosphere to form sulfuric acid.

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

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

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

Throttle Body: Controls engine RPM by adjusting the engine manifold vacuum to the mixer. Consists of a housing shaft, throttle liner and fly valve.

TLEV: Transitional Low Emission Vehicle.

TMAP: Combined Air Inlet and Manifold Pressure Sensor.

Toluene: A liquid aromatic hydrocarbon C_7H_8.

TPS: Throttle Position Sensor.

TSB: Technical Service Bulletin.

ULEV: Ultra Low Emission Vehicle.

USB: Universal Serial Bus. A plug or interface supplied on most personal computers.

Vaporization: A process in which liquid changes states into gas.

Venturi Air Valve Vacuum (VAVV): An amplified air valve vacuum signal coming from the venturi area of the mixer, directly exposed to airflow before the addition of vaporized LPG.

Volt/ohmmeter (VOM): A combination meter used to measure voltage and resistance in an electrical circuit. Available in both analog and digital types. June also referred to as AVOM and DVOM.

Voltage: The electrical pressure that causes current to flow in a circuit. Measured in volts.

Voltage Drop: A lowering of the voltage in a circuit when resistance or electrical load is added.

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

VSS: Vehicle Speed Sensor

Xylene: C_6H_4 $(CH_3)_2$. Any of three toxic, flammable, and oily isomeric aromatic hydrocarbons that are dimethyl homologues of benzene and usually obtained from petroleum or natural gas distillates.

ZEV: Zero Emission Vehicle.

Appendix

2.5L ENGINE SPECIFICATIONS

ENGINE TYPE: Inline 4Cycle L4
COMBUSTION SYSTEM: Naturally Aspirated
EXHAUST SYSTEM: Cast iron with heat shield
VALVE CONFIGURATION: Pushrod Actuated Overhead 2 Valves Per Cylinder
DISPLACEMENT: 2.5 L (181 CID)
BORE: 89.0 mm (3.50 in)
STROKE: 100.0 mm (3.94 in)
COMPRESSION RATIO: 8.7 : 1
WEIGHT: 140 Kg (308 lbs) Dry (Base Engine)
ROTATION: Clockwise When Viewed From the front / Fan side
FUEL TYPE: LPG
MAXIMUM RPM @ FULL LOAD: 3000 RPM Intermittent Operation 2700 RPM Continuous Operation
IDLE RPM: 700 RPM
TIMING: LPG: 0° BTDC at idle
MOMENT OF INERTIA: 190000 Kg mm2 (650 in. LBFS2) w/ Manual Flywheel

IGNITION SYSTEM SPECIFICATIONS

Firing order: 1-3-4-2
Spark Plug Type: FR2A-D
Spark Plug Gap: 0.8 to 0.9 mm (0.031 to 0.035 in)

VALVE SPECIFICATIONS

Valve Lash Intake and Exhaust: 0.38 mm to One Turn Down From Zero
Lash Face Angle Intake and Exhaust: 89.5°
Seat Angle Intake and Exhaust: 45°30’
Maximum Seat Width Intake: 1.4 mm (0.055 in)
Exhaust: 2.2 mm (0.087 in)
Stem Production Intake: 6.965 to 6.980 mm (0.274 to 0.275 in)
Clearance Exhaust: 0.040 to 0.073 mm (0.0016 to 0.0029 in)
Maximum Valve Spring Free Length: 44.92 mm (1.77 in)
Pressure Closed: 177.9 to 200.7 N @ 33.8 mm (39.9 to 45.2Ibs @ 1.33 in)
Open: 347 to 391.2 N @ 25.0 mm (78.0 to 88.0 Ibs @ 0.98 in)
Installed Height: 33.8 mm (1.33 in)
Valve Lift Intake and Exhaust: 8.8 mm (0.35 in)
Valve Spring Damper Not Used

AIR INTAKE SYSTEM

INTAKE RESTRICTION: 8 kPa
BACK PRESSURE: 22 kPa (3.19 PSI); MINIMUM ALLOWABLE EXHAUST PIPE SIZE: 38 mm (11/2 in)

COOLING SYSTEM

MAX COOLANT TEMPERATURE @ TOP TANK OF RADIATOR: 110°C (230°F)
MAXIMUM RESTRICTION AT PUMP INLET: 100 kPa (15 PSI)
COOLING WATER CAPACITY (block only): 3.5 L (3.7 qts)

