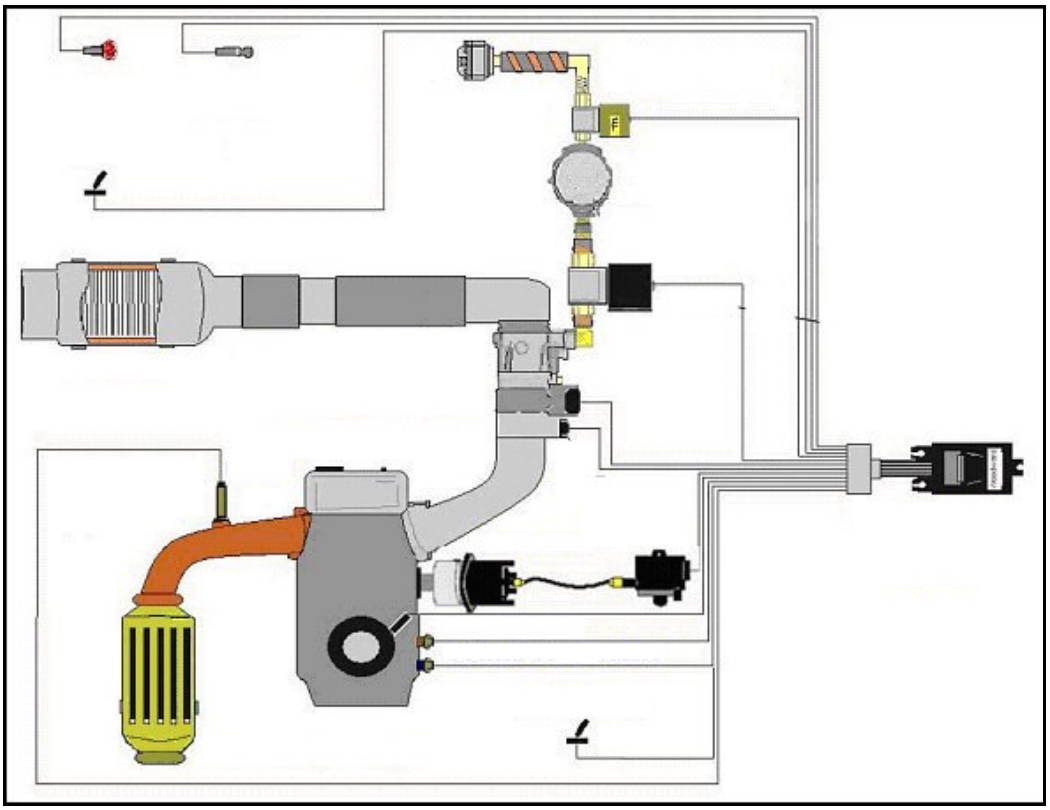
WOODWARD

User Manual



PG-04 Integrated Control System

Governing, Air-Fuel Ratio, and Ignition Control System for Power Generation & Stationary Industrial Engine Applications

Manual 36571

WARNING

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage.

The engine, turbine, or other type of prime mover should be equipped with an over speed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The over speed shutdown device must be totally independent of the prime mover control system. An over-temperature or over-pressure shutdown device may also be needed for safety, as appropriate.

CAUTION

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

In systems where large inductive loads are switched on the DC power buss, surge impulse energy will be present due to the switching. To address surge energy affects on the control, appropriate suppression devices must be installed in the DC power buss prior to the control's power connection.

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts.

- **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).**
- **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.**
- **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.**

IMPORTANT DEFINITIONS

WARNING—indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injury.

CAUTION—indicates a potentially hazardous situation, which, if not avoided, could result in damage to equipment.

NOTE—provides other helpful information that does not fall under the warning or caution categories.

Revisions—a black line alongside the text indicates Text changes.

Contents

Electrostatic Discharge Awareness

All electronic equipment is static-sensitive, some components more than others. To protect these components from static damage, you must take special precautions to minimize or eliminate electrostatic discharges.

Follow these precautions when working with or near the control.

1. Before doing maintenance on the electronic control, discharge the static electricity on your body to ground by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.).

2. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.

3. Keep plastic, vinyl, and Styrofoam materials (such as plastic or Styrofoam cups, cup holders, cigarette packages, cellophane wrappers, vinyl books or folders, plastic bottles, and plastic ash trays) away from the control, the modules, and the work area as much as possible.

4. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:

   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

CAUTION

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Working With LPG Equipment

WARNING

Propane vapor is heavier than air and can collect in low areas when adequate ventilation or air movement is not present to disperse it. Never check for leaks with a flame or match. Use a leak detector solution or an electronic detector. Make sure the container service valve is closed when connecting or disconnecting. If the container service valve does not operate properly, discontinue use and contact your propane supplier. Never insert any object into the pressure relief valve.

