Service

Engine Fuel System and
Diagnostic Code Troubleshooting

Engine Models:

KG2204

KG2204T

Propane, Liquefied Petroleum Gas (LPG) and Natural Gas (NG) Fueled

KOHLER®

TP-6903 11/19d

WARNING: This Product can expose you to chemicals, including carbon monoxide and benzene, which are known to the State of California to cause cancer and birth defects or other reproductive harm.
For more information go to
www. P65warnings.ca.gov

Product Identification Information

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer_____

Model Designation_____

Serial Number _____

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Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

⚠ DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death, or substantial property damage.***

⚠ WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death, or substantial property damage.***

⚠ CAUTION

Caution indicates the presence of a hazard that ***will*** or ***can cause minor personal injury*** or ***property damage***.

⚠ NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

⚠ WARNING



Accidental starting. Can cause severe injury or death.
Disconnect the battery cables before working on the generator set. Remove the negative (--) lead first when disconnecting the battery. Reconnect the negative (--) lead last when reconnecting the battery.

Disconnect and ground spark plug leads before servicing.
Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug leads. 2) Disconnect negative (–) battery cable from battery.
Before disconnecting negative (–) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or LPG/NG fuel vapors are present.

Engine Backfire/Flash Fire

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the engine with the air cleaner removed.

Troubleshooting and/or repairing the sensors or the ECM. A backfire due to an open fuel shut-off valve can cause severe injury or death. If power is supplied to the shut-off valve during ECM or sensor troubleshooting, fuel may enter the air intake manifold or the air cleaner and cause a backfire. Make sure that the fuel supply is turned OFF and that the fuel shut-off valves are DISCONNECTED from the power source BEFORE turning the ECM power on.

Exhaust System

⚠ WARNING



Carbon monoxide can cause severe nausea, fainting, or death.
Avoid inhaling exhaust fumes.
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.

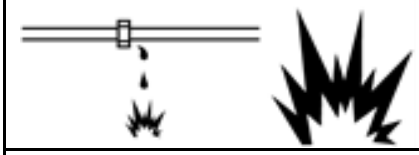
Fuel System

⚠ WARNING



Explosive fuel vapors. Can cause severe injury or death.
Use extreme care when handling, storing, and using fuels.
Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LPG vapor or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

⚠ WARNING



Explosive fuel vapors.
Can cause severe injury or death.
Use extreme care when handling, storing, and using fuels.
Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LPG vapor or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area, away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

LPG (Liquefied Petroleum Gas) is extremely flammable and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.
NG (Natural Gas) is extremely flammable, is lighter than air, and rises. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.
To ensure personal safety, installation and repair of LPG/NG fuel supply systems must be performed only by qualified LPG/NG system technicians. Improperly installed and maintained LPG/NG equipment could cause the fuel supply system or other components to malfunction, causing gas leaks.
Observe federal, state, and local laws governing LPG/NG fuel, storage, and systems.

Hazardous Voltage/Moving Parts

⚠ WARNING



Hazardous voltage.
Will cause severe injury or death.
Disconnect all power sources before opening the enclosure.

⚠ WARNING



Hazardous voltage. Moving parts.
Will cause severe injury or death.
Operate the generator set only when all guards and electrical enclosures are in place.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

⚠ WARNING



Spring-loaded parts. Can cause severe personal injury or property damage.
Wear protective goggles when servicing spring-loaded parts. Hold parts securely during disassembly.

Hot Parts

⚠ WARNING



Hot parts can cause severe burns. Do not touch engine while operating or just after stopping.
Never operate engine with heat shields or guards removed.

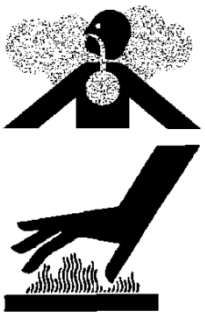
Servicing the exhaust system. Hot parts can cause severe injury or death.
Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

⚠ WARNING



Hot coolant and steam. Can cause severe injury or death.
Before removing the pressure cap, stop the engine and allow it to cool. Then loosen the pressure cap to relieve pressure.

⚠ WARNING



Handling caustic engine fluids and chemical products can cause severe chemical burns, nausea, fainting, or death.
Most chemicals such as used engine oil, antifreeze/coolant, rustproofing agent, inhibiting oil, degreasing agent, spray paint, and adhesives are hazardous to health. Read and follow the user information found on the packaging. Avoid inhalation and skin contact. Use only in well-ventilated areas and use a protective mask when spraying. Store engine fluids and chemical products in a locked cabinet. Contact your local recycling center for disposal information and locations.

Used engine oil. Contact with used engine oil may cause severe skin irritation. Repeated and prolonged skin exposure may have other health risks. Used engine oil is a suspected carcinogen. Avoid contact with skin. Thoroughly wash your hands and nails with soap and water shortly after handling used engine oil. Wash or dispose of clothing or rags containing used engine oil. Dispose of used engine oil in accordance with applicable laws and regulations. Contact your local recycling center for disposal information and locations.

Notes

This manual applies to the Kohler Model KG2204/KG2204T 2.2L engine. The purpose of this manual is to provide an understanding of the fuel system and instructions to troubleshoot the fuel system and sensors.

To troubleshoot the fuel system using the instructions in this manual, use the following steps:

1. Connect to the ECM, electronic control module, to read any logged Diagnostic Troubleshooting Codes (DTC).
   a. A laptop with **Spectrum** software and a Kvaser® cable are required to connect to the ECM.

   Note: Spectrum is a diagnostic scan tool (DST) software program from IMPCO® Technologies, Inc. Refer to the software instruction manual for installation and operation. See Section 2.2 for more information.
2. Refer to **Section 2, Diagnostic Troubleshooting Codes** in this manual to look up the recommended troubleshooting steps for a DTC. The DTC chart lists the components that are most likely causing the DTC fault and the corrective actions.
3. In Section 3, Fuel System Troubleshooting , and Section 4, Electrical System and Sensor Troubleshooting, follow the troubleshooting steps indicated in the DTC chart.
4. If the troubleshooting steps require a component to be replaced, refer to **Section 5, Installation and Removal Procedures**.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

Unless otherwise specified, all units of measurement are metric, followed by the Imperial (U.S.) equivalent.

IMPCO is a registered trademark brand of IMPCO Technologies, Inc.
KVASER is a registered trademark of TIMEGALACTIC AB.

List of Related Materials

Figure 1-1 identifies related literature available for the KG2204/KG2204T engine covered in this manual.

Literature Type	Part Number
Operation Manual, KG2204/KG2204T Engine	TP-6901
Service Manual, KG2204/KG2204T Engine Mechanical	TP-6902
Parts Catalog, KG2204/KG2204T Engine	TP-6904

Figure 1-1 Related Literature

Service Assistance

For professional advice and conscientious service, please contact your nearest Kohler distributor or dealer.

- Visit the Kohler Co. website at KOHLERPower.com.
- Look at the labels and decals on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

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Fax: (86) 10 6518 7955

East China Regional Office, Shanghai
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Fax: (86) 21 6288 0550

India, Bangladesh, Sri Lanka

India Regional Office
Bangalore, India
Phone: (91) 80 3366208
(91) 80 3366231
Fax: (91) 80 3315972

Japan, Korea

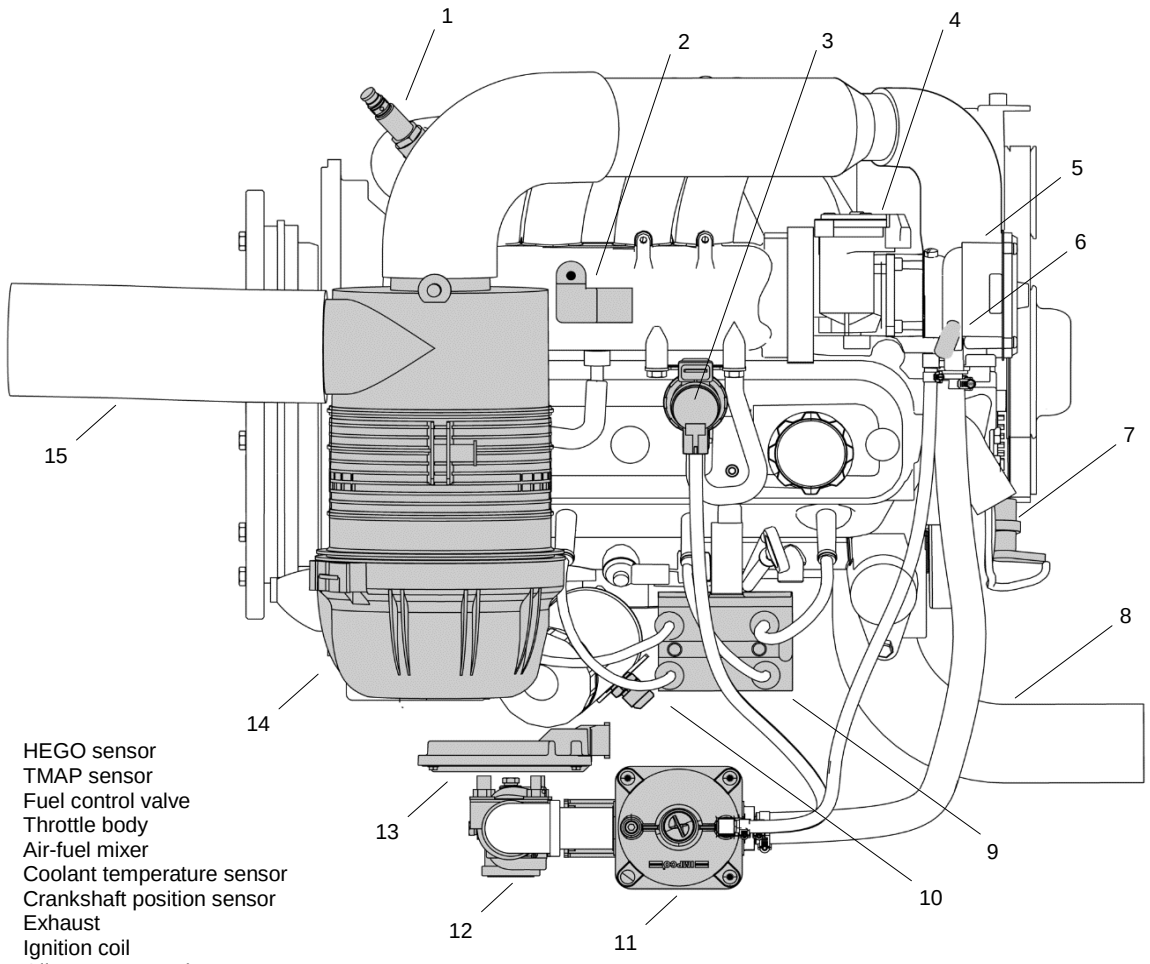
North Asia Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

1.1. Introduction

The KG2204 and KG2204T are four-stroke internal combustion engines certified to operate on Natural Gas (NG) or Liquefied Petroleum Gas (LPG). System configuration is factory preset for NG and can be reset for LPG applications.

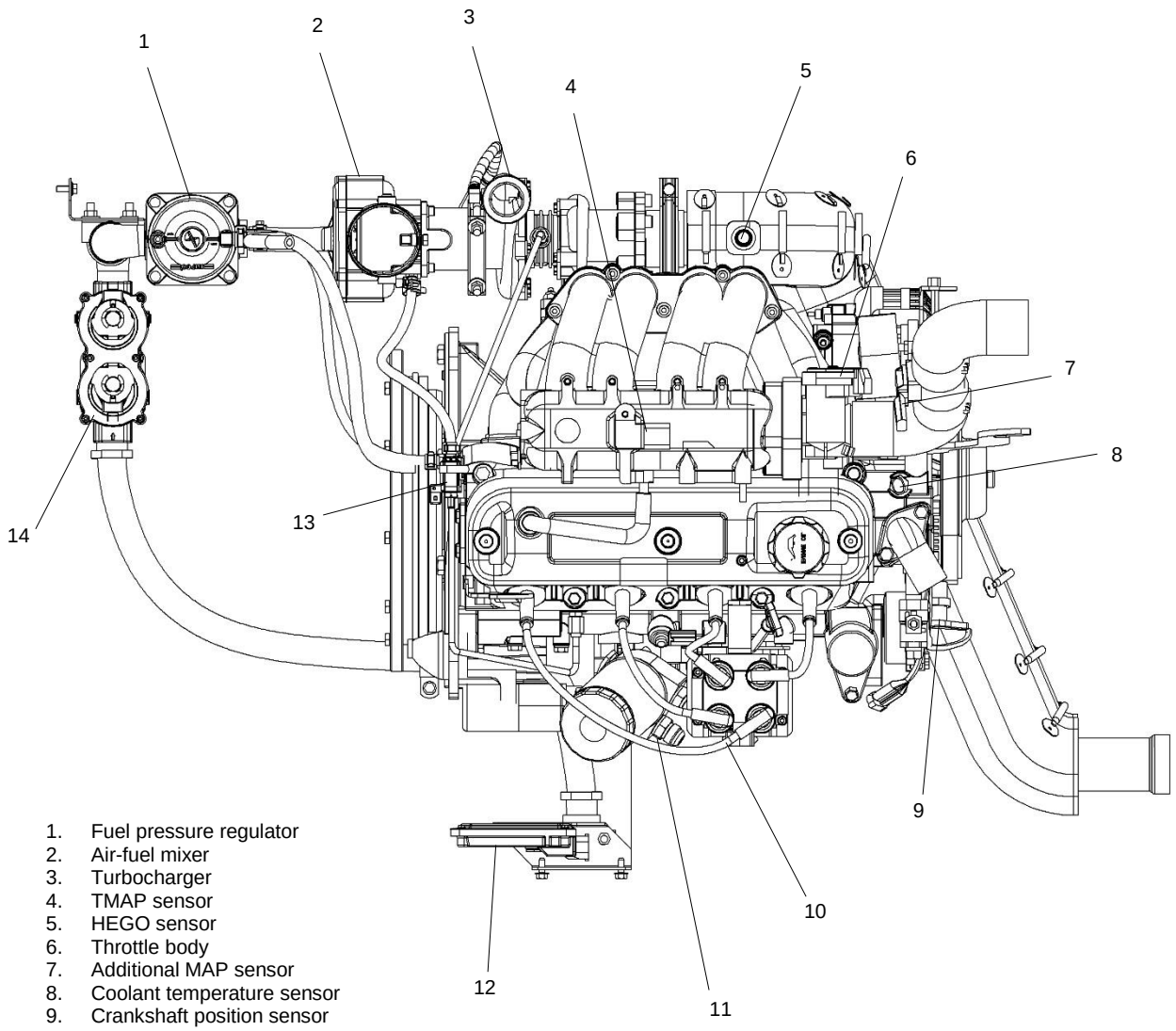
At startup, the engine ECM operates in an open-loop fuel state, which means fuel delivery is based on a fuel calibration program internal to the ECM. The program controls the fuel control valve to achieve stoichiometric combustion.

After the oxygen sensor heats up and the engine coolant temperature reaches a predetermined level, the ECM calibration program transitions to a closed-loop mode. The air/fuel delivery is based on the oxygen sensor input and engine sensor data. The engine ECM uses this data to regulate the fuel control valve (FCV), which is used as a fuel trim device and is located at the intake manifold. The FCV is an electrically controlled engine vacuum switch. When the FCV is energized, the valve opens and, through a vacuum line connection to the fuel regulator, creates a vacuum on the fuel pressure regulator. This vacuum causes the regulator's diaphragm to close, decreasing the fuel delivered to the intake. The FCV signal would be considered a modulated signal sent by the ECM to obtain stoichiometric combustion.



1. HEGO sensor
2. TMAP sensor
3. Fuel control valve
4. Throttle body
5. Air-fuel mixer
6. Coolant temperature sensor
7. Crankshaft position sensor
8. Exhaust
9. Ignition coil
10. Oil pressure sender
11. Fuel pressure regulator
12. Fuel shut-off valve
13. ECM
14. Air cleaner
15. Air intake

Figure 1-1 Fuel System Overview, KG2204 Naturally Aspirated Engine



1. Fuel pressure regulator
2. Air-fuel mixer
3. Turbocharger
4. TMAP sensor
5. HEGO sensor
6. Throttle body
7. Additional MAP sensor
8. Coolant temperature sensor
9. Crankshaft position sensor
10. Ignition coil
11. Oil cooler adapter
12. ECM
13. Fuel control valve
14. Fuel shut-off valve

Note: Air Cleaner removed for clarity.

Figure 1-2 Fuel System Overview, KG2204T Turbocharged Engine

1.2. Air-Fuel Mixer

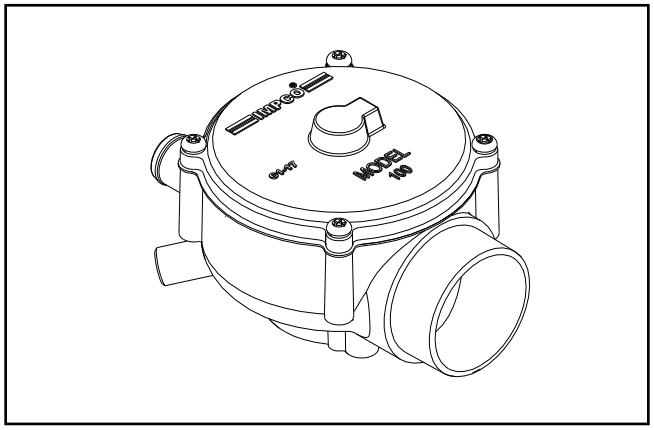


Figure 1-3 Air-Fuel Mixer

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

When the engine begins to crank it draws in air with the air valve covering the inlet, and negative pressure begins to build. This negative pressure signal is communicated to the top of the air valve chamber through vacuum ports in the air valve assembly.

The mixer is equipped with a low speed mixture adjustment which is retained in a tamper proof housing. The mixer has been preset at the factory and should not be adjusted.

Important: The air-fuel mixer has been calibrated for the engine's emissions requirements and should never be disassembled or rebuilt. If the air-fuel mixer is not functioning correctly, order a replacement part. See the engine parts catalog.

1.3. Charge Air Cooler (KG2204T only)

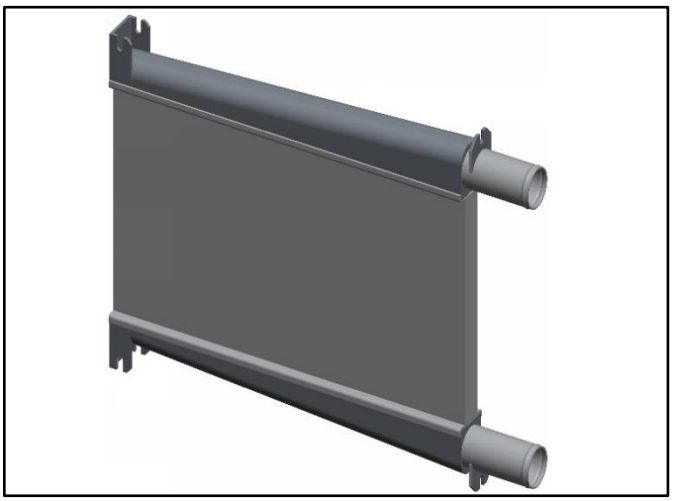


Figure 1-4 Charge Air Cooler

The charge air cooler cools the compressed air/fuel mixture before it enters the intake manifold. The cooler intake manifold charge helps maintain emissions at the high power level of the turbocharged engine.

1.4. Coolant Temperature Sensor

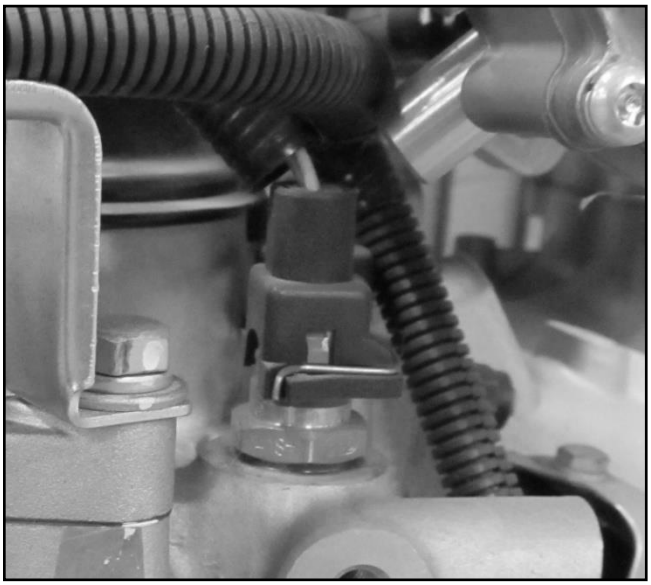


Figure 1-5 Coolant Temperature Sensor

The coolant temperature (CT) sensor is a temperature sensitive variable resistance thermistor located in the engine coolant passage directly underneath the air-fuel mixer. The ECM monitors the change in resistance to calculate engine airflow, to enrich the fuel for cold starts, and to enable other temperature dependent features.

1.5. Crankshaft Position (CKP) Sensor

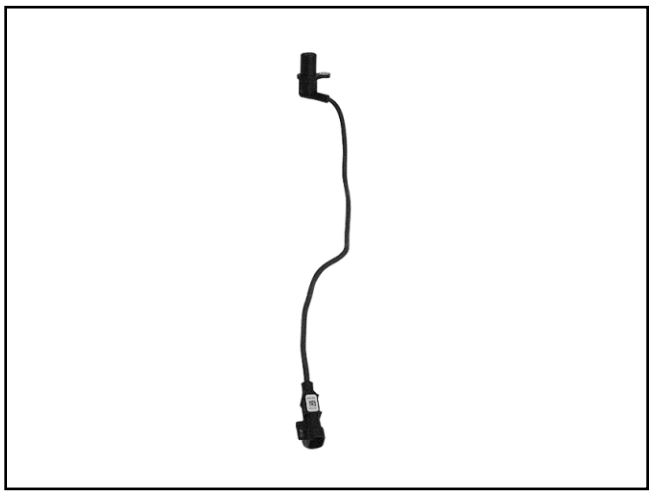


Figure 1-6 Crankshaft Position Sensor

The crankshaft position (CKP) sensor measures the rotary speed and crankshaft turning angle. The ECM ensures the ignition timing for each cylinder depending on the turning signal. The sensor, which consists of a permanent magnet and coil, is installed on the timing gear cover next to the crankshaft pulley. When the crankshaft is turning, the gear ring passes the sensor at different speeds and causes a change of magnet resistance at the sensor to produce a changeable signal.

As the engine starts to crank, the crank position sensor (CS) sends a small AC signal to the ECM. The ECM uses this signal for speed sensing and engine timing. With this CS signal now active, the ECM will send a signal to the electronic throttle (ETC) opening the throttle for fuel flow and initiate the firing of the electronic ignition (Cyl 1, Cyl 2). The ignition system is a waste spark design, meaning two cylinders fire at the same time. One cylinder will fire on its compression stroke and the other will fire on the exhaust stroke (waste spark).

The ECM uses the signal from the crankshaft position sensor to determine where each piston is in relation to its combustion cycle and to activate the ignition control module.

1.6. Electronic Control Module

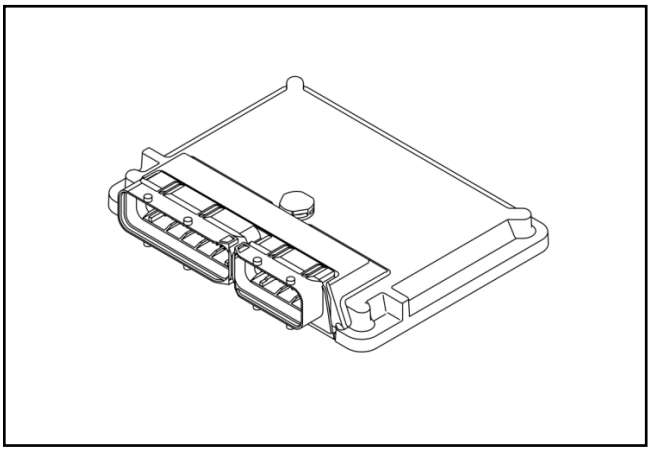
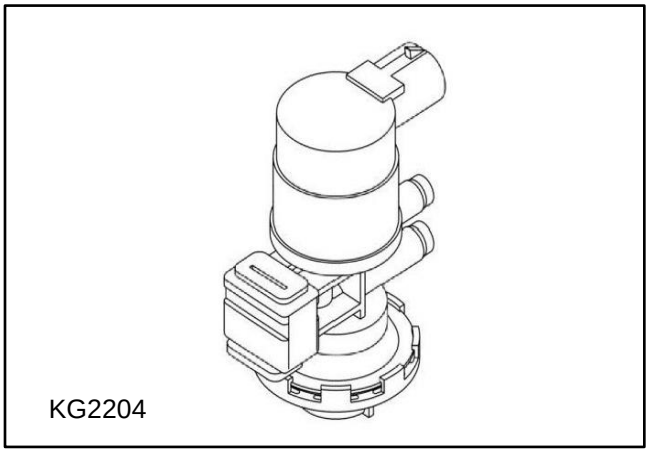


Figure 1-7 Electronic Control Module

To obtain maximum and accurate control of the air fuel ratio, the engine is equipped with an onboard computer or Electronic 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.

The ECM adjusts the engine speed, ignition timing, and fuel supply in response to changes in the applied load, surrounding air temperature, operating temperature of the engine, and amount of oxygen present in the exhaust.