LUBRICATION SYSTEM

OIL PRESSURE (MIN HOT): 274 to 313 kPa (39.7 to 45.4 psi) @ 2000 RPM
OIL TEMPERATURE: Upper Limit: 120°C (248°F)
CRANKCASE CAPACITY: Standard Pan: 3.5 L (3.7 qts) Oil Filter: 0.3 L (0.32 qt)

ENGINE OIL SPECIFICATION: SAE 10W30 (Class SL) All Temperatures SAE 15W40 Above 18°C (0°F) SAE 30W Between 5° and 27°C (40° and 80°F) SAE 40W Above 27°C (80°F)

INDUSTRIAL ENGINE SYSTEMS
BATTERY REQUIREMENT: 12 volt
MAXIMUM ANGULARITY: Front of engine down: 2°; Rear of engine down: 5°; Side to side: 0°

K25 ENGINE TORQUE SPECIFICATIONS

Oil Pan Drain Bolt: 29.4 to 39.2 Nm (21.7 to 28.9 lb ft)
Main Bearing Bolts (with oil): 83.4 to 93.2 Nm (61.5 to 68.7 lb ft)
Connecting Rod Cap Nuts (with oil): 31.4 to 37.3 Nm (23.2 to 27.5 lb ft)
Oil Pump Cover Screws: 6.37 to 7.45 Nm (4.70 to 5.49 lb in)
Camshaft Thrust Plate Bolts: 8.43 to 10.8 Nm (6.22 to 7.96 lb in)
Oil Pump to Crankcase Bolts : 15.7 to 17.7 Nm (11.6 to 13.1 lb in)
Rear Crankshaft Oil Seal Retainer Bolts : 5.6 to 8.4 Nm (4.1 to 6.2 lb in)
Oil Pan to Crankcase Bolts: 6.37 to 7.45 Nm (4.70 to 5.49 lb in)
Oil Pan to Front Cover Bolts: 6.37 to 7.45 Nm (4.70 to 5.49 lb in)
Cylinder Head Bolt (with oil): 65 to 75 Nm (47.9 to 55.3 ft.lbs)
Valve Cover Nuts: 14.7 to 16.7 Nm (10.8 to 12.3 lb in)
Front Cover Bolts: 20.6 to 26.5 Nm (15.2 to 19.5 lb in)
Coolant Pump Bolts: 15.7 to 17.7 Nm (11.6 to 13.1 lb ft)
Coolant Pump Pulley Bolts 6.37 to 7.45 Nm (4.70 to 5.49 lb ft)
Flywheel Bolts (with oil): 132 to 142 Nm (97.3 to 105 lb ft)

Flywheel Housing Bolts and Nuts: 56.9 to 65.7 Nm (42.0 to 48.5 lb ft)
Spark Plugs : 19.6 to 29.4 Nm (14.5 to 21.7 lb ft)
Intake / Exhaust Manifold nut: 41.2 to 48.1 Nm (30.4 to 35.5 lb ft)