WARNING

- **LP gas is highly flammable. To prevent personal injury, keep fire and flammable materials away from the equipment when work is done on the fuel system.**
- **Gas vapor may reduce oxygen available for breathing, cause headache, nausea, dizziness and unconsciousness and lead to injury or death. Always operate equipment in a well-ventilated area.**
- **Liquid propane may cause freezing of tissue or frostbite. Avoid direct contact with skin or tissue; always wear appropriate safety protection including gloves and safety glasses when working with liquid propane.**

CAUTION

Only trained certified technicians should perform disassembly, service or replacement of the regulator/converter or mixer.

CAUTION

LPG fueled machinery may be garaged anywhere gasoline powered vehicles are garaged. When machines are stored for a long period, it is advisable to shut off the tank supply valve and run the machine until the fuel trapped down stream of the valve is depleted.

NOTE

NFPA (National Fire Protection Agency) 58 covers the procedures for storage and garaging for repair purposes, on propane powered equipment.

CAUTION

Safety is an important consideration for any repair facility, and repairing LPG fueled machinery is no exception. Refer to the NFPA (National Fire Protection Agency) for the appropriate fire extinguisher specifications and fluorescent lighting requirements.

Propane has a heavier than air vapor density and will fall if a leak occurs, while natural gas, by comparison, will rise in the event of a leak. This is an important property that technicians need to be aware of when performing maintenance. When repairing propane machinery, the work should be performed in the lowest point of the facility where possible. The tank supply should be shut off, except when required for running equipment.

Chapter 1.
General Information

Woodward's PG-04 control system delivers precise and fully integrated control of fixed-speed, stationary industrial engines such as those found in generator sets, pumps, and other stationary industrial equipment. The PG-04 control system is applicable to spark-ignited engines in a size range from 1.0L to 6.0L with a maximum of six cylinders running on LPG vapor or natural gas.

The PG-04 control system provides electronic control of fuel delivery, spark ignition and air throttling on stationary industrial engine operating on LPG vapor or natural gas.

Features

- Closed-loop control of air-fuel ratio improves equipment durability by reducing maintenance, fuel consumption, and engine component wear.
- Control strategy ensures optimal transient performance for efficient system response.
- Comparisons of actual engine operation to expected values allows the system to compensate for wear, tolerances and adverse operating environments. This improvement in operating economics is a result of the sophisticated software models in the PG-04 control system.
- Programmable fixed speeds can be easily modified via software tool in order to satisfy the specific application speed requirements.
- Monitoring and diagnostic communication via an optional CAN/J1939 allows immediate assessments and corrections either on-site or remotely.
- Individual diagnostic codes detect functional faults, intermittent faults, sensor and actuator failures, and engine protection problems.
- Extensive engine protection features include monitoring of engine coolant temperature, oil pressure, and over speed.
- Fault conditions can be calibrated to trigger a limited operating mode for diagnostics and troubleshooting.
- Auto-Start feature allows reliable engine starting.
- Optional malfunction indicator light for operator alerting

System Overview

The PG-04 control system consists of proven, reliable components that monitor and regulate functions of the following engine subsystems.

Fuel Delivery: LPG and Natural Gas

Spark-Ignition: Distributor (2 to 6 cylinders)
Waste spark (1 to 6 cylinders)

Air Throttling: Electronic throttle (Control by Wire)

LPG & Natural Gas Engines

Components

- Electronic control module
- Electric shut-off solenoid valve with filter
- Fuel pressure regulator
  (N-LPR or Maxitrol for Natural Gas and LPG vapor Systems, or
  Two-Stage pressure regulator/vaporizers for LPG liquid systems)
- L-Series fuel trim valve
- Fixed venturi mixer assembly or air valve mixers
- Electronic throttle assembly or L-Series ITB
- Oxygen sensor
- Temperature and manifold pressure sensors
- Smart Ignition coils

An in-line Woodward L-Series controller serves as a fuel trim valve and controls fuel delivery based on a PWM signal from the SECM. The position of the trim valve biases the fuel delivery pressure at the venturi mixer inlet. The feedback from the oxygen sensor determines if the fuel delivery needs to be increased or decreased. The SECM contains the engine-specific calibration, which provides and maintains optimum performance and response throughout the life of the engine.

Chapter 2.
Operational Overview

PG-04 Functional Diagram

The diagram below shows the PG-04 components that are integrated into an LPG vapor or natural gas engine system. Note that PG-04 can also accept inputs from existing engine sensors (such as coolant and oil pressure) and incorporate that data into the engine control and diagnostic strategies.