1.7. Fuel Control Valve



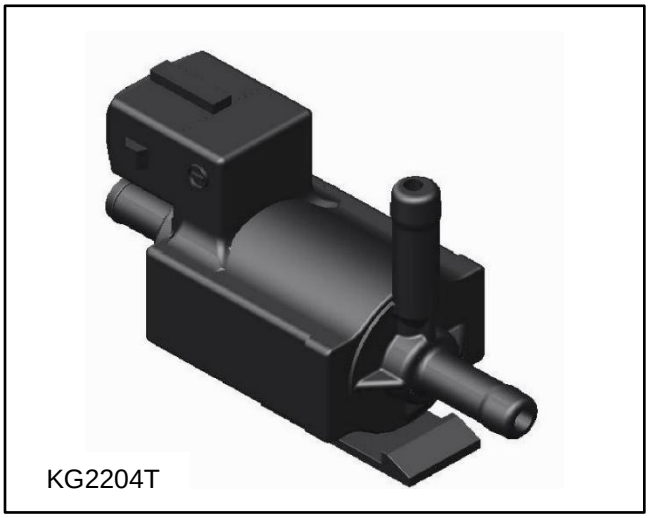


Figure 1-8 Fuel Control Valves

The fuel control valve (FCV) is an electrically controlled engine vacuum switch. When the FCV is energized, the valve opens and, through a vacuum line connection to the fuel regulator, creates a vacuum on the fuel pressure regulator. This vacuum causes the regulator's diaphragm to close, decreasing the fuel delivered to the intake. The FCV signal is a modulated signal sent by the ECM to obtain stoichiometric combustion.

The ECM cycles FCV to provide the rich and lean transitions required for low exhaust emissions and peak engine performance. Based on the fuel requirements of the engine, the ECM sends a signal to control the amount of time that the fuel control valve is open. Opening and closing the fuel control valve alters the fuel pressure delivered from the regulator to the air-fuel mixer.

When the engine starts, the engine ECM is an "open loop" state, which means fuel delivery is based on a fuel calibration program internal to ECM. The program controls the fuel control valve to achieve stoichiometric combustion.

After the oxygen sensor heats up and the engine coolant temperature reaches a predetermined level, the ECM calibration program transitions to a closed-loop mode. The air/fuel delivery is based on the oxygen sensor input and engine sensor data. The engine ECM uses this data to regulate the fuel control valve (FCV), which is used as a fuel trim device and is located at the intake manifold.

1.8. Fuel Pressure Regulator

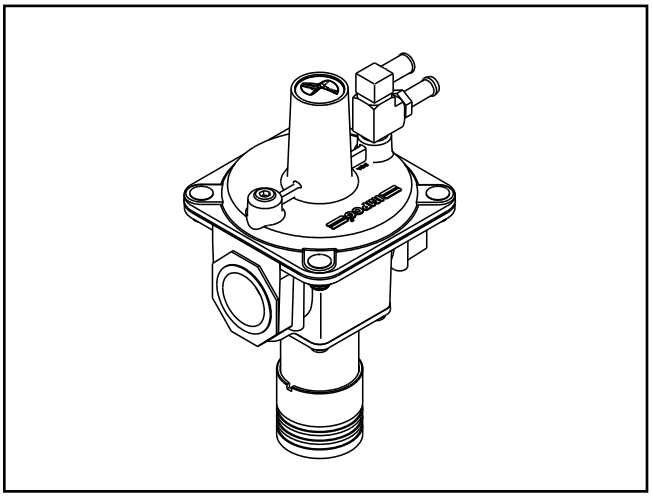


Figure 1-9 Fuel Pressure Regulator

The fuel pressure regulator ensures that the fuel enters the system at a consistent and usable pressure. The fuel selection on the pressure regulator can be manually set for Natural Gas (NG) or Liquefied Petroleum Gas (LPG).

1.9. Fuel Shut-Off Valves

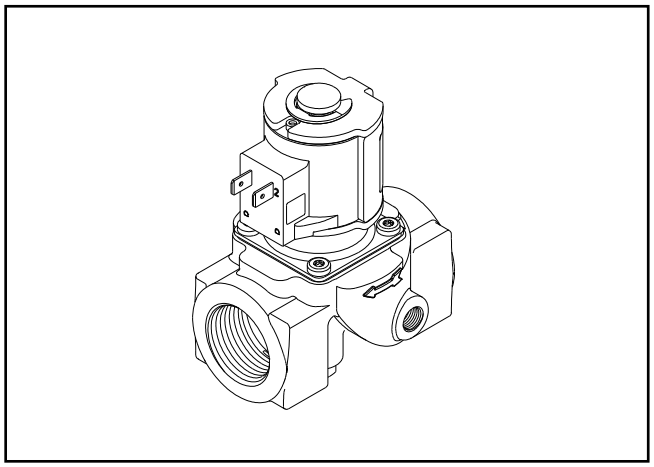


Figure 1-10 Fuel Solenoid Valve

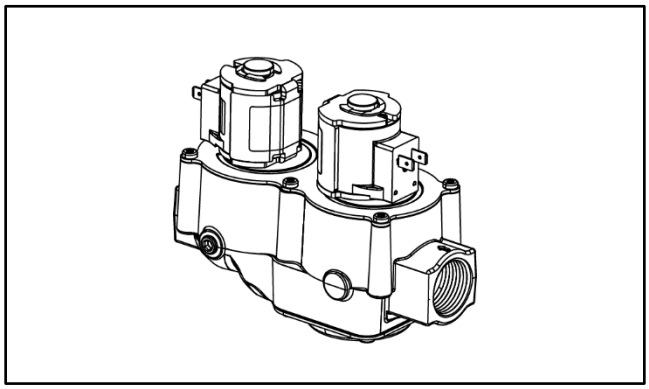


Figure 1-11 Dual-Solenoid Fuel Valve

Two solenoid valves or one dual-solenoid valve are mounted upstream of the engine. The fuel solenoid valves provide automatic fuel on/off control. The engine starting battery powers the solenoid valve and the engine starting controls open the valves when the engine cranks or runs.

1.10. Heated Exhaust Gas Oxygen (HEGO) Sensor

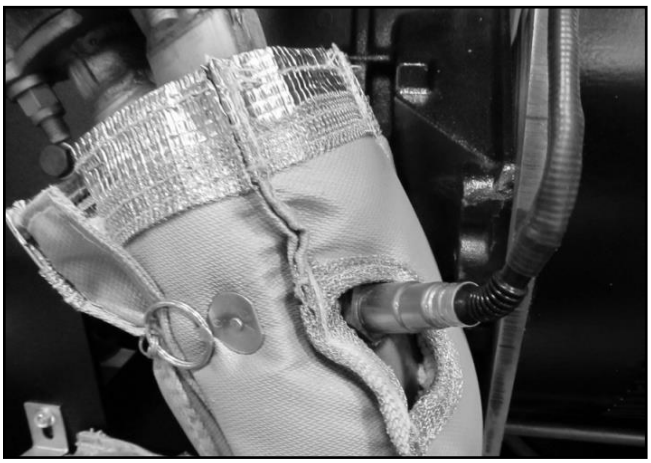


Figure 1-12 HEGO Sensor

The heated exhaust gas oxygen (HEGO) sensor mounts to the exhaust system and is composed of a sensor and an internal heating element.

During operation, heat from the exhaust increases the temperature of the heating element and activates the sensor. Once activated, the sensor measures the oxygen content in the exhaust gas and sends a signal to the ECM.

The ECM uses this signal to adjust the fuel flow to the engine and to prevent the fuel flow from becoming too rich or too lean. If the sensor signal indicates that the fuel is too rich or too lean for an extended period of time, the ECM will log a diagnostic code.

Important: Silicone sprays or inappropriate RTV (room temperature vulcanization) sealers can contaminate the HEGO sensor. Contaminated HEGO sensors can produce false or high readings resulting in poor fuel mixtures and severe performance problems. Always verify that the sealer is safe to use with the HEGO sensor before applying the sealer.

1.11. Ignition System



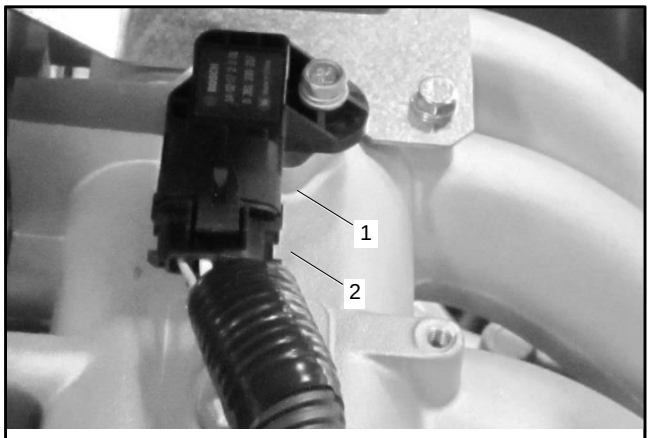
Figure 1-13 Ignition Coil

The ignition system is a wasted spark system. In a wasted spark system, spark is provided to two cylinders simultaneously. One spark plug fires during the compression stroke of a cylinder and creates combustion; while the other spark plug fires during the exhaust stroke and is wasted.

After receiving the crank signal, the ECM sends the ignition control module a triggering signal that tells the ignition module exactly when to make the ignition coil spark. The ignition coil then sends a spark to each engine cylinder through a high tension lead and the spark plugs.

1.12. MAP and TMAP Sensors

1.12.1. Manifold Air Temperature and Manifold Absolute Pressure (TMAP) Sensor



1. TMAP sensor
2. Wire harness connector

Figure 1-14 TMAP Sensor

The TMAP sensor is a combination of two sensors: the manifold absolute pressure (MAP) sensor and the manifold air temperature (MAT) or intake air temperature (IAT) sensor. The MAP Sensor measures the intake manifold pressure and the MAT or IAT sensor measures the air temperature in the intake manifold. The ECM uses the pressure and temperature readings in conjunction with other inputs to estimate the airflow requirement of the engine.

The MAT sensor uses a variable resistance thermistor to measure the air temperature and then sends a voltage signal to the ECM. The ECM interprets the signal voltage to indicate the temperature. If a cold start is indicated, the ECM enriches the fuel mixture.

The MAP (Manifold Absolute Pressure) sensor portion of the TMAP sensor is a pressure transducer connected to the intake manifold. The MAP Sensor uses a variable resistor to measure the absolute pressure in the intake manifold. The ECM uses the signal from the MAP sensor to determine the engine load and then adjusts the fuel mixture to improve performance and emissions.

1.12.2. Up-stream Throttle Manifold Air Pressure (MAP) Sensor (KG2204T only)

The up-stream throttle manifold air pressure sensor on the KG2204T turbocharged engine monitors the absolute pressure (boost pressure) in the air induction system up-stream of the throttle. Data returned by the MAP sensor prompts the ECM to adjust the air-fuel mixture as needed.

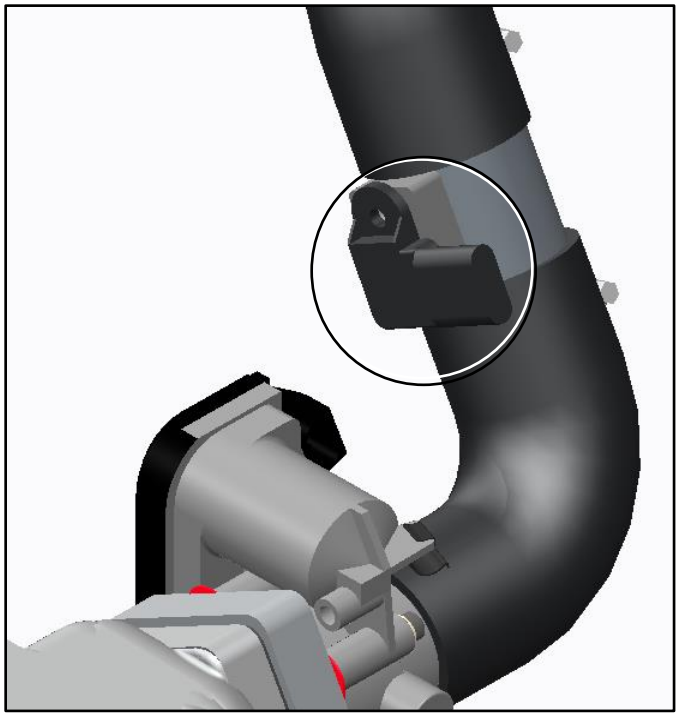


Figure 1-15 Manifold Absolute Pressure (MAP) Sensor, KG2204T

1.13. Oil Pressure Sender



Figure 1-16 Oil Pressure Sender

The oil pressure sender is used to communicate a low oil pressure condition to the ECM. Engine damage can occur if the engine is operated with low oil pressure.

The engine oil pressure sender is designed to ensure adequate lubrication throughout the engine. It provides a pressure value and is monitored by the ECM. If the pressure drops, a DTC will occur.

1.14. Throttle Body

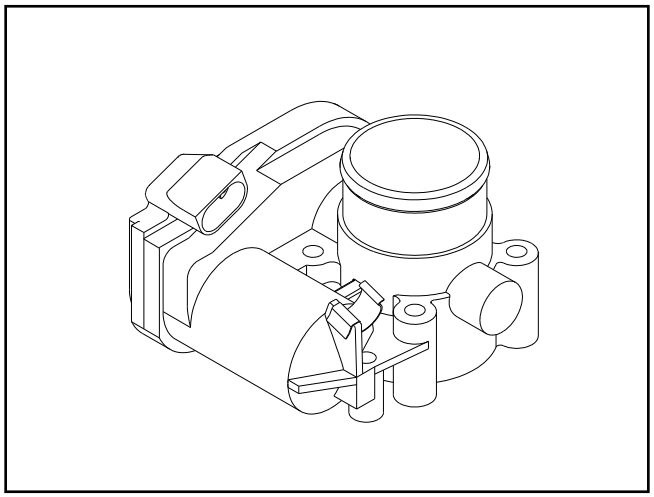


Figure 1-17 Throttle Body

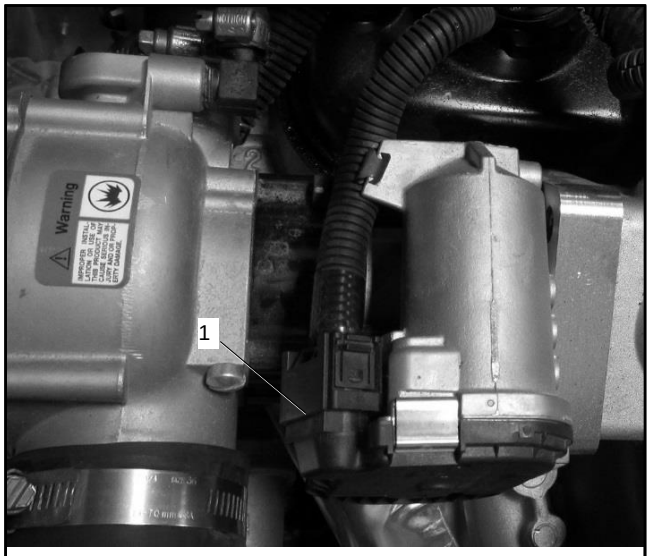
The throttle body controls the amount of fuel that enters the engine and is composed of a throttle blade, electric throttle motor, and a throttle position (TP) sensor.

Engine speed control is maintained by the ECM. Defaults programmed into the ECM software and throttle position sensors allow the ECM to maintain safe operating control over the engine while maintaining speed and load control.

The electronic throttle control (ETC) device utilizes an electric motor connected to the throttle blade. The ECM sends an electrical signal to the motor on the electronic throttle control to increase or decrease the angle of the throttle blade thus increasing or decreasing the fuel supply to the engine.

The electronic throttle control device incorporates an internal Throttle Position (TP) sensor which provides output signals to the ECM as to the location of the throttle shaft and blade. The TP sensor information is used by the ECM to correct for speed and load control.

1.15. Throttle Position (TP) Sensor



1. Throttle position sensor

Figure 1-18 Throttle Position Sensor

The throttle position (TP) sensor is part of the throttle body and is composed of three components: an electronic throttle control (ETC), throttle position sensor 1 (TP1), and throttle position sensor 2 (TP2). TP1 and TP2 determine the throttle blade position and send signals to ECM. The ECM receives information from TP1 and TP2 and sends a signal to the ETC to open or close the throttle blade. The ETC controls an electric motor that opens and closes the throttle blade.

1.16. Turbocharger (KG2204T only)

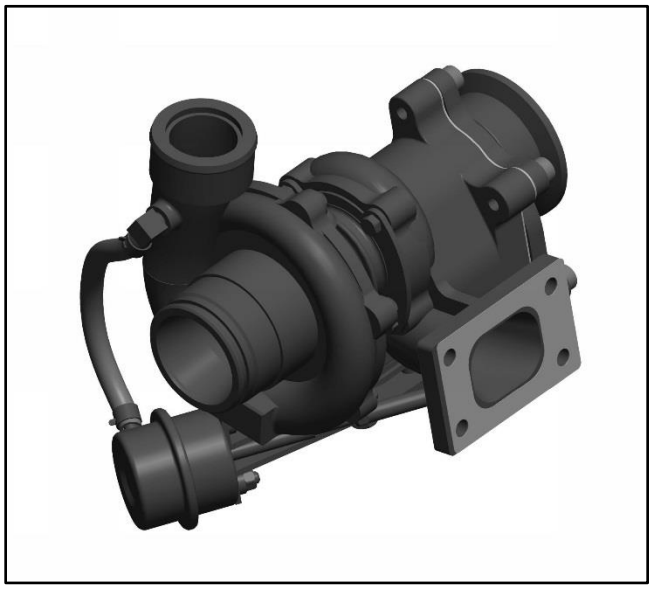


Figure 1-19 Turbocharger

The turbocharger utilizes exhaust gas flowing through the turbine to spin a compressor. The turbocharger compressor increases boost pressure and density of the air/fuel mixture entering the intake manifold resulting in higher power output compared to the naturally aspirated engine.

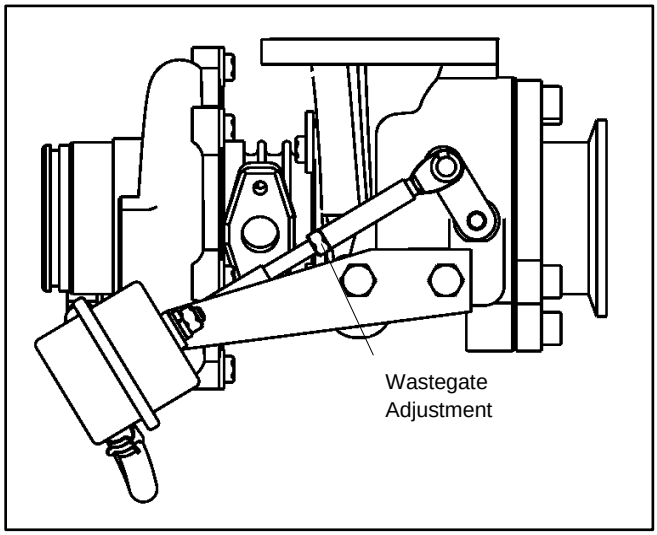


Figure 1-20 Turbocharger Wastegate Adjustment

A wastegate on the turbocharger bypasses exhaust gas around the turbine when the boost pressure reaches a maximum limit. Use Spectrum software to check the boost pressure and adjust the wastegate linkage, if necessary, to achieve a maximum boost pressure of 180 kPa absolute.

1.17. Turbocharger Oil Lines (KG2204T only)

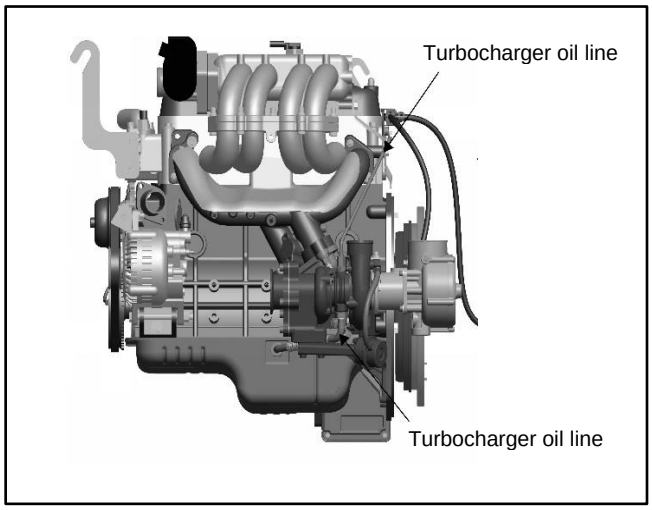


Figure 1-21 Turbocharger oil lines

The turbocharger bearings require oil for lubrication and cooling. Oil is fed to the turbocharger bearings from the oil supply line on the top side of the bearing housing and returned to the oil sump through a line connecting the bottom side of the bearings to the sump.

2.1. Introduction

The table on the following pages lists the diagnostic troubleshooting codes (DTCs), the possible causes, and the corrective actions for the DTC. Use Spectrum software and a Kvaser cable to retrieve logged DTCs from the ECM.

Note: When the KG2204 or KG2204T engine is paired with a Kohler generator set, the diagnostic port is located on the side of the connection box.

2.2. Spectrum Diagnostic Scan Tool (DST)

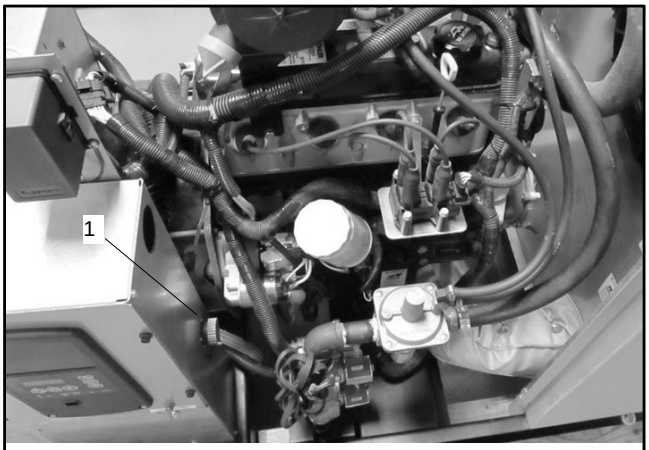
Spectrum is a **diagnostic scan tool (DST)** software available from IMPCO® Technologies, Inc. Refer to the Spectrum instruction manual for software installation and operation.

Use Spectrum to:

- View active and historic diagnostic troubleshooting codes (DTCs).
- Monitor feedback from the sensors.
- Plot sensor feedback to a chart.

Note: Spectrum software, software password, instruction manual, and a Kvaser CAN Bus driver are available on the IMPCO® Technologies website, https://impcotechnologies.com/spectrum-engine-monitor

1. Download Spectrum Series IV software and the Spectrum Instruction Manual.
2. Follow the instructions in the manual to install Spectrum Series IV on a laptop computer.
3. Use a Kvaser cable, Kohler part number GM95122, to connect from a laptop with Spectrum software to the diagnostic port on the generator connection box. See Figure 2-1 Diagnostic Port Location.