Engine Part Tightening Torque

TIGHTENING TORQUE AT VARIOUS POINTS OF ENGINE

Tightening point	Unit	Standard	Max. value
Cylinder head (lubricated)		Separately given	
Main bearing cap (lubricated)		Separately given	
Crankshaft pulley bolt	N•m	220.5	240.1
	kg-m	22.5	24.5
	ft-lb	163	177
Flywheel bolt (lubricated)	N•m	132	142
	kg-m	13.47	14.49
	ft-lb	97	105
Connecting rod nut (lubricated)	N•m	31.4	37.3
	kg-m	3.2	3.81
	ft-lb	23	28
Rear plate bolt	N•m	44.1	58.8
	kg-m	4.5	6.0
	ft-lb	33	43
Camshaft sprocket bolt	N•m	39.2	49
	kg-m	4.0	5.0
	ft-lb	29	36
Oil filter stud	N•m	29.4	39.2
	kg-m	3.0	4.0
	ft-lb	22	29
Oil filter element	N•m	14.7	20.6
	kg-m	1.5	2.1
	ft-lb	11	15
Spark plug	N•m	19.6	29.4
	kg-m	2.0	3.0
	ft-lb	14	22
Engine slinger bolt	N•m	22.6	25.5
	kg-m	2.31	2.6
	ft-lb	17	22
Rocker cover nut	N•m	14.7	16.7
	kg-m	1.5	1.7
	ft-lb	11	13
Water temperature gauge	N•m	15.7	19.6
	kg-m	1.6	2.0
	ft-lb	12	14
Oil pressure switch	N•m	15.7	21.6
	kg-m	1.6	2.2
	ft-lb	12	16
Exhaust manifold nut	N•m	41.2	48.1
	kg-m		4.91
			36
Straight screw plug (For head top face)	N•m	44.1	58.9
	kg-m	4.5	5.5
	ft-lb	33	40
Oil pan drain plug	N•m	29.4	39.2
	kg-m	3.0	4.0
	ft-lb	22	29
Mass air flow sensor mounting screw	N•m	1.27	1.67
	kg-m	0.13	0.17
	in-lb	11	15
Fuel tube flare nut	N•m	16.0	23.0
	kg-m	1.63	2.35
	ft-lb	12	17
Crankshaft position sensor plug bolt	N•m	6.37	7.45
	kg-m	0.65	0.76
	in-lb	56	66
Thermo-housing relief plug	N•m	6.37	7.45
	kg-m	0.65	0.76
	in-lb	56	66

Standard Bolt Tightening Torque

Upper: Lubricated (Antirust oil is applied to abrasive faces of threads and seating faces)

Lower: No lubrication (Threads and seating faces are completely degreased)

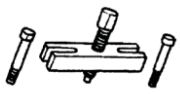
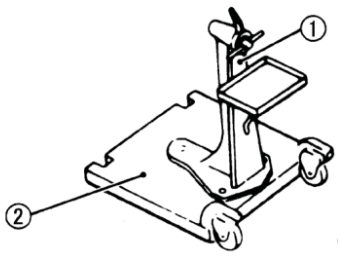
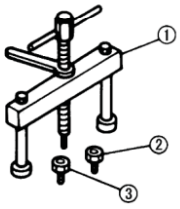
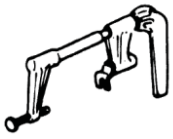
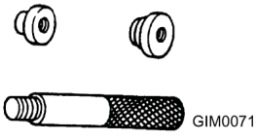
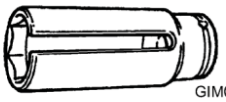
	Thread size		Unit	4T (Bolt)	7T (Bolt)	9T (Bolt)
	Diameter	Pitch				
Hexagon head bolt and nut	M6	1	N•m	3.8 - 4.4	6.4 - 7.5	9.2 - 10.8
			kg-m	0.39 - 0.45	0.65 - 0.76	0.94 - 1.1
			ft-lb, in-lb*	34 - 39*	56 - 66*	82 - 95*
			N•m	5.0 - 6.5	8.4 - 10.8	11.8 - 15.7
			kg-m	0.51 - 0.66	0.86 - 1.1	1.2 - 1.6
			ft-lb, in-lb*	44 - 57*	75 - 95*	9 - 12
	M8	1.25	N•m	9.3 - 10.8	15.7 - 17.7	22.6 - 25.5
			kg-m	0.95 - 1.1	1.6 - 1.8	2.3 - 2.6
			ft-lb, in-lb*	82 - 95	12 - 13	17 - 19
			N•m	12.7 - 15.7	20.6 - 26.5	29.4 - 37.3
			kg-m	1.3 - 1.6	2.1 - 2.7	3.0 - 3.8
			ft-lb, in-lb*	9 - 12	15 - 20	22 - 27
	M10	1.25	N•m	19.6 - 22.6	32.4 - 38.2	47.1 - 53.9
			kg-m	2.0 - 2.3	3.3 - 3.9	4.8 - 5.5
			ft-lb, in-lb*	14 - 17	24 - 28	35 - 40
			N•m	25.5 - 33.3	43.1 - 54.9	61.8 - 78.5
			kg-m	2.6 - 3.4	4.4 - 5.6	6.3 - 8.0
			ft-lb, in-lb*	19 - 25	32 - 41	46 - 58
		1.5	N•m	18.6 - 21.6	30.4 - 36.3	44.1 - 52
			kg-m	1.9 - 2.2	3.1 - 3.7	4.5 - 5.3
			ft-lb, in-lb*	14 - 16	22 - 27	33 - 38
			N•m	24.5 - 31.4	41.2 - 52	58.8 - 74.5
			kg-m	2.5 - 3.2	4.2 - 5.3	6.0 - 7.6
			ft-lb, in-lb*	18 - 23	30 - 38	43 - 55
Flanged bolt	M6	1	N•m	4.9 - 5.7	8.14 - 9.51	11.8 - 13.7
			kg-m	0.5 - 0.58	0.83 - 0.97	1.2 - 1.4
			ft-lb, in-lb*	43 - 50*	72 - 84*	9 - 10
			N•m	6.0 - 7.7	9.8 - 12.7	14.7 - 18.6
			kg-m	0.61 - 0.78	1.0 - 1.3	1.5 - 1.9
			ft-lb, in-lb*	53 - 68*	87 - 113	11 - 14
	M8	1.25	N•m	11.8 - 13.7	19.6 - 23.5	28.4 - 33.3
			kg-m	1.2 - 1.4	2.0 - 2.4	2.9 - 3.4
			ft-lb, in-lb*	9 - 10	14 - 17	21 - 25
			N•m	14.7 - 18.6	24.5 - 31.4	35.3 - 45.1
			kg-m	1.5 - 1.9	2.5 - 3.2	3.6 - 4.6
			ft-lb, in-lb*	11 - 14	18 - 23	26 - 33
	M10	1.25	N•m	24.5 - 29.4	41.2 - 48.1	59.8 - 69.6
			kg-m	2.5 - 3.0	4.2 - 4.9	6.1 - 7.1
			ft-lb, in-lb*	18 - 22	30 - 35	44 - 51
			N•m	30.4 - 39.2	51.0 - 64.7	73.6 - 93.2
			kg-m	3.1 - 4.0	5.2 - 6.6	7.5 - 9.5
			ft-lb, in-lb*	22 - 29	38 - 48	54 - 69
		1.5	N•m	23.5 - 27.5	39.2 - 46.1	56.9 - 65.7
			kg-m	2.4 - 2.8	4.0 - 4.7	5.8 - 6.7
			ft-lb, in-lb*	17 - 20	29 - 34	42 - 48
			N•m	29.4 - 37.3	49.0 - 61.8	69.6 - 89.2
			kg-m	3.0 - 3.8	5.0 - 6.3	7.1 - 9.1
			ft-lb, in-lb*	22 - 27	36 - 46	51 - 66