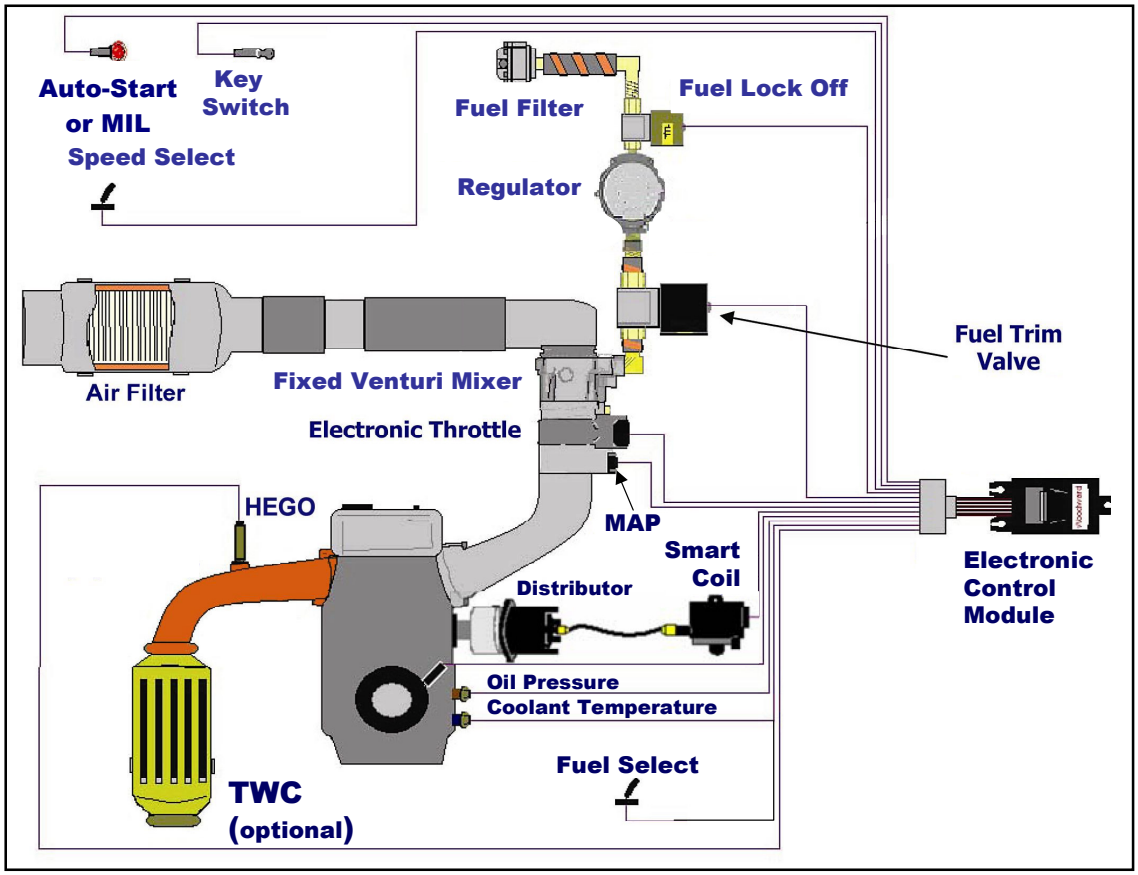


Figure 1. PG-04 Engine Control System

The PG-04 control system main components are:

1. SECM-24: Engine Controller Module
2. L-Series Trim Valve
3. Electronic Throttle
4. Fixed Venturi Mixer
5. Smart Ignition Coils
6. Heated Exhaust Gas Oxygen Sensor
7. Manifold Absolute Pressure and Temperature Sensor
8. Coolant Temperature Sensor
9. Oil Pressure Switch (customer supplied)
10. Fuel Lock-off Solenoid (customer supplied)
11. Speed Sensor (customer-supplied)
12. Catalytic Converter (customer-supplied)

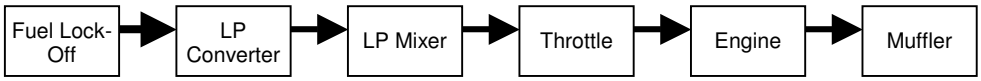
Open vs. Closed Loop Fuel Systems

PG-04 is a closed-loop system utilizing a catalytic muffler to reduce the emission level in the exhaust gas. In order to obtain maximum effect from the catalyst, an accurate control of the air-fuel ratio is required. A small engine control module (SECM) uses a heated exhaust gas oxygen sensor (HEGO) in the exhaust system to monitor exhaust gas content.