1. Diagnostic port

Figure 2-1 Diagnostic Port Location

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0006	632	4	Fuel Shutoff Valve A Control Circuit Low	• Problem with the fuel shutoff valve or leads.	• Check the fuel shutoff valve leads. • Replace fuel shutoff valve.
P0007	632	3	Fuel Control Valve A Control Circuit High	• Problem with the fuel shutoff valve or leads.	• Check the fuel control valve leads. Refer to Section 4.6. • Replace fuel control valve. Refer to Section 5.5.
P0031	3223	4	HEGO sensor Heater Control Circuit Low (Bank 1 Sensor 1)	• Problem with the HEGO sensor or leads.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P0032	3223	3	HO2S Heater Control Circuit High (Bank 1 Sensor 1)	• Problem with the HEGO sensor or leads.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P0037	3232	4	HO2S Heater Control Circuit Low (Bank 1 Sensor 2)	• Not applicable	• Not applicable
P0038	3232	3	HO2S Heater Control Circuit High (Bank 1 Sensor 2)	• Not applicable	• Not applicable
P0051	3261	4	HO2S Heater Control Circuit Low (Bank 2 Sensor 1)	• Not applicable	• Not applicable
P0052	3261	3	HO2S Heater Control Circuit High (Bank 2 Sensor 1)	• Not applicable	• Not applicable
P0057	3271	4	HO2S Heater Control Circuit Low (Bank 2 Sensor 2)	• Not applicable	• Not applicable
P0058	3271	3	HO2S Heater Control Circuit High (Bank 2 Sensor 2)	• Not applicable	• Not applicable
P0068	132	13	MAP/MAT/Throttle Position Correlation	• May indicate a drifted sensor, a contaminated throttle bore, or air leakage after the throttle.	• Check contamination in the throttle bore. • Check for air leakage after the throttle, manifold vacuum leakage, damaged vacuum hoses. • Troubleshoot the TMAP sensor leads. Refer to Section 4.10. • Troubleshoot the TP sensor leads. Refer to Section 4.11.
P0087	159	18	Fuel Rail/System Pressure Too Low	• Not applicable	• Not applicable
P0088	159	16	Fuel Rail/System Pressure Too High	• Not applicable	• Not applicable
P0093	1239	16	Large Fuel Rail Leak	• Not applicable	• Not applicable
P0094	1239	15	Small Fuel Rail Leak	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0102	132	4	Mass or Volume Air Flow Circuit Low Input	• Problem with the TMAP sensor or leads.	• Troubleshoot the TMAP sensor leads. Refer to Section 4.10. • Replace the TMAP sensor. Refer to Section 5.10.
P0103	132	3	Mass or Volume Air Flow Circuit High Input	• Problem with the TMAP sensor or leads.	• Troubleshoot the TMAP sensor leads. Refer to Section 4.10. • Replace the TMAP sensor. Refer to Section 5.10.
P0107	3563	4	Manifold Absolute Pressure/Baro Pressure Circuit Low Input	• Problem with the TMAP sensor or leads.	• Troubleshoot the TMAP sensor leads. Refer to Section 4.10. • Replace the TMAP sensor. Refer to Section 5.10.
P0108	3563	3	Manifold Absolute Pressure/Baro Pressure Circuit High Input	• Problem with the TMAP sensor or leads.	• Troubleshoot the TMAP sensor leads. Refer to Section 4.10. • Replace the TMAP sensor. Refer to Section 5.10.
P0111	105	13	Intake Air Temp Circuit Range/Performance Problem	• Problem with the TMAP sensor or leads.	• Troubleshoot the TMAP sensor leads. Refer to Section 4.10. • Replace the TMAP sensor. Refer to Section 5.10.
P0112	105	4	Intake Air Temp Circuit Low Input	• Problem with the TMAP sensor or leads.	• Troubleshoot the TMAP sensor leads. Refer to Section 4.10. • Replace the TMAP sensor. Refer to Section 5.10.
P0113	105	3	Intake Air Temp Circuit High Input	• Problem with the TMAP sensor.	• Troubleshoot the TMAP sensor leads. Refer to Section 4.10. • Replace the TMAP sensor. Refer to Section 5.10.
P0116	110	13	Engine Coolant Temperature Circuit Range/Performance Problem	• Problem with the CT sensor or leads.	• Check CT sensor leads. Refer to **Section 4.3**. • Replace CT sensor. Refer to Section 5.2
P0117	110	4	Engine Coolant Temperature Circuit Low Input	• Problem with the CT sensor or leads.	• Check CT sensor leads. Refer to **Section 4.3**. • Replace CT sensor. Refer to **Section 5.2**.
P0118	110	3	Engine Coolant Temperature Circuit High Input	• Problem with the CT sensor or leads.	• Check CT sensor leads. Refer to **Section 4.3**. • Replace CT sensor. Refer to **Section 5.2**.
P0121	51	13	Throttle/Pedal Position Sensor/Switch A Circuit Range/Performance Problem	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0122	51	4	Throttle/Pedal Position Sensor/Switch A Circuit Low Input	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0123	51	3	Throttle/Pedal Position Sensor/Switch A Circuit High Input	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0124	51	2	Throttle/Pedal Position Sensor/Switch A Circuit Intermittent	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0125	110	17	Insufficient Coolant Temperature for Closed Loop Fuel Control	• Problem with the CT sensor or leads.	• Check CT sensor leads. Refer to **Section 4.3**. • Replace CT sensor. Refer to Section 5.2.
P0126	110	18	Insufficient Coolant Temperature for Stable Operation	• Problem with the CT sensor or leads.	• Check CT sensor leads. Refer to **Section 4.3**. • Replace CT sensor. Refer to **Section 5.2**.
P0127	105	16	Intake Air Temperature Too High	• Blocked CAC, cabin fan not working, intake air duct separated.	• Clean debris from air cleaner. • Check the fan leads. • Check the fan fuses. • Reconnect intake air duct.
P0128	110	17	Coolant Thermostat (Coolant Temperature Below Thermostat Regulating Temperature)	• Problem with the CT sensor or leads.	• Check CT sensor leads. Refer to **Section 4.3**. • Replace CT sensor. Refer to Section 5.2.
P0129	108	18	Barometric Pressure Too Low	• Actual atmospheric condition, TMAP sensor/leads if you also have a TMAP fault.	• Replace the TMAP sensor. Refer to **Section 5.10**.
P0131	3217	4	HEGO sensor Circuit Low Voltage (B1S1)	• Problem with the HEGO sensor or leads.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P0132	3217	3	HEGO sensor Circuit High Voltage (B1S1)	• Problem with the HEGO sensor or leads.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P0133	3217	13	HEGO sensor Circuit Slow Response (B1S1)	• Problem with the HEGO sensor or leads.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P0134	3217	31	HEGO sensor No Activity Detected (B1S1)	• Problem with the HEGO sensor or leads.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P0137	3227	4	O2 Sensor Circuit Low Voltage (B1S2)	• Not applicable	• Not applicable
P0138	3227	3	O2 Sensor Circuit High Voltage (B1S2)	• Not applicable	• Not applicable
P0139	3227	13	O2 Sensor Circuit Slow Response (B1S2)	• Not applicable	• Not applicable
P0140	3227	31	O2 Sensor No Activity Detected (B1S2)	• Not applicable	• Not applicable
P0151	3256	4	O2 Sensor Circuit Low Voltage (B2S1)	• Not applicable	• Not applicable
P0152	3256	3	O2 Sensor Circuit High Voltage (B2S1)	• Not applicable	• Not applicable
P0153	3256	13	O2 Sensor Circuit Slow Response (B2S1)	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0154	3256	31	O2 Sensor No Activity Detected (B2S1)	• Not applicable	• Not applicable
P0157	3266	4	O2 Sensor Circuit Low Voltage (B2S2)	• Not applicable	• Not applicable
P0158	3266	3	O2 Sensor Circuit High Voltage (B2S2)	• Not applicable	• Not applicable
P0159	3266	13	O2 Sensor Circuit Slow Response (B2S2)	• Not applicable	• Not applicable
P0160	3266	31	O2 Sensor No Activity Detected (B2S2)	• Not applicable	• Not applicable
P0168	174	16	Fuel Temperature Too high	• Not applicable	• Not applicable
P0171	1695	17	System Too Lean, Bank 1	• Problem with fuel delivery or fuel feedback control or an overheated HEGO sensor.	• Check for other DTC codes or misfires. • Check for exhaust leaks ahead of or near the HEGO sensor. • Check fuel system for restrictions. • Check fuel pressure regulator. • Check fuel shutoff valve. • Confirm fuel quality and fuel pressure.
P0172	1695	15	System Too Rich, Bank 1	• Problem with fuel delivery or fuel feedback control.	• Check for other DTC codes or misfires. • Check for exhaust restrictions. • Check fuel system for restrictions. • Confirm fuel quality and fuel pressure. • Check fuel pressure regulator. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P0174	1695	17	System Too Lean, Bank 2	• Not applicable	• Not applicable
P0175	1695	15	System Too Rich, Bank 2	• Not applicable	• Not applicable
P0182	174	4	Fuel Temp Sensor A Circuit Low	• Not applicable	• Not applicable
P0183	174	3	Fuel Temp Sensor A Circuit High	• Not applicable	• Not applicable
P0192	159	4	Fuel Rail Pressure Sensor Circuit Low	• Not applicable	• Not applicable
P0193	159	3	Fuel Rail Pressure Sensor Circuit High	• Not applicable	• Not applicable
P0197	175	4	Oil Temperature Sensor A Circuit Low	• Not applicable	• Not applicable
P0198	175	3	Oil Temperature Sensor A Circuit High	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0217	110	0	Engine Coolant Temperature High Shutdown	• Low coolant, high ambient, plugged radiator, bad CT sensor.	• Check coolant level, clean the radiator from debris. • Check Coolant outlet temp with IR Gun. • Troubleshoot the CT sensor. Refer to **Section 4.3**. • Replace CT sensor. Refer to Section 5.2.
P0219	190	16	Engine Over Speed Condition	• Problem with the throttle body or leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0221	51	31	Throttle/Pedal Position Sensor/Switch B Circuit Range/performance Problem	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0222	51	4	Throttle/Pedal Position Sensor/Switch B Circuit Low	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0223	51	3	Throttle/Pedal Position Sensor/Switch B Circuit High	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0224	51	2	Throttle/Pedal Position Sensor/Switch B Circuit Intermittent	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0234	1127	7	Turbo/Super Charger Overboost Condition	• KG2204T engine with turbocharger only. • Problem in the turbocharger wastegate control circuit.	• Check wastegate and solenoid plumbing. • Check wastegate solenoid operation. • Check for proper preload and opening pressure on the wastegate.
P0236	1127	31	Turbo/Super Charger Boost Sensor A Circuit Range/Performance	• KG2204T engine with turbocharger only.	• Compare manifold pressure and boost pressure sensor values with engine stopped. If values do not match, one of the sensors is incorrect for the application or is out of calibration. Replace the sensor that is reading incorrectly.
P0237	1127	4	Turbo/Super Charger Boost Sensor A Circuit Low	• KG2204T engine with turbocharger only. • Problem in the boost pressure sensor signal circuit.	• Check the electrical connection to the boost pressure sensor. • Check the sensor signal circuit for a short to ground. • Replace the boost pressure sensor.
P0238	1127	3	Turbo/Super Charger Boost Sensor A Circuit High	• KG2204T engine with turbocharger only.	• Check the sensor signal for a short to power. • Check the sensor ground signal to ensure it is not disconnected. • Replace the boost pressure sensor.
P0245	1188	4	Turbo/Super Charger Wastegate Solenoid A Low	• Not applicable	• Not applicable
P0246	1188	3	Turbo/Super Charger Wastegate Solenoid A High	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0261	651	4	Cylinder 1 Injector Circuit Low	• Not applicable	• Not applicable
P0262	651	3	Cylinder 1 Injector Circuit High	• Not applicable	• Not applicable
P0263	651	7	Cylinder 1 Contribution/Balance	• Not applicable	• Not applicable
P0264	652	4	Cylinder 2 Injector Circuit Low	• Not applicable	• Not applicable
P0265	652	3	Cylinder 2 Injector Circuit High	• Not applicable	• Not applicable
P0266	652	7	Cylinder 2 Contribution/Balance	• Not applicable	• Not applicable
P0267	653	4	Cylinder 3 Injector Circuit Low	• Not applicable	• Not applicable
P0268	653	3	Cylinder 3 Injector Circuit High	• Not applicable	• Not applicable
P0269	653	7	Cylinder 3 Contribution/Balance	• Not applicable	• Not applicable
P0270	654	4	Cylinder 4 Injector Circuit Low	• Not applicable	• Not applicable
P0271	654	3	Cylinder 4 Injector Circuit High	• Not applicable	• Not applicable
P0272	654	7	Cylinder 4 Contribution/Balance	• Not applicable	• Not applicable
P0273	655	4	Cylinder 5 Injector Circuit Low	• Not applicable	• Not applicable
P0274	655	3	Cylinder 5 Injector Circuit High	• Not applicable	• Not applicable
P0275	655	7	Cylinder 5 Contribution/Balance	• Not applicable	• Not applicable
P0276	656	4	Cylinder 6 Injector Circuit Low	• Not applicable	• Not applicable
P0277	656	3	Cylinder 6 Injector Circuit High	• Not applicable	• Not applicable
P0278	656	7	Cylinder 6 Contribution/Balance	• Not applicable	• Not applicable
P0279	657	4	Cylinder 7 Injector Circuit Low	• Not applicable	• Not applicable
P0280	657	3	Cylinder 7 Injector Circuit High	• Not applicable	• Not applicable
P0281	657	7	Cylinder 7 Contribution/Balance	• Not applicable	• Not applicable
P0282	658	4	Cylinder 8 Injector Circuit Low	• Not applicable	• Not applicable
P0283	658	3	Cylinder 8 Injector Circuit High	• Not applicable	• Not applicable
P0284	658	7	Cylinder 8 Contribution/Balance	• Not applicable	• Not applicable
P0297	1614	16	Vehicle Overspeed Condition	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0300	1322	31	Random/Multiple Cylinder Misfire Detected	• Not applicable	• Not applicable
P0301	1323	31	Cylinder 1 Misfire Detected	• Not applicable	• Not applicable
P0302	1324	31	Cylinder 2 Misfire Detected	• Not applicable	• Not applicable
P0303	1325	31	Cylinder 3 Misfire Detected	• Not applicable	• Not applicable
P0304	1326	31	Cylinder 4 Misfire Detected	• Not applicable	• Not applicable
P0305	1327	31	Cylinder 5 Misfire Detected	• Not applicable	• Not applicable
P0306	1328	31	Cylinder 6 Misfire Detected	• Not applicable	• Not applicable
P0307	1329	31	Cylinder 7 Misfire Detected	• Not applicable	• Not applicable
P0308	1330	31	Cylinder 8 Misfire Detected	• Not applicable	• Not applicable
P0313	1322	31	Misfire Detected for Low Fuel	• Not applicable	• Not applicable
P0327	731	4	Knock Sensor 1 Circuit Low	• Not applicable.	• Not applicable
P0328	731	3	Knock Sensor 1 Circuit High	• Not applicable.	• Not applicable
P0332	731	4	Knock Sensor 2 Circuit Low	• Not applicable	• Not applicable
P0333	731	3	Knock Sensor 2 Circuit High	• Not applicable	• Not applicable
P0335	636	31	Crankshaft Position Sensor A Circuit	• Problem with the crank position sensor or the leads.	• Troubleshoot the CKP sensor leads. Refer to Section 4.4. • Replace CKP sensor. Refer to Section 5.3.
P0340	637	4	Camshaft Position Sensor A Circuit	• Not applicable.	• Not applicable
P0420	3050	7	Catalyst System Efficiency below threshold	• Not applicable	• Not applicable
P0461	96	7	Fuel Level Sensor A Performance	• Not applicable	• Not applicable
P0462	96	4	Fuel Level Sensor A Circuit Low	• Not applicable	• Not applicable
P0463	96	3	Fuel Level Sensor A Circuit High	• Not applicable	• Not applicable
P0501	84	7	Vehicle Speed Sensor Range/Performance	• Not applicable	• Not applicable
P0502	84	4	Vehicle Speed Sensor Circuit Low Input	• Not applicable	• Not applicable
P0503	84	3	Vehicle Speed Sensor Intermittent/Erratic/high	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0506	188	18	Idle Air Control System RPM Lower Than Expected	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0507	188	16	Idle Air Control System RPM Higher Than Expected	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0508	188	4	Idle Air Control System Circuit Low	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P0509	188	3	Idle Air Control System Circuit High	• Problem with the TP sensor in the throttle body or the leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P050C	3061	18	Cold Start Engine Coolant Temperature Performance	• Diagnostic not set.	• Verify that the CT sensor tracks coolant temperature. Observe the CT sensor reading during engine warm-up. • Check CT sensor leads. Refer to **Section 4.3**. • Check the thermostat and replace if needed. Refer to the **Engine Service Manual**.
P0522	100	4	Engine Oil Pressure Sensor/Switch Low Voltage	• Problem with the oil pressure sender or the leads.	• Check the oil pressure sender leads. Refer to **Section 4.9** • Replace the oil pressure sender. Refer to **Section 5.9**.
P0523	100	3	Engine Oil Pressure Sensor/Switch High Voltage	• Problem with the oil pressure sender or the leads.	• Check the oil pressure sender leads. Refer to **Section 4.9** • Replace the oil pressure sender. Refer to **Section 5.9**.
P0524	100	18	Engine Oil Pressure Too Low	• Low oil fill, engine problem.	• Check the oil level. • Check for leaks • Check for clogged oil filter. • Verify the engine oil pressure.
P0530	3062	31	A/C Refrigerant Pressure Sensor A Circuit	• Not applicable	• Not applicable
P0534	3062	18	Air Conditioner Refrigerant Charge Loss	• Not applicable	• Not applicable
P0545	2433	4	Exhaust Gas Temperature Sensor Circuit Low	• Not applicable	• Not applicable
P0546	2433	3	Exhaust Gas Temperature Sensor Circuit High	• Not applicable	• Not applicable
P0551	2923	7	Power Steering Pressure Switch/Sensor Circuit Performance	• Not applicable	• Not applicable
P0561	167	2	System Voltage Unstable	• Problem with charging system. • Problem with the charging system voltage varying excessively.	• Check the battery and the battery charging alternator for proper operation. • Replace the battery and alternator if needed. Refer to the **Engine Service Manual**.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0562	167	4	System Voltage Low	• Problem with charging system. • Problem with charging system or battery not maintaining a nominal system voltage.	• Check harness, engine, and equipment grounds. • Check the battery fluid levels and for corrosion on the battery posts. • Check the battery charging alternator. • Replace the battery and alternator if needed. Refer to the **Engine Service Manual**.
P0563	167	3	System Voltage High	• Problem with charging system • Problem with charging system or battery not maintaining a nominal system voltage.	• Check the battery and the battery charging alternator for proper operation. • Replace the battery and alternator if needed. Refer to the **Engine Service Manual**.
P0603	(No J1939 DTC)		Internal Control Module Keep Alive Memory (KAM) Error	• There is no saved EEPROM data.	• Clear the DTC code and turn the ECM power off. Wait fifteen minutes and check if the code is regenerated. • Replace the ECM. Refer to Section 5.4.
P0604	(No J1939 DTC)		Internal Control Module Random Access Memory (RAM) Error	• There is a problem with the ECM RAM.	• Clear the DTC code and turn the ECM power off. Wait fifteen minutes and check if the code is regenerated. • Replace the ECM. Refer to Section 5.4.
P0605	(No J1939 DTC)		Internal Control Module Read Only Memory (ROM) Error	• There is a blank or corrupted operating program.	• Clear the DTC code and turn the ECM power off. Wait fifteen minutes and check if the code is regenerated. • Replace the ECM. Refer to Section 5.4.
P0606	(No J1939 DTC)		ECM/PCM Processor	• Either the ECM did not pass a functional test or the boot ROM is corrupt.	• Clear the DTC code and turn the ECM power off. Wait fifteen minutes and check if the code is regenerated. • Replace the ECM. Refer to Section 5.4.
P0610	237	31	Vehicle Options Programming Error	• Not applicable	• Not applicable
P0615	1321	31	Starter Relay Circuit	• Not applicable	• Not applicable
P0622	167	31	Generator Field/F Terminal Circuit	• Not applicable	• Not applicable
P0636	2923	4	Power Steering Control Circuit Low	• Not applicable	• Not applicable
P0637	2923	3	Power Steering Control Circuit High	• Not applicable	• Not applicable
P0638	3464	7	Throttle Actuator Control Range/Performance	• Desired and actual throttle positions do not match.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0642	3509	4	Sensor Reference Voltage A Circuit Low	• Problem with 5 V sensor power supply circuit. Power supply is less than 4.6 V.	• Check electrical connection at ECM for sensor power supply circuit. • Check for sensor power supply circuit shorts to ground. • Check for shorts by disconnecting the TMAP and TP sensors. Monitor the sensor power supply while reconnecting the sensors one at a time. If the voltage falls when a sensor is added, replace that sensor. Refer to **Section 5**.
P0643	3509	3	Sensor Reference Voltage A Circuit High	• Problem with 5 V sensor power supply circuit. Power supply is above 5.4 V.	• Check electrical connection at ECM for sensor power supply circuit. • Check for a short circuit to battery voltage or open circuit in sensor ground wire. • Check for shorts by disconnecting the TMAP and TP sensors. Monitor the sensor power supply while reconnecting the sensors one at a time. If the voltage rises when a sensor is added, replace that sensor. Refer to **Section 5**.
P0646	876	4	A/C Clutch Relay Control Circuit Low	• Not applicable	• Not applicable
P0647	876	3	A/C Clutch Relay Control Circuit High	• Not applicable	• Not applicable
P0650	1213	31	Malfunction Indicator Lamp (MIL) Control Circuit	• Not applicable	• Not applicable
P0652	3510	4	Sensor Reference Voltage B Circuit Low	• Problem with 5 V sensor power supply circuit. Power supply is less than 4.6 V.	• Check electrical connection at ECM for sensor power supply circuit. • Check for sensor power supply circuit shorts to ground. • Check for shorts by disconnecting the TMAP and TP sensors. Monitor the sensor power supply while reconnecting the sensors one at a time. If the voltage falls when a sensor is added, replace that sensor. Refer to **Section 5**.
P0653	3510	3	Sensor Reference Voltage B Circuit High	• Problem with 5 V sensor power supply circuit. Power supply is above 5.4 V.	• Check electrical connection at ECM for sensor power supply circuit. • Check for a short circuit to battery voltage or open circuit in sensor ground wire. • Check for shorts by disconnecting the TMAP and TP sensors. Monitor the sensor power supply while reconnecting the sensors one at a time. If the voltage rises when a sensor is added, replace that sensor. Refer to **Section 5**.
P0654	836	31	Engine RPM Output Circuit	• Not applicable	• Not applicable
P0655	623	31	Overheat Lamp Circuit	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0656	96	31	Fuel Level Output Circuit Fault	• Not applicable	• Not applicable
P0657	650	5	Actuator Power Supply Voltage A Circuit Open	• Problem with the actuator power voltage circuit.	• Check the relay coil and leads for power and continuity.
P0658	650	4	Actuator Power Supply Voltage A Circuit Low	• The actuator power supply is lower than expected.	• Check the actuator relay coil and leads for power and continuity.
P0659	650	3	Actuator Power Supply Voltage A Circuit High	• The actuator power supply is higher than expected.	• Check the relay coil and leads for power and continuity. • Check the battery and battery charging alternator.
P0686	1485	4	ECM/PCM Power Relay Control Circuit Low	• Problem with the power control relay circuit.	• Check power control relay and leads. • While the engine is running, check for high system voltage at the battery, alternator, and the ECM power input pin.
P0687	1485	3	ECM/PCM Power Relay Control Circuit High	• Problem with the power control relay circuit.	• Check power control relay and leads.
P0691	1071	4	Fan 1 Control Circuit Low	• Not applicable	• Not applicable
P0692	1071	3	Fan 1 Control Circuit High	• Not applicable	• Not applicable
P0693	1071	4	Fan 2 Control Circuit Low	• Not applicable	• Not applicable
P0694	1071	3	Fan 2 Control Circuit Low	• Not applicable	• Not applicable
P0695	1071	4	Fan 3 Control Circuit Low	• Not applicable	• Not applicable
P0696	1071	3	Fan 3 Control Circuit Low	• Not applicable	• Not applicable
P0698	3511	4	Sensor Reference Voltage C Circuit Low	• Problem with 5 V sensor power supply.	• Check the ECM leads. • Check for sensor shorts for sensors using 5 V sensor power supply by disconnecting all sensors and then connecting back one at a time. • Isolate a defective sensor. While monitoring the sensor power supply with a scan tool or voltmeter, disconnect all sensors powered from the sensor reference voltage C power supply. When the defective sensor is plugged back in, the voltage will fall. • Replace the ECM. Refer to Section 5.4.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P0699	3511	3	Sensor Reference Voltage C Circuit High	• Problem with 5 V sensor power supply.	• Check the ECM leads. • Check for sensor shorts for sensors using 5 V sensor power supply by disconnecting all sensors and then connecting back one at a time. • Isolate a defective sensor. While monitoring the sensor power supply with a scan tool or voltmeter, disconnect all sensors powered from the sensor reference voltage C power supply. When the defective sensor is plugged back in, the voltage will fall. • Replace the ECM. Refer to Section 5.4.
P1134	3217	2	Oxygen Sensor 1 Bank 1 Erratic Air Fuel Ratio	• Diagnostic not set. • Problem with exhaust leaks or poor HEGO sensor performance.	• Check for exhaust leaks before or near the HEGO sensor. • Check for intake manifold leaks. • Verify that the HEGO sensor is installed securely. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P1135	3217	2	Oxygen Sensor 1 Bank 1 Lean Shift	• Diagnostic not set. • Problem with exhaust leaks or poor HEGO sensor performance.	• Check for exhaust leaks before or near the HEGO sensor. • Check for intake manifold leaks. • Verify that the HEGO sensor is installed securely. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P1136	3217	2	Oxygen Sensor 1 Bank 1 Rich Shift	• Problem with poor HEGO sensor performance.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P1137	3217	31	Oxygen Sensor 1 Bank 1 High Impedance Degradation	• Problem with poor HEGO sensor performance.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P1138	3217	31	HEGO Sensor Overheat	• Problem with poor HEGO sensor performance.	• Check for excessive exhaust temperatures. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P1480	1071	31	Fan 1 Motor Circuit Fault	• Not applicable	• Not applicable
P1481	1071	31	Fan 2 Motor Circuit Fault	• Not applicable	• Not applicable
P1482	1071	31	Fan 3 Motor Circuit Fault	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P1502	1196	31	Vehicle Antitheft triggered	• Not applicable	• Not applicable
P1518	3464	13	Throttle Actuator Zero Cycle Incomplete	• Bad throttle body or leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P1519	3464	13	Throttle Actuator Backup Span Data Lost	• Bad throttle body or leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P1520	3464	13	Throttle Actuator Primary Span Data Lost	• Bad throttle body or leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P1521	3464	13	Throttle Zero Cycle Rest Value Incorrect	• Bad throttle body or leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P1522	3464	13	Throttle Zero Cycle Position Mismatch	• Bad throttle body or leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P1562	167	16	Injector Return Voltage High	• Not applicable	• Not applicable
P1609	1634	31	Calibration/Firmware Mismatch	• ECM not flashed correctly.	• Re-Flash or replace the ECM.
P1630	3464	0	Electronic Throttle Driver Overheat	• Leads/bad throttle body. • Throttle driver temperature has exceeded safe operating limits.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P1631	3464	0	Electronic Throttle Driver Overheat	• Bad throttle body or leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P1632	3464	14	Electronic Throttle Driver Overheat Shutdown	• Bad throttle body or leads.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P1633	3464	14	Electronic Throttle Driver Overvoltage Shutdown	• Bad throttle body or leads. • Throttle driver has received an overvoltage above 30 V.	• Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**. • Check the alternator output at a raised engine speed. • Check harness, engine, and equipment grounds. • Check the battery fluid levels and for corrosion.
P1657	623	31	Stop Engine Lamp Circuit Fault	• Not applicable	• Not applicable
P1666	2628	4	Fuel Shutoff Valve C Control Circuit Low	• Not applicable	• Not applicable
P1667	2628	3	Fuel Shutoff Valve C Control Circuit High	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P1690	911	31	Maintenance Reminder	• Not applicable	• Not applicable
P2096	3227	18	Post Catalyst Fuel Trim System Too Lean	• Not applicable	• Not applicable
P2097	3227	16	Post Catalyst Fuel Trim System Too Rich	• Not applicable	• Not applicable
P2100	3464	5	Throttle Actuator Control Motor Circuit Open	• Open circuit in throttle control motor. • Bad throttle body.	• Check the throttle motor and leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P2102	3464	4	Throttle Actuator Control Motor Circuit Low	• Short circuit across throttle control motor or ground. • Bad throttle body.	• Check the throttle motor leads. Refer to Section 4.11. • Replace the throttle body if the code continues to occur. Refer to **Section 5.1**.
P2103	3464	3	Throttle Actuator Control Motor Circuit High	• Short circuit across throttle control motor or power. • Bad throttle body.	• Check the throttle motor leads. Refer to Section 4.11. • Check for smooth throttle operation. • Replace the throttle body if the code continues to occur. Refer to **Section 5.1**.
P2109	3464	13	Throttle Position Sensor A Minimum Stop Performance	• Problem with throttle body or leads.	• Check for smooth throttle operation. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Perform manual throttle zero process using the scan tool. • Replace the throttle body if the code continues to occur. Refer to **Section 5.1**.
P2111	3464	7	Throttle Actuator Control System - Stuck Open	• Throttle jammed open. • Possible problem with the throttle gear box.	• Check for smooth throttle operation. • Check the throttle for ice or blockage. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**. • If the throttle returns to the default position (fast idle) while disconnected from the ECM, then replace the ECM. Refer to **Section 5.4**.
P2112	3464	7	Throttle Actuator Control System - Stuck Closed	• Throttle jammed closed. • Possible problem with the throttle gear box.	• Check for smooth throttle operation. • Check the throttle for ice or blockage. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**. • If the throttle returns to the default position (fast idle) while disconnected from the ECM, then replace the ECM. Refer to **Section 5.4**.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P2113	3464	13	Throttle Position Sensor B Minimum Stop Performance	• Problem with throttle body or leads.	• Check for smooth throttle operation. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Perform manual throttle zero process using the scan tool. • Replace the throttle body if the code continues to occur. Refer to **Section 5.1**.
P2119	3464	14	Throttle Actuator Control Throttle Body Range/Performance	• Throttle position or signal is incorrect.	• Check for smooth throttle operation. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Perform manual throttle zero process using the scan tool. • Replace the throttle body. Refer to **Section 5.1**.
P2122	91	4	Throttle/Pedal Position Sensor/Switch D Circuit Low Input	• Not applicable	• Not applicable
P2123	91	3	Throttle/Pedal Position Sensor/Switch D Circuit High Input	• Not applicable	• Not applicable
P2127	2972	4	Throttle/Pedal Position Sensor/Switch E Circuit Low Input	• Not applicable	• Not applicable
P2128	2972	3	Throttle/Pedal Position Sensor/Switch E Circuit High Input	• Not applicable	• Not applicable
P2132	2973	4	Throttle/Pedal Position Sensor/Switch F Circuit Low Input	• Not applicable	• Not applicable
P2133	2973	3	Throttle/Pedal Position Sensor/Switch F Circuit High Input	• Not applicable	• Not applicable
P2135	51	7	Throttle/Pedal Position Sensor/Switch A/B Voltage Correlation	• Throttle position sensors do not match.	• Check TP sensor voltage while manually changing the throttle position. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P2138	91	7	Throttle/Pedal Position Sensor/Switch D/E Voltage Correlation	• Not applicable	• Not applicable
P2139	91	7	Throttle/Pedal Position Sensor/Switch D/F Voltage Correlation	• Not applicable	• Not applicable
P2140	91	7	Throttle/Pedal Position Sensor/Switch E/F Voltage Correlation	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P2163	3464	13	Throttle Position Sensor A Maximum Stop Performance	• Problem with throttle movement.	• Check for smooth throttle operation. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Check for proper throttle position voltage readings. • Perform manual throttle zero process using the scan tool. • Replace the throttle body. Refer to **Section 5.1**.
P2164	3464	13	Throttle Position Sensor B Maximum Stop Performance	• Problem with throttle movement.	• Check for smooth throttle operation. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Check for proper throttle position voltage readings. • Perform manual throttle zero process using the scan tool. • Replace the throttle body. Refer to **Section 5.1**.
P2172	3464	14	Throttle Actuator Control System - Sudden High Airflow Detected	• Throttle body damage or air leak between the throttle and engine.	• Check for smooth throttle operation. • Check for vacuum hose leaks. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P2173	3464	14	Throttle Actuator Control System - High Airflow Detected	• Throttle body damage or air leak between the throttle and engine.	• Check for smooth throttle operation. • Check for vacuum hose leaks. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P2174	3464	14	Throttle Actuator Control System - Sudden Low Airflow Detected	• Throttle body damage or air blockage in the air intake system.	• Check for smooth throttle operation. • Check for air intake restrictions. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P2175	3464	14	Throttle Actuator Control System - Low Airflow Detected	• Throttle body damage or air blockage in the air intake system.	• Check for smooth throttle operation. • Check for air intake restrictions. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.
P2176	3464	14	Throttle Actuator Control System - Idle Position Not Learned	• ECM was not able to throttle span after shutdown.	• Troubleshoot any other DTC codes first. • Check for smooth throttle operation. • Check for proper throttle position voltage readings. • Perform manual throttle zero process using the scan tool. • Troubleshoot the TP sensor leads. Refer to Section 4.11. • Replace the throttle body. Refer to **Section 5.1**.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P2177	1695	18	System Too Lean Off Idle	• Problem with the closed-loop feedback control.	• Check for misfires. • Check fuel quality. • Check fuel pressure regulator and outlet pressure. • Check for exhaust leaks. • Check for intake manifold leaks. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2178	1695	16	System Too Rich Off Idle	• Problem with the closed-loop feedback control.	• Check for misfires. • Check fuel quality. • Check fuel pressure regulator and outlet pressure. • Check for exhaust leaks. • Check for intake manifold leaks. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2187	1695	18	System Too Lean at Idle	• Problem with the closed-loop feedback control.	• Check for misfires. • Check fuel quality. • Check fuel pressure regulator and outlet pressure. • Check for exhaust leaks. • Check for intake manifold leaks. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2188	1695	16	System Rich at Idle	• Problem with the closed-loop feedback control.	• Check for misfires. • Check fuel quality. • Check fuel pressure regulator and outlet pressure. • Check for exhaust leaks. • Check for intake manifold leaks. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2191	1695	18	System too Lean at Higher Load	• Problem with the closed-loop feedback control.	• Check for misfires. • Check fuel quality. • Check fuel pressure regulator and outlet pressure. • Check for exhaust leaks. • Check for intake manifold leaks. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P2192	1695	16	System Too Rich at Higher Load.	• Problem with the closed-loop feedback control.	• Check for misfires. • Check fuel quality. • Check fuel pressure regulator and outlet pressure. • Check for exhaust leaks. • Check for intake manifold leaks. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2195	3217	18	HEGO sensor Signal Stuck Lean B1S1	• Problem with the closed-loop feedback control.	• Check for misfires. • Check fuel quality. • Check fuel pressure regulator and outlet pressure. • Check for exhaust leaks. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2196	3217	16	HEGO sensor Signal Stuck Rich B1S1	• Problem with high fuel pressure, intake and exhaust restrictions, or the HEGO sensor.	• Check for restrictions in the air intake system and air cleaner. • Check fuel pressure regulator and outlet pressure. • Check for exhaust restrictions. • Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2231	3217	14	HEGO sensor Signal Circuit Shorted to Heater Circuit	• HEGO heater causing interference with the HEGO signal. • Problem with HEGO sensor or leads.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2243	3217	5	Oxygen Sensor Reference Circuit Bank 1 Sensor 1	• HEGO heater causing interference with the HEGO signal. • Problem with HEGO sensor or leads.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2261	1127	7	Turbo/Super Charger Bypass Valve - Mechanical	• Only supported with the turbo version of the engine. • Boost pressure was not limited during a decal. • Problem with the boost limiting circuit.	• Check the boost pressure sensor connection. • Check for disconnected hoses or leaks in the boost pressure air path. • Check for leakage past the boost valve diaphragm by applying vacuum to the control port. • Replace the valve.
P2262	1127	7	Turbo Boost Pressure Not Detected - Mechanical	• Only supported with the turbo version of the engine. • No boost pressure detected.	• Check the post pressure sensor connection. • Check the air ducting for secure connections. • Check the turbocharger for seizing.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P2263	1127	7	Turbocharger Boost Pressure System Performance	• Only supported with the turbo version of the engine. • Insufficient boost pressure detected.	• Check the post pressure sensor connection. • Check the air ducting for secure connections. • Check the turbocharger for seizing.
P2270	3227	17	O2 Sensor Signal Stuck Lean (post-catalyst)	• Not applicable	
P2271	3227	15	O2 Sensor Signal Stuck Rich (post-catalyst)	• Not applicable.	
P2297	3217	15	HEGO sensor Out of Range During Deceleration	• Problem with HEGO sensor.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2300	1268	5	Ignition Coil A Primary Control Circuit Low	• Bad leads between engine and ignition coil.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Replace the ignition coil. Refer to the Section 5.8.
P2301	1268	6	Ignition Coil A Primary Control Circuit High	• Bad leads between engine and ignition coil.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Swap the positive and negative coil leads to see if leads are reversed. • Replace the ignition coil. Refer to the Section 5.8.
P2302	1393	31	Ignition Coil A Secondary Circuit	• No spark detected by the ECM.	• Check for a disconnected spark plug lead. • Check the spark plug lead continuity. • Check for worn spark plug electrodes. • Replace the spark plug. • Replace the ignition coil. Refer to the Section 5.8.
P2303	1269	5	Ignition Coil B Primary Control Circuit Low	• Bad leads between engine and ignition coil.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Replace the ignition coil. Refer to the Section 5.8.
P2304	1269	6	Ignition Coil B Primary Control Circuit High	• Bad leads between engine and ignition coil.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Swap the positive and negative coil leads to see if leads are reversed. • Replace the ignition coil. Refer to the Section 5.8.
P2305	1394	31	Ignition Coil B Secondary Circuit	• No spark detected by the ECM.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Check for a disconnected spark plug lead. • Check the spark plug lead continuity. • Check for worn spark plug electrodes. • Replace the spark plug. • Replace the ignition coil. Refer to the Section 5.8.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P2306	1270	5	Ignition Coil C Primary Control Circuit Low	• No spark detected by the ECM.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Check for a disconnected spark plug lead. • Check the spark plug lead continuity. • Check for worn spark plug electrodes. • Replace the spark plug. • Replace the ignition coil. Refer to the Section 5.8.
P2307	1270	6	Ignition Coil C Primary Control Circuit High	• No spark detected by the ECM.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Check for a disconnected spark plug lead. • Check the spark plug lead continuity. • Check for worn spark plug electrodes. • Replace the spark plug. • Replace the ignition coil. Refer to the Section 5.8.
P2308	1395	31	Ignition Coil C Secondary Circuit	• No spark detected by the ECM.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Check for a disconnected spark plug lead. • Check the spark plug lead continuity. • Check for worn spark plug electrodes. • Replace the spark plug. • Replace the ignition coil. Refer to the Section 5.8.
P2309	1271	5	Ignition Coil D Primary Control Circuit Low	• No spark detected by the ECM.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Check for a disconnected spark plug lead. • Check the spark plug lead continuity. • Check for worn spark plug electrodes. • Replace the spark plug. • Replace the ignition coil. Refer to the Section 5.8.
P2310	1271	6	Ignition Coil D Primary Control Circuit High	• No spark detected by the ECM.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Check for a disconnected spark plug lead. • Check the spark plug lead continuity. • Check for worn spark plug electrodes. • Replace the spark plug. • Replace the ignition coil. Refer to the Section 5.8.