CAUTION:

- **Except special nuts and bolts.**
- **The bolts applicable to this table have one of the following marks embossed on their heads.**
  4T.....4
  7T.....7
  9T.....9

(*) INDICATES INCHES-POUNDS

SPECIAL TOOL USAGE FOR THE K25 ENGINE

Tool number	Tool name		
KV11103000	Pulley puller	 GIM0065	Removing crankshaft pulley
ST05240001	Engine attachment	 GIM0066	
ST0501S000 (1) ST05011000 (2) ST05012000	Engine stand assembly Engine stand Stand	 GIM0067	
KV101041S0 (1) KV10104110 (2) ST16512001 (3) ST16701001	Crankshaft main bearing cap puller Crankshaft main bearing puller Adapter Adapter	 GIM0068	
ST12070000	Valve lifter	 GIM0069	
ST1524S000 KV10105500 ST15243000	Front oil seal drift Rear oil seal drift Drift rod	 GIM0071	
KV10113700	Heated oxygen sensor wrench	 GIM0072	Removing and installing heated oxygen sensor

Altitude Vs. Ambient Air Pressure Table

Altitude Measured In Feet (ft)	Kilopascals (kPa)	Pounds Per Square Inch (PSIA)
14,000	56-64	8.1-9.2
13,000	58-66	8.4-9.6
12,000	61-69	8.8-10.0
11,000	64-72	9.3-10.4
10,000	66-74	9.6-10.7
9,000	69-77	10.0-11.2
8,000	71-79	10.3-11.4
7,000	74-82	10.7-11.9
6,000	77-85	11.2-12.3
5,000	80-88	11.6-12.8
4,000	83-91	12.0-13.2
3,000	87-95	12.6-13.8
2,000	90-98	12.5-14.2
1,000	94-102	13.6-14.8
0	96-104	13.9-15.0
-1,000	101-105	14.6-15.2

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