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P2311	1396	31	Ignition Coil D Secondary Circuit	• No spark detected by the ECM.	• Troubleshoot the ignition coil and leads. Refer to **Section 4.8**. • Check for a disconnected spark plug lead. • Check the spark plug lead continuity. • Check for worn spark plug electrodes. • Replace the spark plug. • Replace the ignition coil. Refer to the Section 5.8.
P2312	1272	5	Ignition Coil E Primary Control Circuit Low	• Not applicable	• Not applicable
P2313	1272	6	Ignition Coil E Primary Control Circuit High	• Not applicable	• Not applicable
P2314	1397	31	Ignition Coil E Secondary Circuit	• Not applicable	• Not applicable
P2315	1273	5	Ignition Coil F Primary Control Circuit Low	• Not applicable	• Not applicable
P2316	1273	6	Ignition Coil F Primary Control Circuit High	• Not applicable	• Not applicable
P2317	1398	31	Ignition Coil F Secondary Circuit	• Not applicable	• Not applicable
P2318	1274	5	Ignition Coil G Primary Control Circuit Low	• Not applicable	• Not applicable
P2319	1274	6	Ignition Coil G Primary Control Circuit High	• Not applicable	• Not applicable
P2320	1398	31	Ignition Coil G Secondary Circuit	• Not applicable	• Not applicable
P2321	1275	5	Ignition Coil H Primary Control Circuit Low	• Not applicable	• Not applicable
P2322	1275	6	Ignition Coil H Primary Control Circuit High	• Not applicable	• Not applicable
P2323	1399	31	Ignition Coil H Secondary Circuit	• Not applicable.	• Not applicable.
P2336	1352	18	Cylinder 1 Above Knock Threshold	• Not applicable	• Not applicable
P2337	1353	18	Cylinder 2 Above Knock Threshold	• Not applicable	• Not applicable
P2338	1354	18	Cylinder 3 Above Knock Threshold	• Not applicable	• Not applicable.
P2339	1355	18	Cylinder 4 Above Knock Threshold	• Not applicable	• Not applicable.
P2340	1356	18	Cylinder 5 Above Knock Threshold	• Not applicable	• Not applicable.
P2341	1357	18	Cylinder 6 Above Knock Threshold	• Not applicable	• Not applicable
P2342	1358	18	Cylinder 7 Above Knock Threshold	• Not applicable	• Not applicable
P2343	1359	18	Cylinder 8 Above Knock Threshold	• Not applicable	• Not applicable

P-Code	SPN	FMI	Description	Possible Cause	Corrective Action
P2428	2433	18	Exhaust Overheat	• Not applicable	• Not applicable
P2560	2430	18	Engine Coolant Level Low	• Not applicable	• Not applicable
P2626	3217	5	HEGO sensor Pumping Current Trim Circuit/Open	• Problem with the HEGO sensor.	• Troubleshoot the HEGO sensor for bad leads. Refer to Section 4.7. • Replace the HEGO sensor. Refer to Section 5.7.
P2666	2807	4	Fuel Shutoff Valve B Control Circuit Low	• Not applicable	• Not applicable
P2667	2807	3	Fuel Shutoff Valve B Control Circuit High	• Not applicable	• Not applicable

Introduction

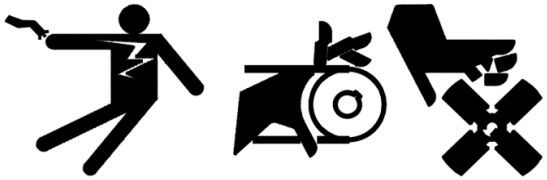
The following symptom tables contain groups of possible causes for each symptom. If no diagnostic troubleshooting codes (DTCs) are recorded by the ECM, then check for the most likely cause first.

Before using this section, you should determine that:

- The ECM is operating correctly.
- No Diagnostic Trouble Codes (DTCs) are stored.

Several of the following symptom procedures call for a careful visual and physical check. These checks are very important as they can lead to prompt diagnosis and correction of a problem.

⚠ WARNING



Accidental starts can cause severe injury or death.
Disconnect and ground spark plug leads before servicing.
Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug leads. 2) Disconnect negative (–) battery cable from battery.
Before disconnecting negative (–) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or LPG/NG fuel vapors are present.

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the engine with the air cleaner removed.

⚠ WARNING



Carbon monoxide can cause severe nausea, fainting, or death.
Avoid inhaling exhaust fumes.
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.

⚠ WARNING



Electrical shock can cause injury.
Do not touch wires while engine is running.

⚠ WARNING



Explosive fuel vapors. Can cause severe injury or death.
Use extreme care when handling, storing, and using fuels.
Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LPG vapor or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

⚠ WARNING



Explosive fuel can cause fires and severe burns.
If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

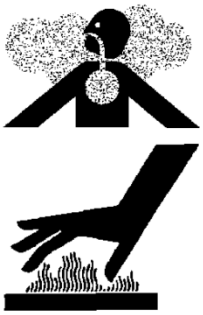
LPG (Liquefied Petroleum Gas) is extremely flammable and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

NG (Natural Gas) is extremely flammable, is lighter than air, and rises. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

To ensure personal safety, installation and repair of LPG/NG fuel supply systems must be performed only by qualified LPG/NG system technicians. Improperly installed and maintained LPG/NG equipment could cause the fuel supply system or other components to malfunction, causing gas leaks.

Observe federal, state, and local laws governing LPG/NG fuel, storage, and systems.

⚠ WARNING



Handling caustic engine fluids and chemical products can cause severe chemical burns, nausea, fainting, or death.
Most chemicals such as used engine oil, antifreeze/coolant, rustproofing agent, inhibiting oil, degreasing agent, spray paint, and adhesives are hazardous to health. Read and follow the user information found on the packaging. Avoid inhalation and skin contact. Use only in well-ventilated areas and use a protective mask when spraying. Store engine fluids and chemical products in a locked cabinet. Contact your local recycling center for disposal information and locations.

Used engine oil. Contact with used engine oil may cause severe skin irritation. Repeated and prolonged skin exposure may have other health risks. Used engine oil is a suspected carcinogen. Avoid contact with skin. Thoroughly wash your hands and nails with soap and water shortly after handling used engine oil. Wash or dispose of clothing or rags containing used engine oil. Dispose of used engine oil in accordance with applicable laws and regulations. Contact your local recycling center for disposal information and locations.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

3.1. Fuel System Intermittent Problems

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

Definition: The problem is not always observable and may or may not store a Diagnostic Trouble Code (DTC).

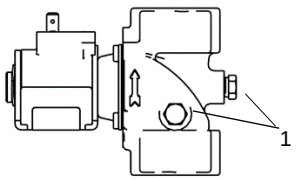
Intermittent fuel system problems can be the most challenging to diagnose. It is important when diagnosing intermittent problems to operate the engine system while monitoring with Spectrum software and a pressure gauge set.

For example: If a lean fuel mixture at full load produced a DTC, one of the first things to look at would be the fuel pressure. The fuel pressure would need to be monitored with Spectrum while the engine is operating at full load, not at low or no load because the leaning effect does not occur until full load.

3.2. Fuel System Basic Checks

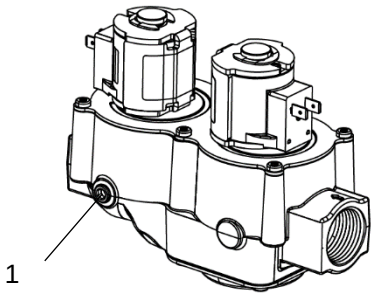
When checking for air or fuel delivery problems, keep the process simple and check the basics. Make sure that air and fuel are being delivered to the fuel regulator.

1. Use a manometer to verify fuel pressure at the fuel pressure port. Fuel delivery to the engine must be between 5-11 inches water at all times.



1. Fuel pressure ports

Figure 3-1 Fuel Shut-off Valve

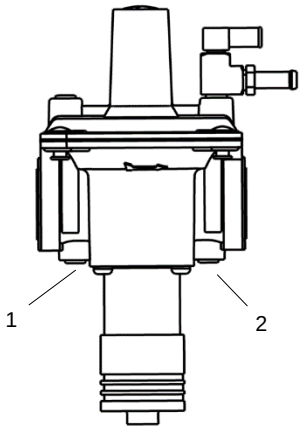


1. Fuel pressure ports, one on each side

Figure 3-2 Dual-Solenoid Fuel Valve

2. Verify that both fuel shut-off valves are working.
   a. Disconnect the positive (+) battery lead from the gas valve terminal.
   b. Apply 12 VDC to the gas valve terminal and listen for an audible click, indicating that the valve actuates.
   c. Replace the gas valve if it does not actuate in step 2.
3. Verify that the fuel pressure regulator is working and is set correctly for the fuel type used, NG or LPG.
4. To check the inlet pressure, connect a manometer to the inlet port of the fuel pressure regulator. See Figure 3-3.
   - NG = 5–11 inches of water pressure
   - LPG = 5–11 inches of water pressure

5. To check the outlet pressure, connect a manometer to the outlet port of the fuel pressure regulator. See Figure 3-3.
   - NG = 1–3 inches of water pressure
   - LPG = 1–4 inches of water vacuum
6. Verify air intake system is intact. If the generator has hoses, couplers or tubing, make sure all connections are secure and there are no cracks.
7. Check the air filter for restrictions.



1. Inlet port
2. Outlet port

Figure 3-3 Fuel Pressure Regulator

Checks	Action
Fuel System Check	• Locate the correct symptom table. • Check the items indicated under that symptom. • Operate the engine under the conditions the symptom occurs. Verify HEGO switching between lean and rich (cycling of voltage). **Note:** Normal HEGO switching indicates the fuel system is in closed loop and operating correctly at that time. • Take a data snapshot using Spectrum under the condition that the symptom occurs to review at a later time.

Visual and Physical Checks	• Check that the ECM ground connection is clean, tight, and in its proper location.
	• Check the vacuum hoses for splits, kinks and proper connections.
	• Check thoroughly for any type of leak or restriction.
	• Check for air leaks at all the mounting areas of the intake manifold sealing surfaces.
	• Check for proper installation and leakage around the regulator, mixer and throttle body.
	• Check the ignition leads for the following conditions:
	  ○ Cracking
	  ○ Hardening
	  ○ Proper routing
	  ○ Carbon tracking
	• Check the wiring for the following items: proper connections, pinches, or cuts.

Figure 3-4 Fuel System Basic Troubleshooting

3.3. No Start

Definition: The engine cranks but does not start.

Checks	Action
Preliminary Checks	None

ECM Checks	• Use Spectrum to :
	  o Check for proper communication with the ECM
	  o Check battery power, ignition power and ground circuits to the ECM.

Sensor Checks	• Check the TMAP sensor. • Check the crankshaft position sensor for output (rpm). This can be verified by an RPM signal on Spectrum.
Fuel System Checks	**Note:** A closed gas supply valve will create a no start condition. • Verify proper operation of the shut-off solenoid valves. • Check for air intake system leakage around the fuel pressure regulator, air-fuel mixer and throttle body. • Check for air intake system leakage at all connections between the air-fuel mixer and throttle body on turbocharged engines. • Check the fuel system pressures.

Ignition System Checks	• Check for the proper ignition voltage output.
	• Verify that the spark plugs are correct.
	• Check the spark plugs for the following conditions:
	  o Wet plugs (oil fouling)
	  o Cracks.
	  o Wear.
	  o Improper gap.
	  o Burned electrodes.
	  o Heavy deposits.
	• Check for bare or shorted ignition leads.
	• Check for loose ignition coil connections at the coil.

Engine Mechanical Checks	• Check for the following:
	  o Manifold vacuum leaks.
	  o Air-fuel mixer vacuum leaks.
	  o Charge air cooler leaks on turbocharged engines.
	  o Engine vacuum leaks.
	  o Improper valve timing.1
	  o Low compression.
	  o Improper valve clearance.
	  o Worn rocker arms.
	  o Broken or weak valve springs.
	  o Worn camshaft lobes.

Exhaust System Checks	• Check the exhaust system for a possible restriction:
	  o Inspect the exhaust system for damaged or collapsed pipes.
	  o Inspect the muffler for signs of heat distress or for possible internal failure.
	• Check that the turbocharger turbine and compressor blades do not rub or bind against the turbocharger housing.

Figure 3-5 No Start Troubleshooting

3.4. Hard Start

Definition: The engine cranks but does not start for a long time. The engine does eventually run, or may start but immediately stalls.

Checks	Action
Preliminary Checks	• Make sure the engine's operator is using the correct starting procedure.
Sensor Checks	• Check the coolant temperature sensor with Spectrum. Compare the engine coolant temperature with the ambient air temperature on a cold engine. If the coolant temperature reading is more than 10 degrees greater or less than the ambient air temperature on a cold engine, check for high resistance in the coolant sensor circuit. • Check the crankshaft position sensor. • Check the electronic throttle connections.
Fuel System Checks	**Note:** A partially closed fuel supply valve will create an extended crank or no start condition. • Check the air-fuel mixer assembly for proper installation and leakage. o Verify proper operation of the fuel shut-off solenoid valves. o Verify proper operation of the system fuel pressure regulator. o Check for air intake system leakage between the air-fuel mixer, throttle body and air filter assembly. Check the fuel system pressures.
Ignition System Checks	**Note:** Natural Gas and Liquefied Petroleum Gas require higher secondary ignition system voltages than the equivalent gasoline operating conditions. • Check for the proper ignition voltage output. • Verify that the spark plugs are the correct type and properly gapped. • Check the spark plugs for the following conditions: o Wet plugs (oil fouling). o Cracks. o Wear. o Burned electrodes. o Heavy deposits. • Check for bare or shorted ignition leads. • Check for loose ignition coil connections. • If the engine starts but then immediately stalls, check the crankshaft position sensor. • Check for improper gap, debris or faulty connections.
Engine Mechanical Checks	• Check for the following: o Engine vacuum leaks. o Manifold vacuum leaks. o Charge air cooler leaks on turbocharged engines. o Mixer vacuum leaks. o Improper valve timing. o Low compression. o Improper valve clearance. o Worn rocker arms. o Broken or weak valve springs. o Worn camshaft lobes.
Exhaust System Checks	• Check the exhaust system for a possible restriction: o Inspect the exhaust system for damaged or collapsed pipes. o Inspect the muffler for signs of heat distress or for possible internal failure. • Check that the turbocharger turbine and compressor blades do not rub or bind against the turbocharger housing.

Figure 3-6 Hard Start Troubleshooting

3.5. Cuts Out and Misses

Definition: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases, but normally felt below 1500 rpm. The exhaust has a steady spitting sound at low speed or hard acceleration resulting from fuel starvation that can cause the engine to cut-out.

Checks	Action
Preliminary Checks	None

Ignition System Checks	• Start the engine.
	• Check for proper ignition output voltage with a spark tester.
	• Check for a cylinder misfire.
	• Verify that the spark plugs are the correct type and properly gapped.
	• Remove the spark plugs and check for the following conditions:
	  o Insulation cracks.
	  o Wear.
	  o Improper gap.
	  o Burned electrodes.
	  o Heavy deposits.
	• Visually/physically inspect the ignition for the following:
	  o Ignition leads for arcing and proper routing.
	  o Cross-firing.
	  o Ignition coils for cracks or carbon tracking.

Engine Mechanical Checks	• Perform a cylinder compression check. Check the engine for the following:
	  o Improper valve timing.
	  o Improper valve clearance.
	  o Worn rocker arms.
	  o Worn camshaft lobes.
	  o Broken or weak valve springs.
	  o Check the intake and exhaust manifold passages for casting flash.

Fuel System Checks	• Check the fuel system for:
	  o Plugged fuel filter (if equipped).
	  o Low fuel pressure.
	  o Check the condition of the wiring to the shut-off valves.

Figure 3-7 Cuts Out or Misses Troubleshooting

3.6. Hesitation, Sag, or Stumble

Definition: The engine has a momentary lack of response when accelerating. The condition can occur at any engine speed. The condition may cause the engine to stall if it's severe enough.

Checks	Action
Preliminary Checks	None.
Fuel System Checks	• Check the fuel pressure. • Check for low fuel pressure during a moderate or full throttle acceleration. If the fuel pressure drops below specification, there is possibly a faulty fuel pressure regulator or a restriction in the fuel system. • Check the TMAP sensor response and accuracy. • Check shut-off electrical connections. • Check the fuel pressure regulator, air-fuel mixer and throttle body for proper installation and leakage.
Ignition System Checks	• Check for proper ignition output voltage with a spark tester. • Verify that the spark plugs are the correct type and properly gapped. • Check for faulty spark plug leads. • Check for oil-fouled spark plugs.
Additional Check	• Check for manifold vacuum or air induction system leaks. • Check the alternator output voltage. • Check for air intake system leakage at all connections between the air-fuel mixer and throttle body. • Check for charge air cooler leaks on turbocharged engines. • Check for sticking of the turbocharger wastegate.

Figure 3-8 Hesitation, Sag, or Stumble Troubleshooting

3.7. Backfire

Definition: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the engine with the air cleaner removed.

⚠ WARNING



Electrical shock can cause injury.
Do not touch wires while engine is running.

Checks	Action
Preliminary Check	None.
Ignition System Checks	• Check for proper ignition output voltage with a spark tester. • Check the spark plug leads by connecting an ohmmeter to the ends of each lead in question. If the meter reads over 15,000 ohms, replace the leads. • Check the connection at ignition coil. • Check for deteriorated spark plug lead insulation. • Remove the plugs and inspect them for the following conditions: o Wet plugs (oil fouling). o Cracks. o Wear. o Improper gap. o Burned electrodes. o Heavy deposits.
Engine Mechanical Check	• Check the engine for the following: o Improper valve timing. o Engine compression. o Manifold vacuum leaks. o Intake manifold gaskets. o Sticking or leaking valves. o Exhaust system leakage.

Figure 3-9 Backfire Troubleshooting

3.8. Lack of Power or Sluggishness

Definition: The engine delivers less than expected power. There is little or no increase in speed when increasing the engine throttle.

Checks	Action
Preliminary Checks	• Use Spectrum to check the ECM for stored DTC codes. • Remove the air filter and check for dirt or restriction.
Fuel System Checks	• Check for contaminated fuel or improper fuel pressure. • Check for the proper ignition output voltage with a spark tester. • Check the fuel pressure regulator, air-fuel mixer and throttle body for proper installation and leakage. Check all air inlet ducts for condition and proper installation. • Check for fuel leaks in supply lines. • Verify that the fuel supply valve on the supply line is open.
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. • Check for proper operation of the TMAP sensor.
Exhaust System Checks	• Check the exhaust system for a possible restriction: o Inspect the exhaust system for damaged or collapsed pipes. o Inspect the turbocharger turbine and compressor blades for binding or wear on turbocharged engines. o Inspect the wastegate and wastegate linkage for sticking, binding or wear on turbocharged engines. o Inspect the muffler for signs of heat distress or for possible internal failure.
Engine Mechanical Check	• Check the engine for the following: o Engine compression. o Valve timing. o Improper or worn camshaft. • Refer to Engine Service Manual.
Additional Check	• Check that the ECM grounds are clean, tight, and in their proper locations. • Check the alternator output voltage. • If all procedures have been completed and no malfunction has been found, review and inspect the following items: • Visually and physically, inspect all electrical connections within the suspected circuit and/or systems. • Check the Spectrum data. • Check the charge air cooler for fouling on turbocharged engines.

Figure 3-10 Lack of Power or Sluggishness Troubleshooting

3.9. Poor Fuel Economy

Definition: Fuel economy, as measured by refueling records, is noticeably lower than expected. Also, the economy is noticeably lower than it was on this engine at one time, as previously shown by refueling records.

Checks	Action
Preliminary Checks	• Check the air cleaner element (filter) for dirt or being plugged. • Visually check the vacuum hoses for splits, kinks, and proper connections.
Fuel System Checks	• Check that the fuel pressure regulator is functioning properly. • Check the fuel system for leakage.
Sensor Checks	• Check the TMAP sensor.
Ignition System Checks	• Verify that the spark plugs are the correct type and properly gapped. • Remove the plugs and inspect them for the following conditions: o Wet plugs (oil fouling). o Cracks. o Wear. o Improper gap. o Burned electrodes. o Heavy deposits. • Check the ignition leads for the following items: o Cracking. o Hardness. o Proper connections.
Cooling System Checks	Check the engine thermostat to see if it is stuck open or for the wrong heat range.

Figure 3-11 Poor Fuel Economy Troubleshooting

3.10. Rough, Unstable, or Incorrect Engine Speed and Stalling

Definition: The engine runs unevenly when under no load. If severe enough, the engine may shake. The engine speed may vary in rpm. Either condition may be severe enough to stall the engine.

Definition: Checks	Action
Preliminary Check	None.
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance: • Check for silicone contamination from fuel or improperly used sealant. If contaminated, the sensor may have a white powdery coating resulting in a high but false signal voltage (rich exhaust indication). The ECM will reduce the amount of fuel delivered to the engine causing a severe performance problem. • Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.
Fuel System Checks	• Check for rich or lean symptom that causes the condition. • Monitoring the HEGO sensor will help identify the problem. • Verify proper operation of the fuel pressure regulator. • Perform a cylinder compression test. Refer to Engine Service Manual. • Check the regulator fuel pressure. • Check the fuel pressure regulator, air-fuel mixer and throttle body for proper installation and leakage.
Ignition System Checks	• Check for proper ignition output voltage with a spark tester. • Verify that the spark plugs are the correct type and properly gapped. • Remove the plugs and inspect them for the following conditions: o Wet plugs (oil fouling). o Cracks. o Wear. o Improper gap. o Burned electrodes. o Blistered insulators. o Heavy deposits. • Check the spark plug leads by connecting an ohmmeter to the ends of each lead in question. If the meter reads over 15,000 ohms, replace the leads.
Additional Checks	• Check for vacuum leaks. Vacuum leaks can cause poor engine performance. • Check that the ECM grounds are clean, tight, and in their proper locations. • Check that the battery cables and ground straps are clean and secure. • Erratic voltage may cause all sensor readings to be skewed resulting in poor engine performance.
Engine Mechanical Check	Check the engine for: • Broken motor mounts. • Improper valve timing. • Low compression. • Improper valve clearance. • Worn rocker arms. • Broken or weak valve springs. • Worn camshaft lobes.

Figure 3-12 Engine Speed and Stalling Troubleshooting

3.11. Hunting and Surging

Definition: The engine has a power variation under a steady throttle. The engine feels as if it speeds up and slows down with no change to the throttle.

Checks	Action
Preliminary Checks	None.
Sensor Checks	Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance.
Fuel System Checks	• Check for rich or lean symptom that causes the condition. • While running the engine, monitor the HEGO sensor. • Check the fuel pressure while the condition exists. • Verify proper fuel control shut-off valve operation. • Verify that the fuel supply valve on the gas supply line is fully open.

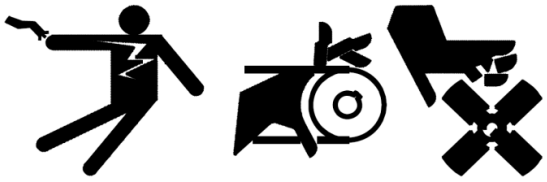
Ignition System Checks	• Check for proper ignition output voltage with a spark tester.
	• Verify that the spark plugs are the correct type and properly gapped.
	• Remove the plugs and inspect them for the following conditions:
	  ○ Wet plugs (oil fouling).
	  ○ Cracks.
	  ○ Wear.
	  ○ Improper gap.
	  ○ Burned electrodes.
	  ○ Heavy deposits.
	• Check the Crankshaft Position (CKP) sensor.

Additional Check	• Check that the ECM grounds are clean, tight, and in their proper locations. • Check the alternator output voltage. • Check the vacuum hoses for kinks or leaks.

Figure 3-13 Hunting and Surging Troubleshooting

Notes

⚠ WARNING



Accidental starts can cause severe injury or death.
Disconnect and ground spark plug leads before servicing.
Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug leads. 2) Disconnect negative (–) battery cable from battery.
Before disconnecting negative (–) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or LPG/NG fuel vapors are present.

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the engine with the air cleaner removed.

⚠ WARNING



Avoid possible death or serious injury! Pinch and entanglement hazards!
Never check drive belt tension while the engine is running.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

⚠ WARNING



Carbon monoxide can cause severe nausea, fainting, or death.
Avoid inhaling exhaust fumes.
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.

⚠ WARNING



Explosive fuel vapors. Can cause severe injury or death.
Use extreme care when handling, storing, and using fuels.
Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LPG vapor or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

⚠ WARNING



Explosive fuel can cause fires and severe burns.
If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

LPG (Liquefied Petroleum Gas) is extremely flammable and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

NG (Natural Gas) is extremely flammable, is lighter than air, and rises. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

To ensure personal safety, installation and repair of LPG/NG fuel supply systems must be performed only by qualified LPG/NG system technicians. Improperly installed and maintained LPG/NG equipment could cause the fuel supply system or other components to malfunction, causing gas leaks.

Observe federal, state, and local laws governing LPG/NG fuel, storage, and systems.

Used engine oil. Contact with used engine oil may cause severe skin irritation. Repeated and prolonged skin exposure may have other health risks. Used engine oil is a suspected carcinogen. Avoid contact with skin. Thoroughly wash your hands and nails with soap and water shortly after handling used engine oil. Wash or dispose of clothing or rags containing used engine oil. Dispose of used engine oil in accordance with applicable laws and regulations. Contact your local recycling center for disposal information and locations.

⚠ WARNING



Electrical shock can cause injury.
Do not touch wires while engine is running.

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Troubleshooting and/or repairing the sensors or the ECM. A backfire due to an open fuel shut-off valve can cause severe injury or death. If power is supplied to the shut-off valve during ECM or sensor troubleshooting, fuel may enter the air intake manifold or the air cleaner and cause a backfire. Make sure that the fuel supply is turned OFF and that the fuel shut-off valves are DISCONNECTED from the power source BEFORE turning the ECM power on.

⚠ WARNING



Hot parts can cause severe burns.
Do not touch engine while operating or just after stopping.
Never operate engine with heat shields or guards removed.

Servicing the exhaust system. Hot parts can cause severe injury or death.
Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

⚠ WARNING



Hot coolant and steam. Can cause severe injury or death.
The coolant may be hot. Use caution when removing hose(s) to prevent contact.

4.1. Introduction

Many of the troubleshooting steps require the use of a digital Volt-Ohm meter (DVOM) when checking for voltage and resistance and may also require the ECM to be either powered or turned off. The troubleshooting steps cover the following sensors and components:

- Coolant Temperature Sensor
- Crankshaft Position (CKP) Sensor
- Electrical System Intermittent Problems
- Fuel Control Valve
- Heated Exhaust Gas Oxygen (HEGO) Sensor
- Ignition Coil
- Oil Pressure Sender
- TMAP and MAP Sensors
- Throttle Position (TP) Sensor

4.2. Powering the ECM

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Troubleshooting and/or repairing the sensors or the ECM. A backfire due to an open fuel shut-off valve can cause severe injury or death. If power is supplied to the shut-off valve during ECM or sensor troubleshooting, fuel may enter the air intake manifold or the air cleaner and cause a backfire. Make sure that the fuel supply is turned OFF and that the fuel shut-off valves are DISCONNECTED from the power source BEFORE turning the ECM power on.

Note:
Refer to controller operation manual TP-6694 or SB-724 for the APM402 ECM power on and off procedure.

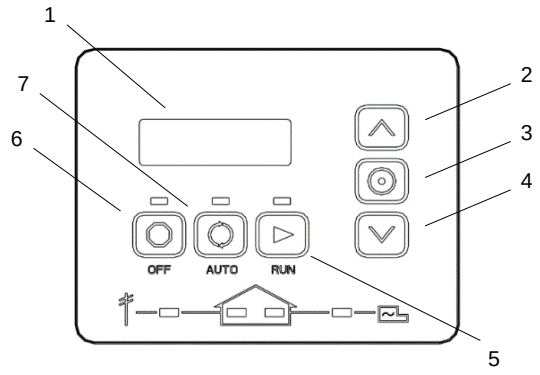
These instructions explain how to turn the ECM power on and off on generator sets equipped with the Kohler® RDC2 generator set controller.

To turn the ECM power ON and OFF using Kohler® SiteTech™ software:

1. Use SiteTech™ to connect to the equipment controller.
2. Locate ***ECM Power*** under the Genset System Configuration group.
3. Change the setting to ***ON*** to power the ECM***.***
4. Change the setting to ***OFF*** to turn off the ECM power.

To turn the ECM power ON and OFF using the RDC2 controller:

1. From the main menu, scroll down (press the Down arrow) to ***Overview*** and press the Selection button.
2. In the Overview menu, scroll down to ***SW Version***. Press and hold the Selection button until the display shows ***ECM powered*** to power the ECM.
3. Press the Stop button to turn off the ECM power.



1. 2-line LCD display
2. Up button
3. Select button
4. Down button
5. RUN button
6. OFF button
7. AUTO button

Figure 4-1 RDC2 Controller Interface

4.3. Coolant Temperature Sensor Troubleshooting

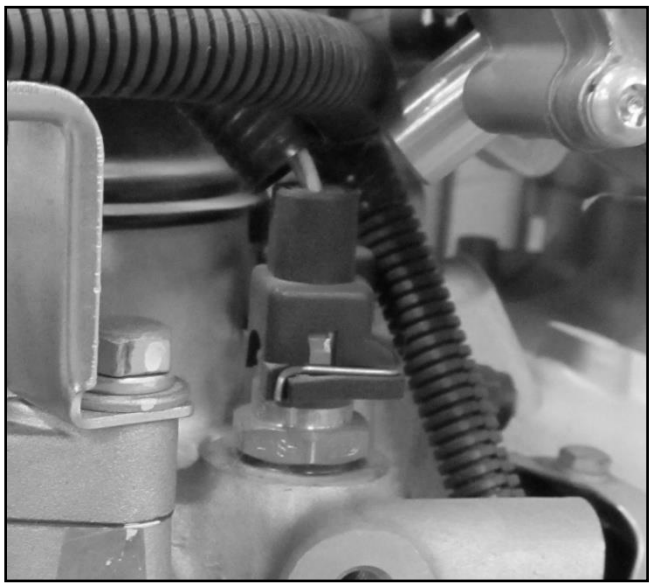


Figure 4-2 Coolant Temperature Sensor

⚠ WARNING



Hot coolant and steam. Can cause severe injury or death.
The coolant may be hot. Use caution when removing hose(s) to prevent contact.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

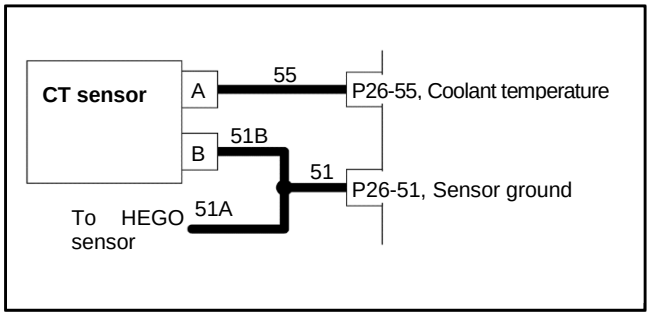


Figure 4-3 Coolant Temperature Sensor Wiring Diagram

Temp (°C)	Temp (°F)	Ohms
150	302	57.50
110	230	144.25
100	212	186.50
90	194	243.25
80	176	322.50
70	158	435.75
60	140	595.50
45	113	987.50
30	86	1707.00
5	41	4712.00

Figure 4-4 CT Sensor Resistance

Refer to Figure 4-3 Coolant Temperature Sensor Wiring Diagram and follow the steps in the troubleshooting chart to verify that:

- The CT sensor is providing the correct resistance.
- The sensor leads have continuity (no open circuits).
- The sensor leads are not shorted.

When troubleshooting the CT sensor, use Figure 4-4 to determine the CT sensor resistance.

Action	Yes	No
• Turn the ECM power OFF. • Disconnect the CT sensor connector. • Using a DVOM, check the resistance between terminals A and B of the CT sensor and compare the resistance reading to the chart, **Figure 4-4.** Does the resistance value agree with the chart?	Go to the next step.	Replace the sensor.
• Turn the ECM power OFF. • Disconnect the wire harness at the ECM. • Using a DVOM, check for continuity between the following: o CT connector pin A and P26-55. o CT connector pin B and P26-51. Does the DVOM show continuity?	Go to the next step.	Repair the open circuit.
• Using a DVOM check for continuity between CT connector pin A and engine ground. Does the DVOM show continuity?	Repair the sensor signal short to ground.	Go to the next step.
• Replace the CT sensor. Refer to **Section 5.2** Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Use Spectrum to verify if the DTC code was regenerated. • Observe engine performance. Does the engine operate normally with no stored codes?	Troubleshooting is complete.	Go to the next step.
• Replace the ECM. Refer to Section 5.4. Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature • Use Spectrum to verify if the DTC code was regenerated. • Observe engine performance. Does the engine operate normally with no stored codes?	Troubleshooting is complete.	Check ECM for any other DTCs. Repeat these troubleshooting steps.

Figure 4-5 Coolant Temperature Sensor Troubleshooting

4.4. Crankshaft Position (CKP) Sensor Troubleshooting

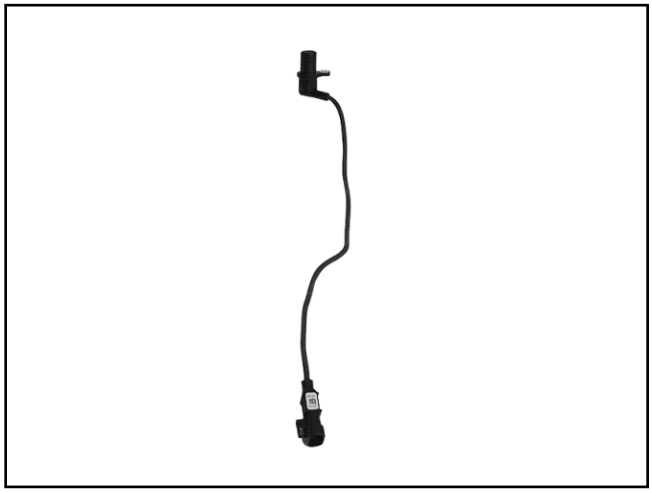


Figure 4-6 Crankshaft Position Sensor

⚠ WARNING



Avoid possible death or serious injury! Pinch and entanglement hazards!
Never check drive belt tension while the engine is running.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

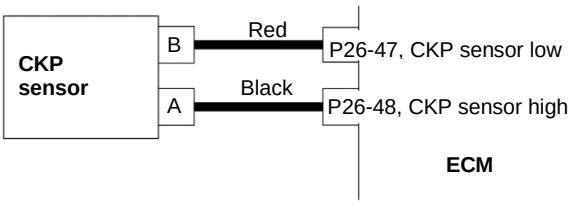


Figure 4-7 Crankshaft Position Sensor Wiring Diagram

Refer to Figure 4-7 and follow the steps in the troubleshooting chart to verify that:

- The sensor leads have continuity (no open circuits).
- The sensor leads are not shorted.

Action	Yes	No
• Check the battery connections, the battery, and engine grounds. Are the power ground terminals clean and tight?	Go to the next step.	Repair the circuit as necessary.
• Turn the ECM power OFF. • Disconnect ECM connector. • Disconnect Crankshaft Position Sensor (CKP) connector. • Using a DVOM, check for continuity between the following: • CKP connector pin A and P26 pin 47. • CKP connector pin B and P26 pin 48. Does the DVOM show continuity?	Go to the next step.	Repair the open circuit as necessary.
Using a DVOM, check for continuity between the following: • CKP connector pin A and engine ground. • CKP connector pin B and engine ground. Does the DVOM show continuity?	Repair the shorted circuit as necessary.	Go to the next step.
• Replace crankshaft position sensor. Refer to **Section 5.3**. Is the replacement complete?	Go to the next step.	-
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Observe the engine performance. • After operating the engine, check for any stored codes. Does the engine operate normally with no stored codes?	The system is OK.	Go to the next step.
• Replace the ECM. Refer to Section 5.4. Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Observe the engine performance. • After operating the engine, check for any stored codes. Does the engine operate normally with no stored codes?	The system is OK.	Restart the crankshaft position sensor troubleshooting procedure. Look for other DTC codes stored in the ECM.

Figure 4-8 Crankshaft Position Sensor Troubleshooting

4.5. Electrical System Intermittent Problems

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

⚠ WARNING



Electrical shock can cause injury.
Do not touch wires while engine is running.

Definition: The problem is not always observable and may or may not store a Diagnostic Trouble Code (DTC).

Use the plot function in the Spectrum software to troubleshoot intermittent electrical problems. Set up the plot for the sensor code that is stored in the ECM.

For example: If an intermittent Intake Air Temperature (IAT) code is set, tag the IAT voltage and watch the plot. While watching the plot, agitate the electrical lead 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.

Checks	No
Preliminary Checks	• Do not use the DTC table if a fault is intermittent. The use of the DTC tables with this condition may result in the replacement of good parts.
Faulty Electrical Connections or Wiring	• Faulty electrical connections or wiring can cause most intermittent problems. • Check the suspected circuit for the following conditions: • Connectors poorly mated, terminals not fully seated in the connector (backed out). Terminals not properly formed or damaged. • Lead terminals poorly connected. • Terminal tension is insufficient. • Carefully remove all the connector terminals in the problem circuit in order to ensure the proper contact tension. • Checking for poor terminal to lead connections requires removing the terminal from the connector body.
Operational Test	• If a visual and physical check does not locate the cause of the problem, operate the engine with Spectrum digital scan tool connected. When the problem occurs, an abnormal voltage or scan reading indicates a problem circuit.
Intermittent DTC codes	• The following components can cause intermittent DTCs: • A defective relay. • Switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating. • The ignition secondary voltage shorted to a ground. • The Diagnostic Test Terminal intermittently shorted to ground.
Loss of DTC Memory	• To check for the loss of the DTC Memory: • Disconnect the TMAP sensor. • Run engine under no load. • The ECM should store a TMAP DTC which should remain in the memory when the engine is turned OFF. If the TMAP DTC does not store and remain, the ECM is faulty.

Figure 4-9 Electrical System Intermittent Problems Troubleshooting

4.6. Fuel Control Valve Troubleshooting

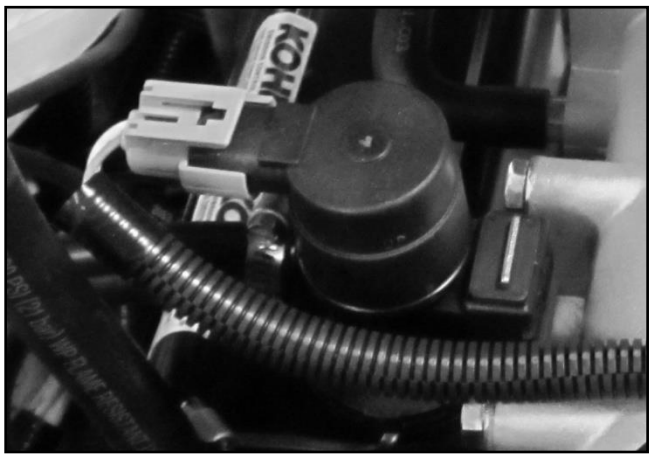


Figure 4-10 Fuel Control Valve, KG2204



Figure 4-11 Fuel Control Valve, KG2204T

⚠ WARNING



Explosive fuel can cause fires and severe burns.
If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

LPG (Liquefied Petroleum Gas) is extremely flammable and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.
NG (Natural Gas) is extremely flammable, is lighter than air, and rises. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.
To ensure personal safety, installation and repair of LPG/NG fuel supply systems must be performed only by qualified LPG/NG system technicians. Improperly installed and maintained LPG/NG equipment could cause the fuel supply system or other components to malfunction, causing gas leaks.
Observe federal, state, and local laws governing LPG/NG fuel, storage, and systems.

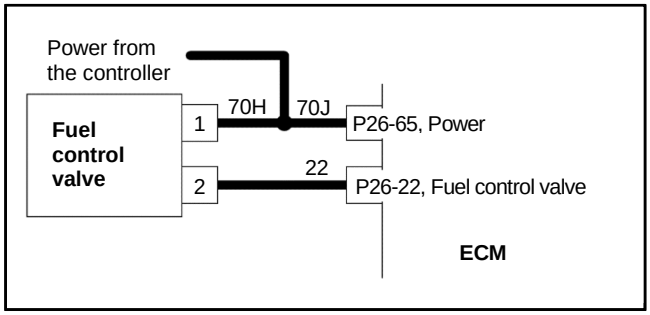


Figure 4-12 Fuel Control Valve Wiring Diagram

Refer to Figure 4-12 and follow the steps in the troubleshooting chart to verify that:

- The fuel control valve is working correctly
- The fuel control valve leads have continuity (no open circuits).
- The fuel control valve leads are not shorted.

Action	Yes	No
• Turn the ECM power OFF. • Disconnect the Fuel Control Valve (FCV) connector. • Using a DVOM, check the resistance between the two pins of the FCV solenoid Does the DVOM show a resistance value greater than 42 Ohms? Does the DVOM show a resistance value of less than 30 Ohms?	Replace the FCV.	Go to the next step.
• With the ECM power OFF, disconnect the ECM wire harness connector. • Using a DVOM, check continuity between FCV connector pin 2 and ECM connector P26 pin 22. Does the DVOM show continuity?	Go to the next step.	Repair the open FCV control circuit as required.
Using a DVOM, check for continuity between FCV connector pin 2 and engine ground. Does the DVOM show continuity?	Repair the shorted to ground FCV control circuit as required.	Go to the next step.
Inspect the ECM wire harness and connector and FCV connector for damage, corrosion, or contamination. Did a problem exist?	Correct the problem as required.	Go to the next step.
Replace the fuel control valve. Refer to **Section 5.5**.	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum software, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Observe the engine performance. • After operating the engine, check for any stored codes. Does the engine operate normally with no stored codes?	System OK.	Go to the next step.
• Replace the ECM. Refer to Section 5.4. Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum software, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Observe the engine performance. • After operating the engine, check for any stored codes. Does the engine operate normally with no stored codes?	System OK.	Restart the fuel control valve troubleshooting procedure. Look for other DTC codes stored in the ECM.

Figure 4-13 Fuel Control Valve Troubleshooting

4.7. Heated Exhaust Gas Oxygen (HEGO) Sensor Troubleshooting

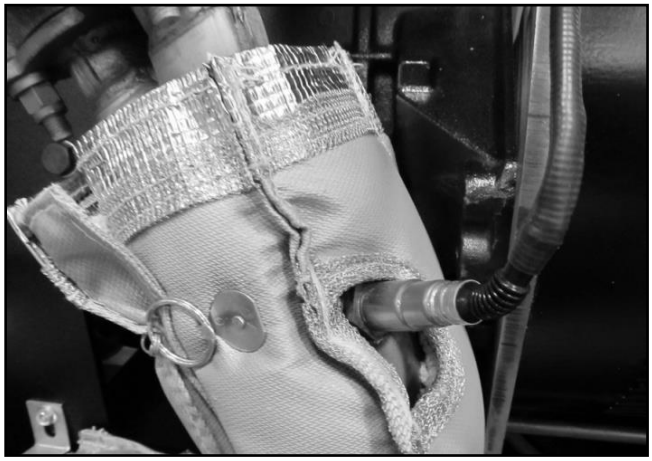


Figure 4-14 HEGO Sensor

⚠ WARNING



Hot parts can cause severe burns.
Do not touch engine while operating or just after stopping.
Never operate engine with heat shields or guards removed.

Servicing the exhaust system. Hot parts can cause severe injury or death.
Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Troubleshooting and/or repairing the sensors or the ECM. A backfire due to an open fuel shut-off valve can cause severe injury or death. If power is supplied to the shut-off valve during ECM or sensor troubleshooting, fuel may enter the air intake manifold or the air cleaner and cause a backfire. Make sure that the fuel supply is turned OFF and that the fuel shut-off valves are DISCONNECTED from the power source BEFORE turning the ECM power on.

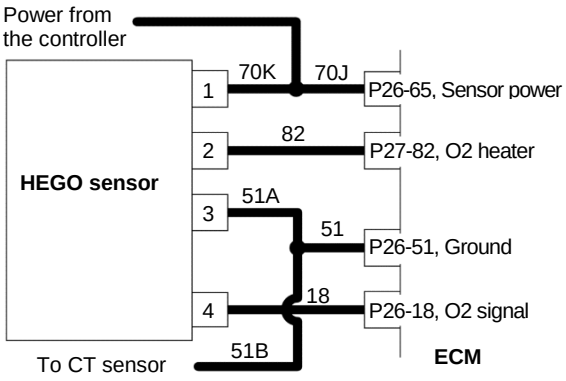


Figure 4-15 HEGO Sensor Wiring Diagram

Refer to Figure 4-15 and follow the steps in the troubleshooting chart to verify that:

- The HEGO sensor is working correctly and is not damaged.
- The sensor leads have continuity (no open circuits).
- The sensor leads are not shorted.

Important: Silicone sprays or inappropriate RTV (room temperature vulcanization) sealers can contaminate the HEGO sensor. Contaminated HEGO sensors can produce false or high readings resulting in poor fuel mixtures and severe performance problems. Always verify that the sealer is safe to use with the HEGO sensor before using.

Action	Yes	No
• Check the air-fuel mixer for vacuum leaks. • Check that air can flow through the air intake duct and that the air intake duct is undamaged and unrestricted. • Check that the air filter is clean and undamaged. • Check that the HEGO sensor is installed securely and that the leads are not damaged, corroded, or contacting the exhaust manifold or secondary ignition leads. • Check that the ECM grounds are clean and tight. • Inspect the ECM, HEGO sensor, and wire harness connection pins for damage, corrosion, or contamination. • Inspect the HEGO sensor for silicon contamination. On the tip of the sensor that was exposed to the exhaust, check for a white powdery coating. • Use Spectrum to check the ECM for additional diagnostic troubleshooting codes (DTCs). • Diagnose any other DTCs before proceeding with this chart. Always repair existing codes starting with the lowest numerical code set first. Did you find a problem?	Repair or replace any damaged components.	Go to the next step.
• Turn the ECM power OFF. • Using a DVOM, measure the resistance of the HEGO heater (sensor side) between pins 1 and 2. Does the DVOM show a resistance value less than 5 Ohms or greater than 25 Ohms (resistance should be between 5 and 25 Ohms)?	Replace the HEGO sensor.	Go to the next step.
• Disconnect the wire harness from the ECM • With the ECM power OFF, check for continuity between the following: o P26-18 and HEGO connector pin 4. o P27-82 and HEGO connector pin 2. o P26-51 and HEGO connector pin 3. o P26-65 and HEGO connector pin 1. Does the DVOM show continuity?	Go to the next step.	Repair any open circuits as necessary.
• Connect the wire harness to the ECM. • With the ECM power turned OFF, disconnect the wire harness from the HEGO sensor. • Check for continuity between HEGO connector pin 4 and engine ground. Does the DVOM show continuity?	Repair the signal shorted to ground circuit.	Go to the next step.
• Turn off the fuel supply and disconnect the power leads to the fuel shut-off valves to prevent fuel from inadvertently entering the intake manifold. • Turn the ECM power ON. • Check for voltage between HEGO connector pins 3 and 4. Does Spectrum now show HEGO voltage at less than 0.1 V?	Replace the HEGO sensor.	Go to the next step.
• With the ECM power on and the wire harness disconnected from the HEGO sensor, check for voltage at the HEGO connector pin 4 and engine ground Does the DVOM show above 0.5 V?	Repair the circuit short to voltage as necessary.	Go to the next step.
• With the ECM power ON, check for voltage between HEGO connector pins 1 and 2. Does the DVOM show voltage?	Verify that the HEGO sensor is working properly (skip to the last step).	Go to the next step.
• With the ECM power ON, check for voltage between the HEGO connector pin 1 and engine ground. Does the DVOM show voltage?	Repair any open circuits as necessary.	Go to the next step.
• With the ECM power ON, check for voltage between the HEGO connector pin 2 and battery positive. Does the DVOM show voltage?	Repair the HEGO heater ground shorted to voltage.	Go to the next step.

Action	Yes	No
• Replace the HEGO sensor. Refer to Section 5.7. Is the replacement complete?	Go to the next step.	
Verify that the HEGO sensor is working properly: • Connect any disconnected components. • Clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start and run the engine until operating temperature is reached. • Observe engine performance. • Turn the engine off and check for any stored diagnostic codes. Does the engine operate normally with no stored codes?	The system is OK.	Restart HEGO troubleshooting procedure.
• Replace the ECM. Refer to Section 5.4. Is the replacement complete?	Go to the next step.	-
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Use Spectrum to verify if the DTC code was regenerated. • Observe engine performance. Does the engine operate normally with no stored codes?	The system is OK.	Check for and troubleshoot any other diagnostic codes.

Figure 4-16 HEGO Sensor Troubleshooting

4.8. Ignition Coil Troubleshooting



Figure 4-17 Ignition Coil

⚠ WARNING



Electrical shock can cause injury.
Do not touch wires while engine is running.

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Troubleshooting and/or repairing the sensors or the ECM. A backfire due to an open fuel shut-off valve can cause severe injury or death. If power is supplied to the shut-off valve during ECM or sensor troubleshooting, fuel may enter the air intake manifold or the air cleaner and cause a backfire. Make sure that the fuel supply is turned OFF and that the fuel shut-off valves are DISCONNECTED from the power source BEFORE turning the ECM power on.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

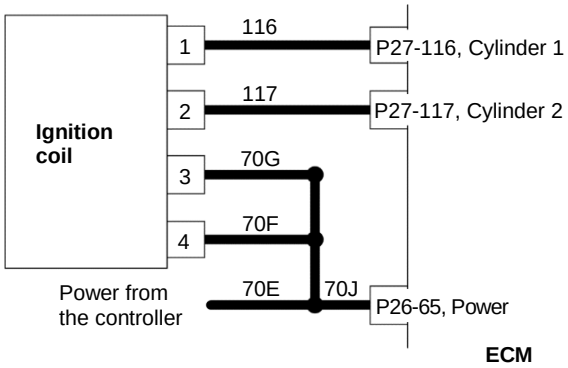


Figure 4-18 Ignition Coil Wiring Diagram

Refer to Figure 4-18 and follow the steps in the troubleshooting chart to verify that:

- The ignition coil is working correctly and is not damaged.
- The ignition coil leads have continuity (no open circuits).
- The ignition coil leads are not shorted.
- Power is being provided to the ignition coil.

4.8.1. Ignition System and No Spark

⚠ WARNING



Electrical shock can cause injury.
Do not touch wires while engine is running.

When ignition systems fail, the most common symptom will be rough running, misfire, or lack of engine power. Ignition issues are often related to a lack of timely maintenance. If beyond the recommended maintenance time, change the plugs and leads. Refer to the equipment or engine operation manual for the maintenance interval chart.

A no spark condition can be caused by issues with the crank position sensor, ignition coil, spark plug leads, wire harness, or ECM.

Important: When the engine is running, do not pull the ignition coil off of its spark plug to verify if it's sparking. This method can damage an ignition coil.

- Before diagnosing no spark ignition issues, make sure the ECM is receiving the initialization signal on P26-3 and P26-65 and the crank position sensor is working.
- If spark is present, the ignition coil is likely good. Use an HEI spark tester when checking for engine spark.
- Pull the leads off of the spark plugs and check individual cylinders for spark. If consistent spark is present, replace the spark plugs. If inconsistent spark is present, bypass the plug leads and check for spark directly from the ignition coil.
- To verify that the ignition coil is working, attach a spark plug tester directly to the coil secondary and test for spark.
    - If spark is present, the ignition coil is good.
    - If spark is not present, troubleshoot the ignition coil using the chart in Figure 4-19.

Action	Yes	No
• Turn the ECM power ON. • Connect Spectrum in system Data Mode. • Crank the engine. Does the DTC reset?	Go to the next step.	Troubleshoot as an intermittent problem.
• Turn the ECM power OFF. • Disconnect the ignition module connector. • Disconnect the ECM connector. • Using a DVOM, check for continuity between the following: o The ignition connector pin 1 and ECM connector P27 pin 116. o The ignition connector pin 2 and ECM connector P27 pin 117. Does the DVOM show continuity?	Go to the next step.	Repair the open circuit as necessary.
• Using a DVOM, check for continuity between the following: o The ignition connector pin 1 and engine ground. o The ignition connector pin 2 and engine ground. Does the DVOM show continuity?	Repair the shorted circuit.	Go to the next step.
• Connect the wire harness to the ECM. • Turn off the fuel supply and disconnect the power leads to the fuel shut-off valves to prevent fuel from inadvertently entering the intake manifold. • Turn the ECM power ON. • Check for voltage on connector pins 3 and 4. • Does the DVOM show voltage?	Go to the next step.	Repair the open circuit as necessary.
• Replace the ignition module. Refer to Section 5.8. Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Observe the engine performance. • After operating the engine, check for any stored codes. Does the engine operate normally with no stored codes?	System OK.	Go to the next step.
• Replace the ECM. Refer to Section 5.4. Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Observe the engine performance. • After operating the engine, check for any stored codes. Does the engine operate normally with no stored codes?	System OK.	Restart the ignition coil troubleshooting procedure. Look for other DTC codes stored in the ECM.

Figure 4-19 Ignition Coil Troubleshooting

4.9. Oil Pressure Sender Troubleshooting



Figure 4-20 Oil Pressure Sender

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

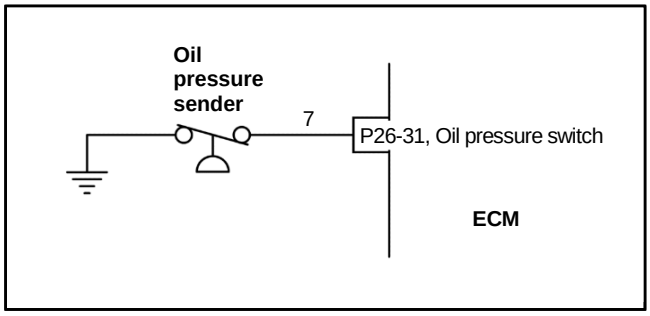


Figure 4-21 Oil Pressure Sender Wiring Diagram

If an oil pressure fault occurs, always verify the oil pressure before checking for an electrical malfunction. If there are no problems with the oil pressure level (indicating a problem with the sensor), proceed with the following oil pressure sender troubleshooting.

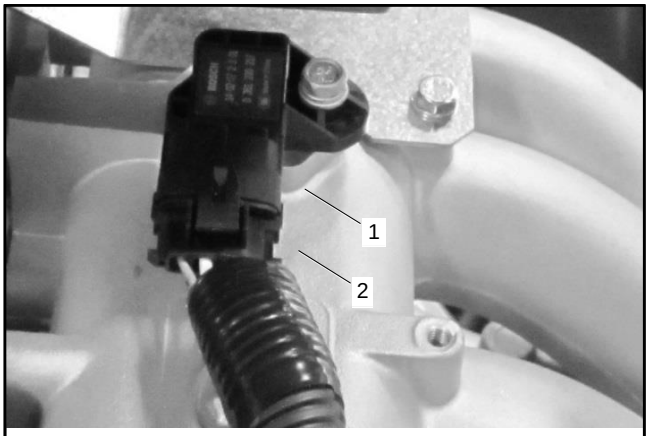
Refer to Figure 4-21 and follow the steps in the troubleshooting chart to verify that:

- The engine oil pressure is correct.
- The oil pressure sender is working correctly and is not damaged.
- The oil pressure sender leads have continuity (no open circuits).
- The oil pressure sender leads are not shorted.

Action	Yes	No
• Verify that the engine has oil pressure using a mechanical oil pressure gauge before proceeding with this chart. Oil pressure must remain above 6 psi. Does the engine have oil pressure above 6 psi?	Go to the next step.	Repair faulty lubrication system
• Turn the ECM power ON. • Connect Spectrum in system data mode. • Note all codes stored in the ECM. Clear any stored codes. • Start the engine and operate to full operating temperature. Does the DTC reset?	Go to the next step.	Troubleshoot as an intermittent problem.
• Clear the DTC. • Turn the ECM power OFF. • Disconnect the oil pressure sender connector and isolate the connector from the engine ground. • Start and run the engine. Does the DTC reset?	Go to the next step.	Replace the oil pressure sender (skip the next two steps)
• Disconnect the ECM harness connector. • Inspect the ECM connector pin for damage, corrosion, or contamination. Did you find a problem?	Repair the circuit as necessary.	Replace the oil pressure sender (skip the next step)
• Turn the ECM power OFF. • Using a DVOM, check for continuity between the oil pressure sender connector pin and ECM connector P26 pin 31. Does the DVOM show continuity?	Go to the next step.	Repair the shorted circuit as necessary.
• Turn the ECM power OFF. • Using a DVOM, check for continuity between the oil pressure sender connector pin and engine ground. Does the DVOM show continuity?	Repair the shorted circuit as necessary.	Go to the next step.
• Replace the oil pressure sender. Refer to **Section 5.9**. Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Observe the engine performance. • After operating the engine, check for any stored codes. Does the engine operate normally with no stored codes?	The system is OK.	Go to the next step.
• Replace the ECM. Refer to Section 5.4. Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Observe the engine performance. • After operating the engine, check for any stored codes. Does the engine operate normally with no stored codes?	The system is OK.	Restart the oil pressure sender troubleshooting procedure. Look for other DTC codes stored in the ECM.

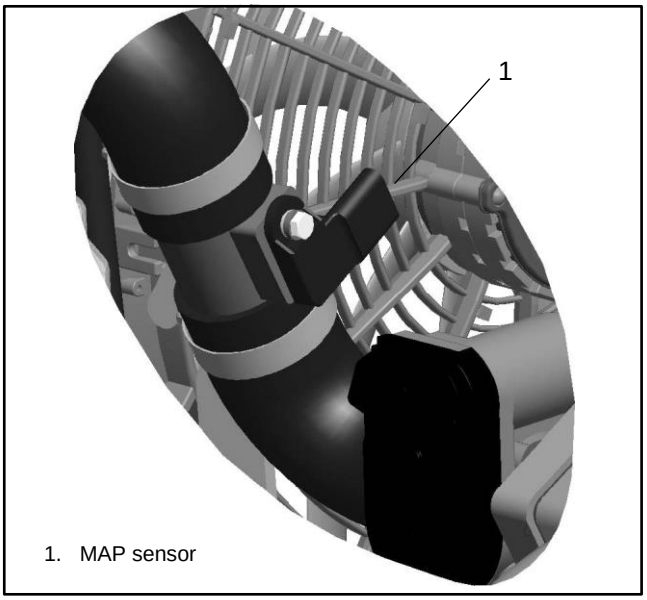
Figure 4-22 Oil Pressure Sender Troubleshooting

4.10. Temperature Manifold Pressure (TMAP) and MAP Sensor Troubleshooting



1. TMAP sensor
2. Wire harness connector

Figure 4-23 TMAP Sensor, KG2204 and KG2204T



1. MAP sensor

Figure 4-24 MAP Sensor, KG2204T

⚠ WARNING



Hot parts can cause severe burns.
Do not touch engine while operating or just after stopping.
Never operate engine with heat shields or guards removed.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

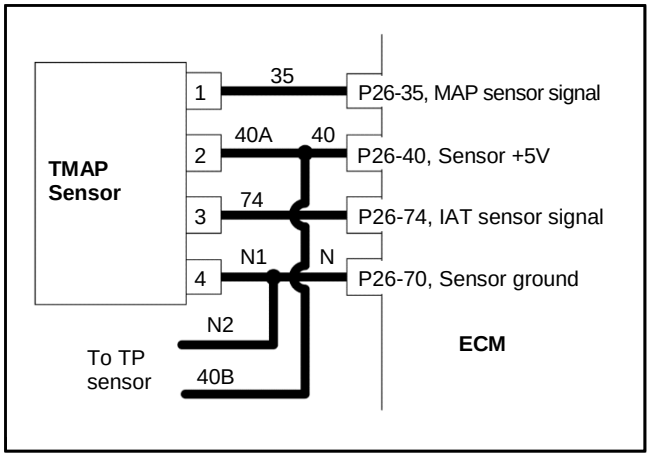


Figure 4-25 TMAP Sensor Wiring Diagram

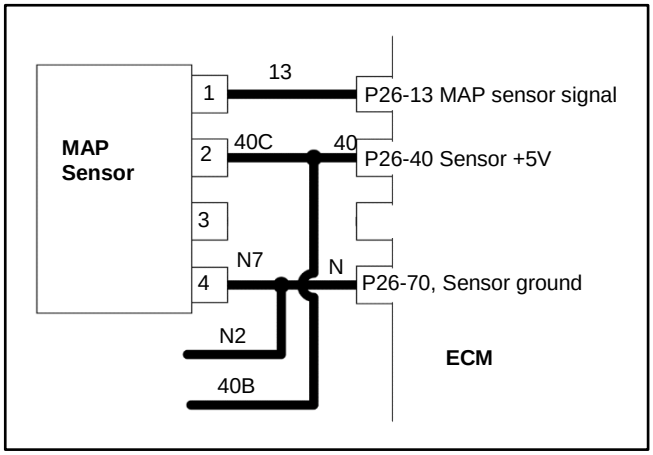


Figure 4-26 MAP Sensor Wiring Diagram, KG2204T

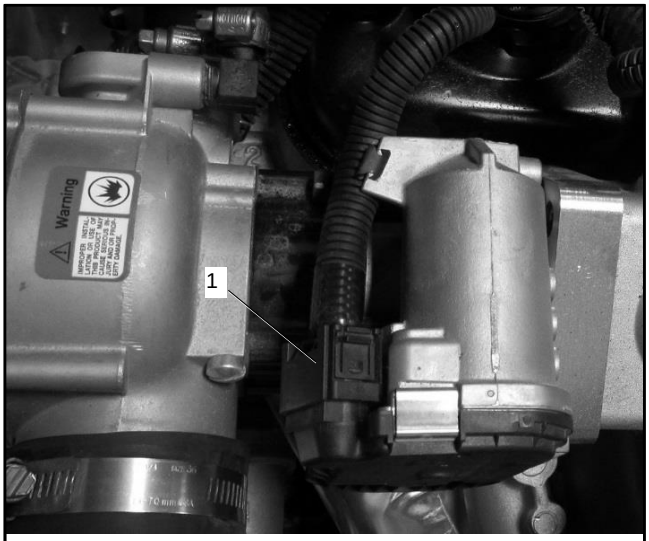
Use the following steps to troubleshoot the TMAP and MAP sensors. Check both the MAP and IAT portions of the TMAP sensor. Refer to Figure 4-25 and follow the steps in the troubleshooting chart to verify that:

- The TMAP sensor is working correctly and is not damaged.
- The sensor leads have continuity (no open circuits).
- The sensor leads are not shorted.

Action	Yes	No
• Turn the ECM power ON. • Connect Spectrum in the data stream mode. • Clear the diagnostic code. • Turn the ECM power OFF. • Turn the ECM power ON. Does the diagnostic troubleshooting code (DTC) re-set?	Go to the next step.	Troubleshoot as an intermittent problem.
• Inspect the throttle connector terminals for damage, corrosion or contamination Did you find a problem?	Repair the circuit as necessary.	Go to the next step.
• Turn the ECM power OFF. • Disconnect the wire harness connector from the ECM. • Disconnect the wire harness connector from the TMAP or MAP sensor. • Inspect TMAP connector pins 2 and 4, and ECM connector P26 pin 70 and P26 pin 40 for damage, corrosion, or contamination. Did you find a problem?	Repair the damaged wire harness connection.	Go to the next step.
With the ECM power OFF, check for continuity between the following: • TMAP connector pin 1 and ECM connector P26 pin 35. • TMAP connector pin 2 and ECM connector P26 pin 40. • TMAP connector pins 3 and P26-74. • TMAP connector pin 4 and ECM connector P26 pin 70. • MAP connector pin 1 and ECM P26-13. • Map connector pin 2 and ECM P26-40. • MAP connector pin 4 and ECM P26-70. Does the DVOM show continuity?	Go to the next step.	Repair the open circuit as necessary.
With the ECM power OFF, check for continuity between the following: • TMAP or MAP connector pin 1 and engine ground. • TMAP or MAP connector pin 2 and engine ground. • TMAP connector pin 3 and engine ground. Does the DVOM show continuity?	Repair the shorted circuit as necessary.	Go to the next step.
• Using a DVOM check for continuity between TMAP connector pins 1 and 3. Does the DVOM show continuity?	Repair the shorted signal to 5 volt circuit as necessary.	Go to the next step.
• Replace the TMAP or MAP sensor. Refer to **Section 5.10**. Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Use Spectrum to verify if the DTC code was regenerated. • Observe engine performance. Does the engine operate normally with no stored codes?	The system is OK.	Go to the next step.
• Replace the ECM. Refer to Section 5.4. Is the replacement complete?	Go to the next step.	-
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Use Spectrum to verify if the DTC code was regenerated. • Observe engine performance. Does the engine operate normally with no stored codes?	The system is OK.	Check for and troubleshoot any other diagnostic codes.

Figure 4-27 TMAP or MAP Sensor Troubleshooting

4.11. Throttle Position (TP) Sensor Troubleshooting



1. Throttle position sensor

Figure 4-28 Throttle Position Sensor

⚠ WARNING



Explosive fuel can cause fires and severe burns.
If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

LPG (Liquefied Petroleum Gas) is extremely flammable and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

NG (Natural Gas) is extremely flammable, is lighter than air, and rises. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

To ensure personal safety, installation and repair of LPG/NG fuel supply systems must be performed only by qualified LPG/NG system technicians. Improperly installed and maintained LPG/NG equipment could cause the fuel supply system or other components to malfunction, causing gas leaks.

Observe federal, state, and local laws governing LPG/NG fuel, storage, and systems.

⚠ WARNING



Hot parts can cause severe burns.
Do not touch engine while operating or just after stopping.
Never operate engine with heat shields or guards removed.

Servicing the exhaust system. Hot parts can cause severe injury or death.
Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Troubleshooting and/or repairing the sensors or the ECM. A backfire due to an open fuel shut-off valve can cause severe injury or death. If power is supplied to the shut-off valve during ECM or sensor troubleshooting, fuel may enter the air intake manifold or the air cleaner and cause a backfire. Make sure that the fuel supply is turned OFF and that the fuel shut-off valves are DISCONNECTED from the power source BEFORE turning the ECM power on.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

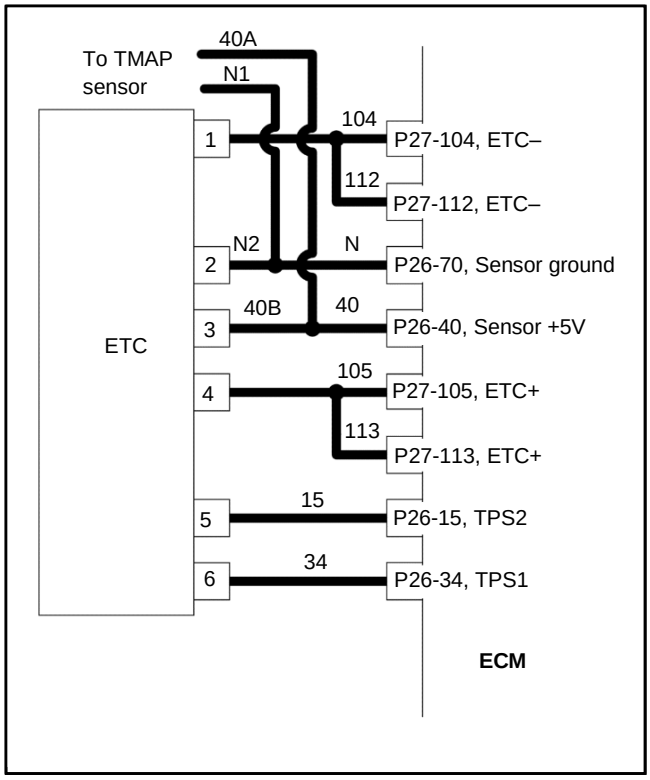


Figure 4-29 TP Sensor Wiring Diagram

The ECM monitors feedback from the electronic throttle control (ETC) through leads TPS1 and TPS2. The ECM controls the signal through leads ETN and ETP to adjust the throttle position and maintain the programmed engine speed.

	Closed	Partially Open	Fully Open
TPS1	0V	Between 0V–5V	5V
TPS2	5V	Between 5V–0V	0V

Refer to Figure 4-29 and follow the steps in the troubleshooting chart to check the throttle position sensors TPS1 and TPS2. Verify that:

- The TP sensor is working correctly and is not damaged.
- The sensor leads have continuity (no open circuits).
- The sensor leads are not shorted.

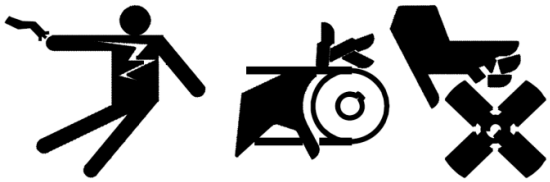
Action	Yes	No
• Turn the ECM power ON. • Connect Spectrum to the ECM in **data stream** mode. • Clear the diagnostic troubleshooting code (DTC). • Start the engine. Does DTC re-set?	Go to the next step.	Troubleshoot as an intermittent problem.
• Check the electronic throttle for a foreign object in the throttle bore or damaged throttle bore or fly assembly. Did you find any damage or a foreign object in the bore?	Remove the foreign object or replace the throttle if damage is found. Go to the last step.	Go to the next step.
• Turn the ECM power OFF. • Disconnect electronic throttle connector. • Disconnect ECM wire harness connector. • Inspect the electronic throttle connector and ECM wire harness connector for damage, corrosion, or contamination. Did you find a problem?	Correct the problem as required. Go to the last step.	Go to the next step.
• With the ECM power OFF, check for continuity between the following: o Sensor connector pin 1 and ECM connector P27 pin 104. o Sensor connector pin 2 and ECM connector P26 pin 70. o Sensor connector pin 3 and ECM connector P26 pin 40. o Sensor connector pin 4 and ECM connector P27 pin 105. o Sensor connector pin 5 and ECM connector P26 pin 15. o Sensor connector pin 6 and ECM connector P26 pin 34. Does the DVOM show continuity?	Go to the next step.	Repair the open circuit as necessary.
• With the ECM power OFF, check for continuity between the following: o Sensor connector pin 1 and engine ground. o Sensor connector pin 2 and engine ground. o Sensor connector pin 3 and engine ground. o Sensor connector pin 4 and engine ground. o Sensor connector pin 5 and engine ground. o Sensor connector pin 6 and engine ground. Does the DVOM show continuity?	Repair the shorted circuit to ground as necessary.	Go to the next step.
• With the ECM power OFF, check for continuity between the following: o ECM connector P27 pin 104 and ECM connector P27 pin 112. o ECM connector P27 pin 105 and ECM connector P27 pin 113. o Sensor connector pin 1 and ECM connector P27 pin 112. o Sensor connector pin 4 and ECM connector P27 pin 113. Does the DVOM show continuity?	Repair the shorted circuit to ground as necessary.	Go to the next step.
• Turn off the fuel supply and disconnect the power leads to the fuel shut-off valves to prevent fuel from inadvertently entering the intake manifold. • Turn the ECM power ON. • Check for voltage between the sensor connector pin 1 and engine ground. Does the DVOM show voltage?	Go to the next step.	Repair the shorted circuit to voltage as necessary.
• Turn the ECM power ON. • Check for voltage between the following: • Sensor connector pin 5 and engine ground. • Sensor connector pin 6 and engine ground. Does the DVOM show voltage?	Go to the next step.	Repair the shorted circuit to voltage as necessary.
• Replace the throttle. Refer to **Section 5.1**. Is the replacement complete?	Go to the next step.	

Action	Yes	No
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Use Spectrum to verify if the DTC code was regenerated. • Observe engine performance. Does the engine operate normally with no stored codes?	The system is OK.	Go to the next step.
• Replace the ECM. Refer to Section 5.4. Is the replacement complete?	Go to the next step.	
• Remove all test equipment except Spectrum. • Connect any disconnected components. • Using Spectrum, clear DTC information from the ECM. • Turn the ECM power OFF and wait 30 seconds. • Start the engine and operate to full operating temperature. • Use Spectrum to verify if the DTC code was regenerated. • Observe engine performance. Does the engine operate normally with no stored codes?	The system is OK.	Check ECM for any other DTCs. Repeat these troubleshooting steps.

Figure 4-30 Throttle Position Sensor Troubleshooting

The following section includes the installation and removal procedures for fuel system components and sensors. If the troubleshooting steps determine that a component is damaged and replacement is needed, use the following procedures to remove and replace that component.

⚠ WARNING



Accidental starts can cause severe injury or death. Disconnect and ground spark plug leads before servicing.
Before working on engine or equipment, disable engine as follows: 1) Disconnect spark plug leads. 2) Disconnect negative (–) battery cable from battery.
Before disconnecting negative (–) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or LPG/NG fuel vapors are present.

⚠ WARNING



Risk of Fire. Can cause severe injury or death.
Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the engine with the air cleaner removed.

⚠ WARNING



Carbon monoxide can cause severe nausea, fainting, or death.
Avoid inhaling exhaust fumes.
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled.

⚠ WARNING



Explosive fuel vapors. Can cause severe injury or death.
Use extreme care when handling, storing, and using fuels.
Gas fuel leaks. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Check the LPG vapor or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.

⚠ WARNING



Explosive fuel can cause fires and severe burns.
If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

LPG (Liquefied Petroleum Gas) is extremely flammable and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

NG (Natural Gas) is extremely flammable, is lighter than air, and rises. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

To ensure personal safety, installation and repair of LPG/NG fuel supply systems must be performed only by qualified LPG/NG system technicians. Improperly installed and maintained LPG/NG equipment could cause the fuel supply system or other components to malfunction, causing gas leaks.

Observe federal, state, and local laws governing LPG/NG fuel, storage, and systems.

Used engine oil. Contact with used engine oil may cause severe skin irritation. Repeated and prolonged skin exposure may have other health risks. Used engine oil is a suspected carcinogen. Avoid contact with skin. Thoroughly wash your hands and nails with soap and water shortly after handling used engine oil. Wash or dispose of clothing or rags containing used engine oil. Dispose of used engine oil in accordance with applicable laws and regulations. Contact your local recycling center for disposal information and locations.

⚠ WARNING



Electrical shock can cause injury.
Do not touch wires while engine is running.

⚠ WARNING



Hot parts can cause severe burns.
Do not touch engine while operating or just after stopping.
Never operate engine with heat shields or guards removed.

Servicing the exhaust system. Hot parts can cause severe injury or death.
Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

5.1. Air-Fuel Mixer, Adapter, and Throttle Body Assembly

⚠ WARNING



Explosive fuel can cause fires and severe burns.
If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

LPG (Liquefied Petroleum Gas) is extremely flammable and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

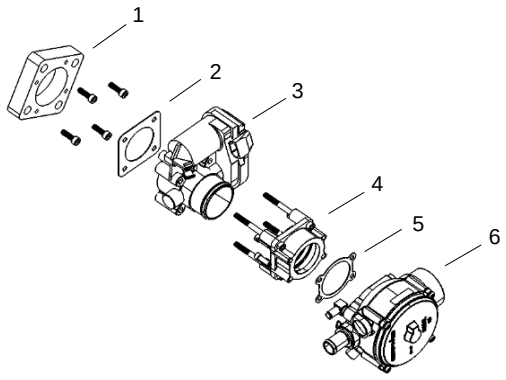
NG (Natural Gas) is extremely flammable, is lighter than air, and rises. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

To ensure personal safety, installation and repair of LPG/NG fuel supply systems must be performed only by qualified LPG/NG system technicians. Improperly installed and maintained LPG/NG equipment could cause the fuel supply system or other components to malfunction, causing gas leaks.

Observe federal, state, and local laws governing LPG/NG fuel, storage, and systems.

Refer to the Engine Service Manual for detailed assembly and disassembly instructions.

5.1.1. Throttle Body and Air-Fuel Mixer Removal, KG2204



1. Throttle body adapter plate
2. Throttle body gasket
3. Throttle body
4. Air-fuel mixer adapter
5. Mixer gasket
6. Air-fuel mixer

Figure 5-1 Component Exploded View, KG2204

Note: To loosen the four mounting bolts securing the air-fuel mixer valve and throttle body assembly to the upper intake manifold, cut off a hex wrench as needed to fit into the tight location.

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Relieve the fuel system pressure.
6. Remove wire harness from the throttle body.
7. Remove the air intake hose and fuel intake hose from the air-fuel mixer. Ventilate the area to clear fumes.
8. Remove the four socket head cap screws securing the air-fuel mixer valve and throttle body assembly to the upper intake manifold. Remove air-fuel mixer valve and throttle body as a unit from the upper intake manifold.
9. Remove the four screws holding the throttle body adapter plate to the intake manifold and then remove the adapter from the upper intake manifold.
10. To separate the air-fuel mixer valve from the throttle body, use a rotational motion while pulling

the two components apart. Use caution not to damage the O-rings.

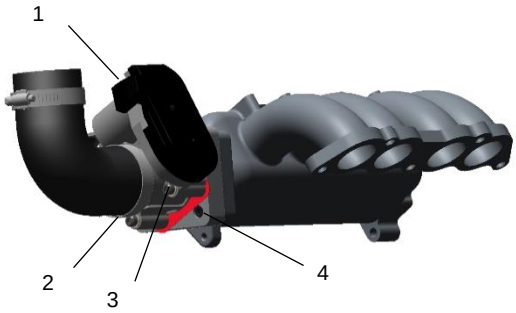
11. Remove four socket head cap screws securing air-fuel mixer to the air-fuel mixer adapter and then remove the adapter and the mixer gasket.
12. Place tape or a clean cloth over the intake to prevent items from falling inside the engine.

5.1.2. Throttle Body and Air-Fuel Mixer Installation, KG2204

1. Install the throttle body adapter plate to the upper intake manifold. Secure with four socket head cap screws.
2. Position the mixer gasket between the air-fuel mixer adapter and the air-fuel mixer.
3. Assemble the air-fuel mixer adapter to the air-fuel mixer valve. Secure with four socket head cap screws.
4. Use lubricant on the O-rings. Assemble the throttle body into the air-fuel mixer valve adapter. Use caution not to damage O-rings.
5. Position the throttle body gasket between the throttle body adapter and the throttle body.
6. Install the air-fuel mixer valve and throttle body assembly to the upper intake manifold as a unit. Secure with four socket head cap screws.
7. Attach the air intake hose and fuel intake hoses to the mixer.
8. Install wire harness to throttle position sensor.
9. Reconnect the battery.
10. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
11. Turn on the fuel supply.
12. Start the engine and check for leaks with the engine running.

Turn off the engine.

5.1.3. Throttle Body Removal, KG2204T



1. Disconnect wire harness.
2. Remove clamp and hose.
3. Remove 4 bolts to remove throttle body with gasket.
4. Remove 4 bolts to remove adaptor plate.

Figure 5-2 Throttle Body Assembly, KG2204T

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Remove wire harness from the throttle body.
5. Remove the air hose from the throttle body.
6. Remove the four socket head cap screws securing the throttle body assembly to the upper intake manifold. Remove the throttle body from the upper intake manifold.

Remove the four screws holding the throttle body adapter plate to the intake manifold and then remove the adapter from the upper intake manifold.

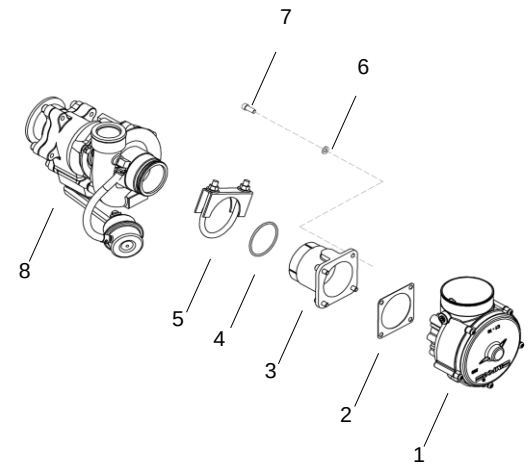
7. Place tape or a clean cloth over the intake to prevent items from falling inside the engine.

5.1.4. Throttle Body Installation, KG2204

1. Position the throttle body gasket between the adapter and the upper intake manifold.
2. Install the throttle body adapter plate to the upper intake manifold. Secure with four socket head cap screws.
3. Position the throttle body gasket between the throttle body adapter and the throttle body.
4. Install the air-fuel mixer valve and throttle body assembly to the upper intake manifold as a unit. Secure with four socket head cap screws.
5. Attach the air intake hose and fuel intake hoses to the mixer.
6. Install wire harness to throttle position sensor.
7. Reconnect the battery.
8. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
9. Turn on the fuel supply.
10. Start the engine and check for leaks with the engine running.
11. Turn off the engine.

5.1.5. Air-Fuel Mixer Removal, KG2204T

Note: For turbocharger removal and installation instructions, refer to the engine service manual.



1. Air-fuel mixer
2. Mixer gasket
3. Adapter
4. O-ring
5. Clamp
6. Washer
7. Screw
8. Turbocharger

Figure 5-3 Air-Fuel Mixer Exploded View, KG2204T

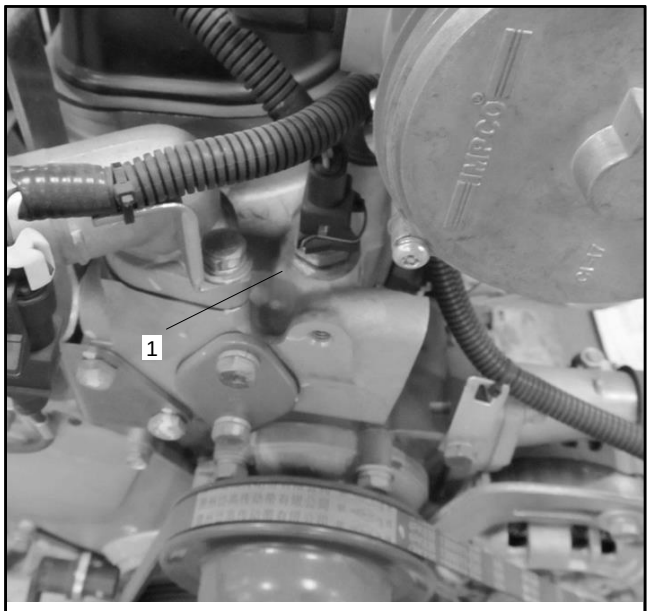
1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Relieve the fuel system pressure.
6. Remove the air intake hose and the fuel intake hose from the air-fuel mixer. Ventilate the area to clear fumes.
7. Loosen the clamp at the adapter connection to the turbocharger.

8. To separate the air-fuel mixer from the turbocharger, use a rotational motion while pulling the two components apart. Use caution not to damage the O-rings.
9. Remove four socket head cap screws securing air-fuel mixer to the air-fuel mixer adapter and then remove the adapter and the mixer gasket.

5.1.6. Air-Fuel Mixer Installation, KG2204T

1. Position the mixer gasket between the air-fuel mixer adapter and the air-fuel mixer.
2. Assemble the air-fuel mixer adapter to the air-fuel mixer. Secure with four socket head cap screws.
3. Use lubricant on the O-rings. Assemble the air-fuel mixer adapter onto the turbocharger. Use caution not to damage O-rings. Tighten the clamp.
4. Attach the air intake and fuel intake hoses to the mixer.
5. Reconnect the battery.
6. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
7. Turn on the fuel supply.
8. Start the engine and check for leaks with the engine running.
9. Turn off the engine.

5.2. Coolant Temperature (CT) Sensor



1. CT sensor location

Figure 5-3 CT Sensor Location

⚠ WARNING



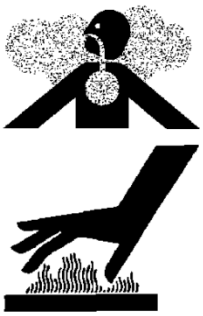
Hot coolant and steam. Can cause severe injury or death.
The coolant may be hot. Use caution when removing hose(s) to prevent contact.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

⚠ WARNING



Handling caustic engine fluids and chemical products can cause severe chemical burns, nausea, fainting, or death.

Most chemicals such as used engine oil, antifreeze/coolant, rustproofing agent, inhibiting oil, degreasing agent, spray paint, and adhesives are hazardous to health. Read and follow the user information found on the packaging. Avoid inhalation and skin contact. Use only in well-ventilated areas and use a protective mask when spraying. Store engine fluids and chemical products in a locked cabinet. Contact your local recycling center for disposal information and locations.

5.2.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Drain the coolant.
6. Locate the CT sensor on the coolant below the air-fuel mixer.
7. Remove the wire harness from the CT sensor.
8. Unscrew the sensor from the engine.

5.2.2. Installation Procedure

1. Apply a light coat of Loctite® 567 or equivalent pipe thread sealant on the threads of the ECT.
2. Install the CT sensor into the engine and torque until tight.
3. Connect the CT sensor electrical connector.
4. Refill the coolant.
5. Reconnect the battery.
6. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
7. Start the engine and let run until it reaches normal operating temperature and verify correct operation. Check for leaks. If leaks are found, repair as necessary.
8. Turn off the engine.
9. If a DTC code is found, refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.
10. Allow the engine to cool, check coolant level and add coolant if necessary.

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5.3. Crankshaft Position (CKP) Sensor

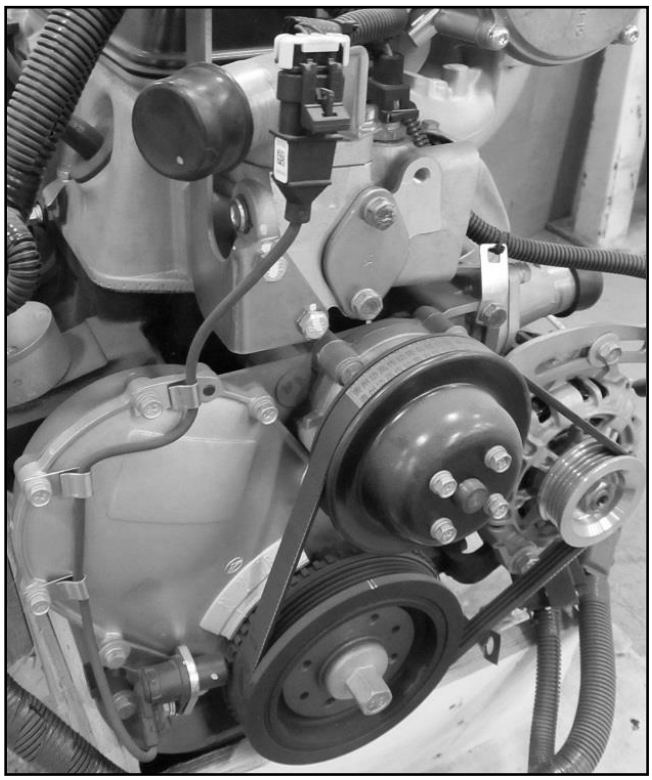


Figure 5-4 Crankshaft Position Sensor

⚠ WARNING



Avoid possible death or serious injury! Pinch and entanglement hazards!
Never check drive belt tension while the engine is running.

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

Refer to the Engine Service Manual section for detailed instructions for assembly and disassembly of the crankshaft position sensor.

5.3.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Remove three electrical harness clamp bolts, flat washers, and lock washers from crankshaft position sensor wiring harness.
6. Remove the mounting bolt, flat washer, and lock washer from the crankshaft position sensor.
7. Remove the sensor.

5.3.2. Installation Procedure

1. Install the crankshaft position sensor to the mounting bracket.
2. Use the mounting bolt, flat washer, and lock washer to secure the crankshaft position sensor.
3. Use three electrical harness clamp bolts, flat washers, and lock washers to secure the sensor wiring harness.
4. Reconnect the battery.
5. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
6. Turn on the fuel supply.
7. Start and run the engine until normal operating temperature is reached.
8. Turn off the engine.
9. Check for any DTCs and troubleshoot. Refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.

5.4. Electronic Control Module (ECM)

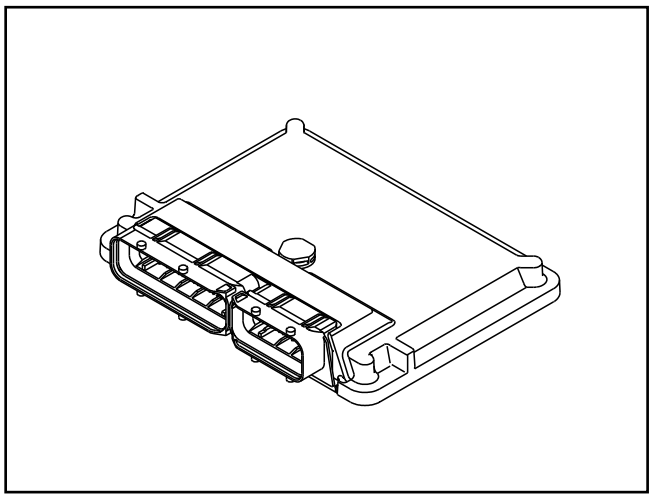


Figure 5-4 Electronic Control Module

5.4.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Unlock the connectors and unplug the wire harness from the ECM.
6. Gently rock the ECM while pulling back to remove the ECM from the adhesive strips on the mounting bracket.

5.4.2. Installation Procedure

1. Clean the ECM bracket surface with a 50:50 mixture of isopropyl alcohol and water.

Note: For tape to successfully bond, the ideal temperature range is 21° C – 38° C (70° F – 100° F) and the minimum temperature requirement is 10° C (50° F).

2. Apply black bonding tape, Kohler part number 32000 00110, to the back of the ECM.
3. Press and hold the ECM onto the mounting bracket for 1 minute.
4. Plug the connectors into the ECM and push the locks into place.
5. Reconnect the battery.
6. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
7. Turn on the fuel supply.
8. Connect to the ECM with Spectrum.
9. Start engine and let run until it reaches normal operating temperature.
10. Turn off the engine.
11. Check for any DTC codes and clear.
12. Verify that the engine is working and in a closed loop relationship with the ECM and that no DTC codes are logged.
13. If a DTC code is found, refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.

5.5. Fuel Control Valve

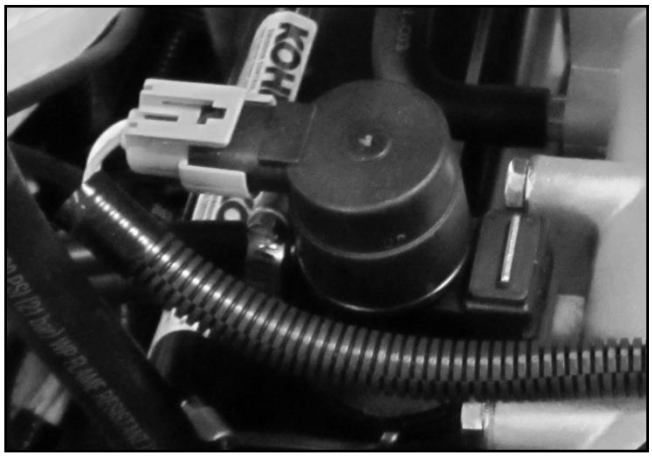


Figure 5-5 Fuel Control Valve, KG2204

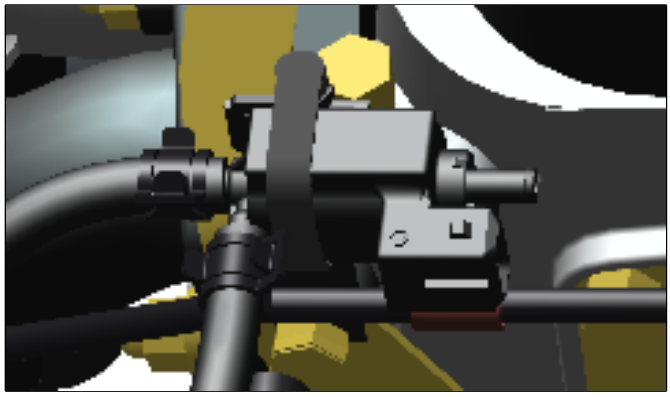


Figure 5-6 Fuel Control Valve, KG2204T

⚠ WARNING



Explosive fuel can cause fires and severe burns.
If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

LPG (Liquefied Petroleum Gas) is extremely flammable and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.
NG (Natural Gas) is extremely flammable, is lighter than air, and rises. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.
To ensure personal safety, installation and repair of LPG/NG fuel supply systems must be performed only by qualified LPG/NG system technicians. Improperly installed and maintained LPG/NG equipment could cause the fuel supply system or other components to malfunction, causing gas leaks.
Observe federal, state, and local laws governing LPG/NG fuel, storage, and systems.

5.5.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Disconnect wire harness.
6. Disconnect the vacuum hoses.
7. While rocking the fuel control valve back and forth, gently pull up on the valve and remove from the mounting bracket.

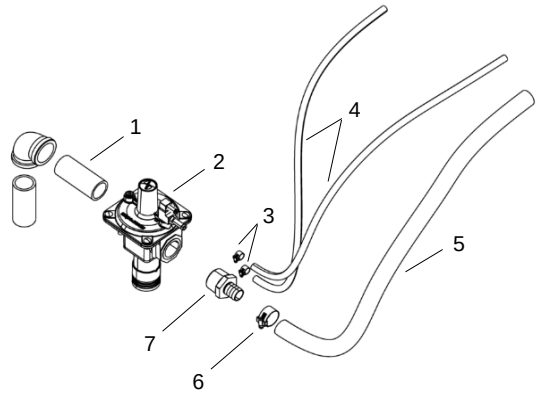
5.5.2. Installation Procedure

1. Press the fuel control valve into the mounting bracket.
2. Connect both vacuum hoses.

Note: The lower hose is attached to the intake manifold and the upper hose is attached to the fuel pressure regulator.

3. Attach the wire harness.
4. Reconnect the battery.
5. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
6. Turn on the fuel supply.
7. Start the engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected make repairs. Verify correct operation in all throttle ranges.
8. Turn off the engine.
9. Check for any DTCs and troubleshoot. Refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.

5.6. Fuel Pressure Regulator



1. Pipe nipple
2. Fuel pressure regulator
3. Vacuum hose clamps
4. Vacuum hoses
5. Fuel line hose
6. Hose clamp
7. Hose connector

Figure 5-7 Fuel Pressure Regulator

⚠ WARNING



Explosive fuel can cause fires and severe burns.
If a gaseous odor is detected, ventilate the area and contact an authorized service technician.

LPG (Liquefied Petroleum Gas) is extremely flammable and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

NG (Natural Gas) is extremely flammable, is lighter than air, and rises. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

To ensure personal safety, installation and repair of LPG/NG fuel supply systems must be performed only by qualified LPG/NG system technicians. Improperly installed and maintained LPG/NG equipment could cause the fuel supply system or other components to malfunction, causing gas leaks.

Observe federal, state, and local laws governing LPG/NG fuel, storage, and systems.

5.6.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply and relieve the fuel system pressure.
5. Disconnect the vacuum hoses attached to the fuel pressure regulator.
6. Remove the fuel-line hose clamp and hose from the fuel pressure regulator. Ventilate the area to clear fumes.

Note: Do not put any side pressure on the regulator or pipe that may strip or damage any of the threads.

7. To remove the fuel pressure regulator from the pipe nipple, rotate the entire fuel pressure regulator clockwise.
8. To remove the hose connector from the pressure regulator, place the fuel pressure regulator in a vice and remove the hose connector with a wrench.

5.6.2. Installation Procedure

1. To install the hose connector into the fuel pressure regulator, place the fuel pressure regulator in a vice. Add **a PTFE (Polytetrafluoroethylene) paste that is appropriate for NG or LPG applications** onto the male threads of the hose connector and thread the hose connector with a wrench.
2. Place PTFE paste on the male threads of the fuel nipple.

Note: Do not put any side pressure on the regulator or pipe that may strip or damage any of the threads.

3. Position and rotate the fuel pressure regulator onto the pipe nipple.
4. Reconnect vacuum hoses to the fittings on the fuel pressure regulator and tighten the hose clamps.
5. Position the fuel-line hose onto the hose adapter and tighten the fuel-line hose clamp to secure.
6. Reconnect the battery.
7. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
8. Reconnect the fuel line and turn on the fuel supply.
9. Turn the ECM power ON and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected make repairs.
10. Press RUN to start the engine and check for leaks using a soapy solution or an electronic leak detector. If leaks are detected, make repairs. Verify correct operation in all throttle ranges.
11. Turn off the engine.
12. Check for any DTCs and troubleshoot. Refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.

5.7. Heated Exhaust Gas Oxygen Sensor (HEGO)

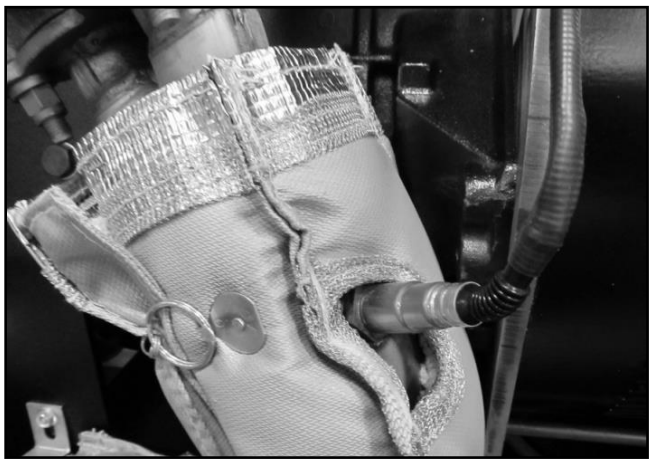


Figure 5-8 HEGO Sensor

⚠ WARNING



Hot parts can cause severe burns.
Do not touch engine while operating or just after stopping.
Never operate engine with heat shields or guards removed.

5.7.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Wait for the exhaust to cool.
6. Locate the HEGO sensor.
7. Disconnect the HEGO sensor wire harness.
8. Using a HEGO sensor socket, remove the HEGO sensor.

5.7.2. Installation Procedure

Important: Silicone sprays or inappropriate RTV (room temperature vulcanization) sealers can contaminate the HEGO sensor. Contaminated HEGO sensors can produce false or high readings resulting in poor fuel mixtures and severe performance problems. Always verify that the sealer is safe to use with the HEGO sensor before using.

1. Before installing the HEGO sensor, lubricate the threads with an appropriate anti-seize compound. Avoid contaminating the sensor tip with the compound.
2. Install the HEGO sensor and torque to **41 Nm (30 ft. lb.)**.
3. Reconnect the wire harness connection to the HEGO sensor.
4. Reconnect the battery.
5. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
6. Turn on the fuel supply.
7. Start and run the engine until normal operating temperature is reached.
8. Turn off the engine.
9. Check for any DTCs and troubleshoot. Refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.

5.8. Ignition Coil



Figure 5-9 Ignition Coil

⚠ WARNING



Electrical shock can cause injury.
Do not touch wires while engine is running.

Refer to the Engine Service Manual, Ignition Coil Removal and Installation, for more detailed assembly and disassembly instructions.

5.8.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Disconnect the wire harness and the spark plug leads from the ignition coil.
6. Remove the four ignition coil mounting bolts, flat washers, lock washers, and nuts that secure the ignition coil to the bracket
7. Remove the ignition coil.

5.8.2. Installation Procedure

1. Position the ignition coil on the bracket.
2. Secure the ignition coil with four ignition coil mounting bolts, flat washers, lock washers, and nuts.
3. Connect the wire harness and spark plugs to the ignition coil.
4. Reconnect the battery.
5. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
6. Turn on the fuel supply.
7. Start the engine and check for proper operation in all throttle ranges.
8. Turn off the engine.
9. If a DTC code is found, refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.

5.9. Oil Pressure Sender



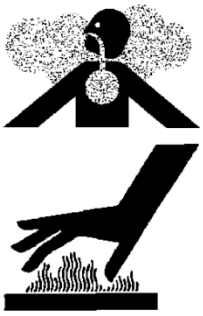
Figure 5-10 Oil Pressure Sender

⚠ WARNING



Rotating parts can cause severe injury.
Stay away while the engine is in operation.
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

⚠ WARNING



Handling caustic engine fluids and chemical products can cause severe chemical burns, nausea, fainting, or death.
Most chemicals such as used engine oil, antifreeze/coolant, rustproofing agent, inhibiting oil, degreasing agent, spray paint, and adhesives are hazardous to health. Read and follow the user information found on the packaging. Avoid inhalation and skin contact. Use only in well-ventilated areas and use a protective mask when spraying. Store engine fluids and chemical products in a locked cabinet. Contact your local recycling center for disposal information and locations.

Used engine oil. Contact with used engine oil may cause severe skin irritation. Repeated and prolonged skin exposure may have other health risks. Used engine oil is a suspected carcinogen. Avoid contact with skin. Thoroughly wash your hands and nails with soap and water shortly after handling used engine oil. Wash or dispose of clothing or rags containing used engine oil. Dispose of used engine oil in accordance with applicable laws and regulations. Contact your local recycling center for disposal information and locations.

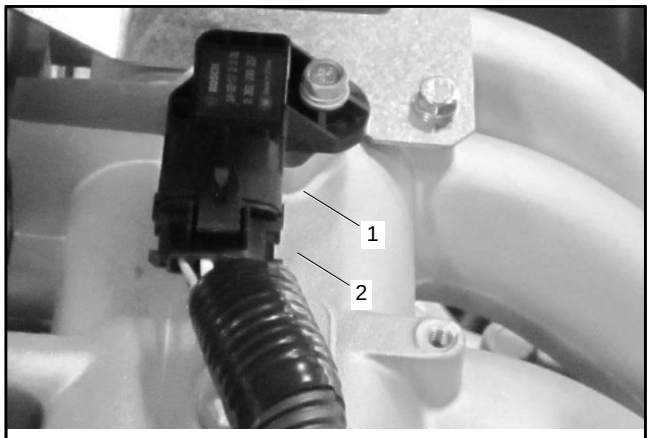
5.9.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Wait for the engine to cool.
6. Locate the oil pressure sender on the oil filter adapter.
7. Disconnect the wire harness from oil pressure sender.
8. Using a wrench, turn the oil pressure sender counter-clockwise to remove.

5.9.2. 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 and torque until tight.
3. Attach the wire harness.
4. Reconnect the battery.
5. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
6. Turn on the fuel supply.
7. Start the engine and let run until it reaches normal operating temperature. Check for oil leaks around the oil pressure sender. If leaks are found, repair as necessary.
8. Turn off the engine.
9. Check for any DTCs and troubleshoot. Refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.

5.10. Temperature Manifold Pressure (TMAP) Sensor



1. TMAP sensor
2. Wire harness connector

Figure 5-11 TMAP Sensor

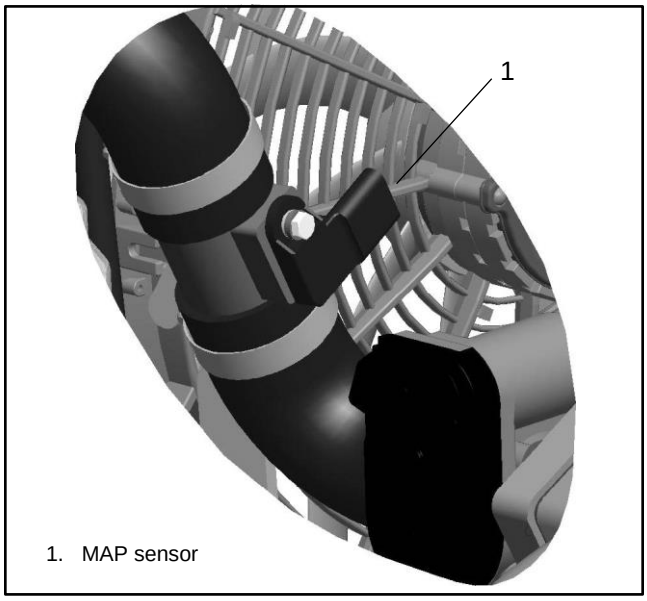
5.10.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Locate the TMAP sensor on the intake manifold.
6. Disconnect the wire harness from the TMAP sensor.
7. Remove the retaining screw.
8. Remove TMAP Sensor by pulling straight up with a slight rocking motion.

5.10.2. Installation Procedure

1. Lightly apply petroleum jelly to the O-ring on the TMAP sensor.
2. Install the TMAP sensor and secure with the retaining screw. Torque the retaining screw to **9.9 Nm (7.3 ft. lb.)**.
3. Reconnect the wire harness.
4. Reconnect the battery.
5. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
6. Turn on the fuel supply.
7. Start and run the engine until normal operating temperature is reached.
8. Turn off the engine.
9. Check for any DTCs and troubleshoot. Refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.

5.11. Manifold Pressure (MAP) Sensor, KG2204T



1. MAP sensor

Figure 5-12 MAP Sensor, KG2204T

5.11.1. Removal Procedure

1. Make sure that the engine is off.
2. If the engine is used as part of a generator set, disconnect AC power to the generator set by opening the upstream circuit breaker.
3. Disconnect the engine starting battery, negative (-) lead first.
4. Shut off the fuel supply.
5. Locate the MAP sensor on the CAC hose, near the throttle body.
6. Disconnect the wire harness from the MAP sensor.
7. Remove the retaining screw.
8. Remove MAP Sensor by pulling straight up with a slight rocking motion.

5.11.2. Installation Procedure

1. Lightly apply petroleum jelly to the O-ring on the MAP sensor.
2. Install the MAP sensor and secure with the retaining screw. Tighten the retaining screw to **9.9 Nm (7.3 ft. lb.)**.
3. Reconnect the wire harness.
4. Reconnect the battery.
5. If the engine is used as part of a generator set, re-apply the AC power supply to the generator set by closing the upstream circuit breaker.
6. Turn on the fuel supply.
7. Start and run the engine until normal operating temperature is reached.
8. Turn off the engine.
9. Check for any DTCs and troubleshoot. Refer to **Section 2**, **Diagnostic Troubleshooting Codes** for further diagnosis.

Notes

American Standard Fasteners Torque Specifications

Size	Torque Measurement	Assembled into Cast Iron or Steel			Assembled into Aluminum, Grade 2 or 5
		Grade 2	Grade 5	Grade 8	
8-32	N•m (in. lb.)	1.8 (16)	2.3 (20)	—	See Note 3
10-24	N•m (in. lb.)	2.9 (26)	3.6 (32)	—	
10-32	N•m (in. lb.)	2.9 (26)	3.6 (32)	—	
1/4-20	N•m (in. lb.)	6.8 (60)	10.8 (96)	14.9 (132)	
1/4-28	N•m (in. lb.)	8.1 (72))	12.2 (108)	16.3 (144)	
5/16-18	N•m (in. lb.)	13.6 (120)	21.7 (192)	29.8 (264)	
5/16-24	N•m (in. lb.)	14.9 (132)	23.1 (204)	32.5 (288)	
3/8-16	N•m (ft. lb.)	24.0 (18)	38.0 (28)	53.0 (39)	
3/8-24	N•m (ft. lb.)	27.0 (20)	42.0 (31)	60.0 (44)	
7/16-14	N•m (ft. lb.)	39.0 (29)	60.0 (44)	85.0 (63)	
7/16-20	N•m (ft. lb.)	43.0 (32)	68.0 (50)	95.0 (70)	
1/2-13	N•m (ft. lb.)	60.0 (44)	92.0 (68)	130.0 (96)	
1/2-20	N•m (ft. lb.)	66.0 (49)	103.0 (76)	146.0 (108)	
9/16-12	N•m (ft. lb.)	81.0 (60)	133.0 (98)	187.0 (138)	
9/16-18	N•m (ft. lb.)	91.0 (67)	148.0 (109)	209.0 (154)	
5/8-11	N•m (ft. lb.)	113.0 (83)	183.0 (135)	259.0 (191)	
5/8-18	N•m (ft. lb.)	128.0 (94)	208.0 (153)	293.0 (216)	
3/4-10	N•m (ft. lb.)	199.0 (147)	325.0 (240)	458.0 (338)	
3/4-16	N•m (ft. lb.)	222.0 (164)	363.0 (268)	513.0 (378)	
1-8	N•m (ft. lb.)	259.0 (191)	721.0 (532)	1109.0 (818)	
1-12	N•m (ft. lb.)	283.0 (209)	789.0 (582)	1214.0 (895)	

1. The torque values above are general guidelines. Always use the torque values specified in the service manuals and/or assembly drawings when they differ from above torque values.
2. The torque values above are based on new plated threads. Increase torque values by 15% if non-plated threads are used.
3. Hardware threaded into aluminum must have either two diameters of thread engagement or a 30% or more reduction in the torque to prevent stripped threads.
4. Torques values are calculated as equivalent stress loading on American hardware with an approximate preload of 90% of the yield strength and a friction coefficient of 0.125.

Metric Fasteners Torque Specifications

Size	Torque Measurement	Assembled into Cast Iron or Steel			Assembled into Aluminum Grade 5.8 or 8.8
		Grade 5.8	Grade 8.8	Grade 10.9	
M6 x 1.00	N•m (ft. lb.)	6.2 (4.6)	12 (9)	13.6 (10)	See Note 3
M8 x 1.25	N•m (ft. lb.)	15.0 (11)	29.6 (22)	33.0 (24)	
M8 x 1.00	N•m (ft. lb.)	16.0 (11)	24.0 (18)	34.0 (25)	
M10 x 1.50	N•m (ft. lb.)	30.0 (22)	52.5 (39)	65.0 (48)	
M10 x 1.25	N•m (ft. lb.)	31.0 (23)	47.0 (35)	68.0 (50)	
M12 x 1.75	N•m (ft. lb.)	53.0 (39)	80.0 (59)	115.0 (85)	
M12 x 1.50	N•m (ft. lb.)	56.0 (41)	85.0 (63)	122.0 (90)	
M14 x 2.00	N•m (ft. lb.)	83.0 (61)	135.0 (100)	180.0 (133)	
M14 x 1.50	N•m (ft. lb.)	87.0 (64)	133.0 (98)	190.0 (140)	
M16 x 2.00	N•m (ft. lb.)	127.0 (94)	194.0 (143)	278.0 (205)	
M16 x 1.50	N•m (ft. lb.)	132.0 (97)	201.0 (148)	287.0 (212)	
M18 x 2.50	N•m (ft. lb.)	179.0 (132)	273.0 (201)	390.0 (288)	
M18 x 1.50	N•m (ft. lb.)	189.0 (140)	289.0 (213)	413.0 (305)	

1. The torque values above are general guidelines. Always use the torque values specified in the service manuals and/or assembly drawings when they differ from above torque values.
2. The torque values above are based on new plated threads. Increase torque values by 15% if non-plated threads are used.
3. Hardware threaded into aluminum must have either two diameters of thread engagement or a 30% or more reduction in the torque to prevent stripped threads.
4. Torques values are calculated as equivalent stress loading on American hardware with an approximate preload of 90% of the yield strength and a friction coefficient of 0.125.

Appendix B Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	advanced digital control; analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
Ah	amp-hour
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
APDC	Air Pollution Control District
API	American Petroleum Institute
approx.	approximate, approximately
APU	Auxiliary Power Unit
AQMD	Air Quality Management District
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CAN	controller area network
CARB	California Air Resources Board
CAT5	Category 5 (network cable)
CB	circuit breaker
CC	crank cycle
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cert.	certificate, certification, certified
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
CMOS	complementary metal oxide substrate (semiconductor)
com	communications (port)
coml	commercial
Coml/Rec	Commercial/Recreational
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cUL	Canadian Underwriter's Laboratories
CUL	Canadian Underwriter's Laboratories
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dB(A)	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E^2PROM, EEPROM	electrically-erasable programmable read-only memory
E, emer.	emergency (power source)
ECM	electronic control module, engine control module
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example (*exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lb.	foot pounds (torque)
ft./min.	feet per minute
ftp	file transfer protocol
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temp., high engine temp.
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IBC	International Building Code
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lb.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	internet protocol
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard
k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)
KBus	Kohler communication protocol
kg	kilogram
kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz

kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
kWth	kilowatt-thermal
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound, pounds
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
$m^3/hr.$	cubic meters per hour
$m^3/min.$	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCCB	molded-case circuit breaker
MCM	one thousand circular mils
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
ms	millisecond
m/sec.	meters per second
mtg.	mounting
MTU	Motoren-und Turbinen-Union
MW	megawatt
mW	milliwatt
μF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
OC	overcrank
OD	outside diameter
OEM	original equipment manufacturer
OF	overfrequency
opt.	option, optional
OS	oversize, overspeed
OSHA	Occupational Safety and Health Administration
OV	overvoltage
oz.	ounce
p., pp.	page, pages
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph., Ø	phase
PHC	Phillips® head Crimptiter (screw)
PHH	Phillips® hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read-only memory
psi	pounds per square inch
psig	pounds per square inch gauge
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart, quarts
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RBUS	RS-485 proprietary communications
RDO	relay driver output
ref.	reference
rem.	remote
Res/Coml	Residential/Commercial
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
RO	read only
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTDs	Resistance Temperature Detectors
RTU	remote terminal unit
RTV	room temperature vulcanization
RW	read/write
SAE	Society of Automotive Engineers
scfm	standard cubic feet per minute
SCR	silicon controlled rectifier
s, sec.	second
SI	*Systeme international d'unites,* International System of Units
SI/EO	side in/end out
sil.	silencer
SMTP	simple mail transfer protocol
SN	serial number
SNMP	simple network management protocol
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec	specification
specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SMS	short message service
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TB	terminal block
TCP	transmission control protocol
TD	time delay
TDC	top dead center
TDEC	time delay engine cooldown
TDEN	time delay emergency to normal
TDES	time delay engine start
TDNE	time delay normal to emergency
TDOE	time delay off to emergency
TDON	time delay off to normal
temp.	temperature
term.	terminal
THD	total harmonic distortion
TIF	telephone influence factor
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
UF	underfrequency
UHF	ultrahigh frequency
UIF	user interface
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
URL	uniform resource locator (web address)
US	undersize, underspeed
UV	ultraviolet, undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
WO	write only
w/o	without
wt.	weight
xfmr	transformer

Notes

Notes

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