Conversely, an open-loop system does not receive the feedback from the sensors. Without the feedback information, the system cannot adjust/compensate its operation in order to maintain the desired performance.

The following two schematics show the difference between open-loop and closed-loop control systems.

Open Loop Fuel System



Closed Loop Fuel System

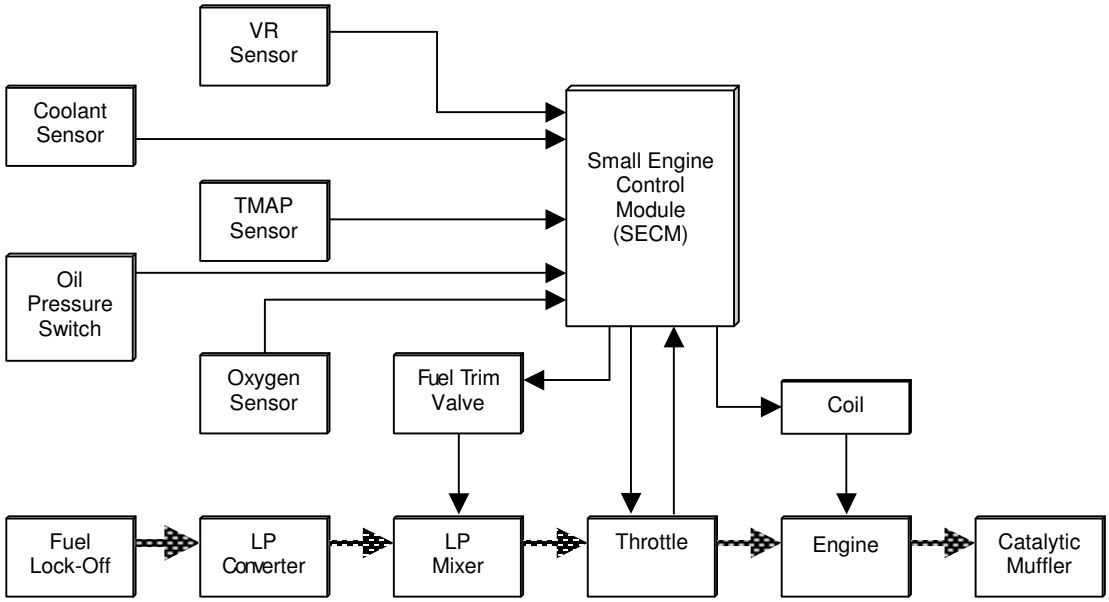


Figure 2. Comparison of Open-Loop and Closed-Loop Control

PG-04 Key Components

Electric Fuel Lock-off Solenoid:
(Customer-Supplied Component)

The function of the fuel lock-off solenoid is to stop the flow of fuel into the engine. These solenoids are normally closed. When the SECM powers up, it sends a signal to the solenoid to open; thus, allowing flow of fuel into the engine. The fuel lock-off returns to its normally closed position if there is a loss in power from the SECM. The PG-04 control system is designed to operate with a vapor fuel lock-off, which can operate on natural gas or LPG vapor.

The picture below **(Figure 3)** shows a typical vapor fuel shut-off solenoid that can be used in the PG-04 control system.

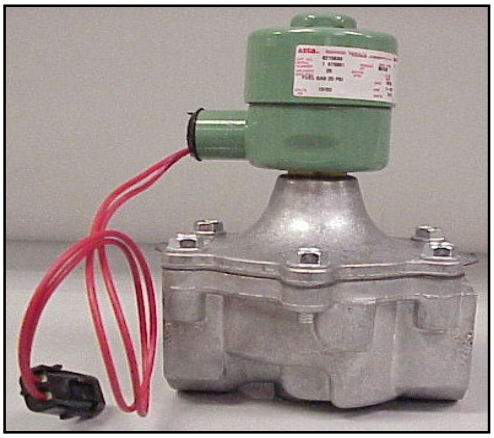


Figure 3. Vapor Lock-off Solenoid

N-LPR Pressure Regulator

Designed for sensitivity and simple operation, the N-LPR regulator **(Figure 4)** is used with low-pressure gaseous fuels where dependable starting is required. Because of its extreme sensitivity, it provides superior performance in most remote starting applications such as stand-by power generators. (Up to 25 KW)

For larger engines operating in either natural gas or LPG vapor, a pressure-reducing valve (RV61—Maxitrol) could be used to replace the N-LPR pressure regulator.

When the PG-04 control system is applied to engines fueled by LPG liquid, a pressure regulator/vaporizer must be selected and applied for proper operation. Contact Woodward for assistance in selecting these components.

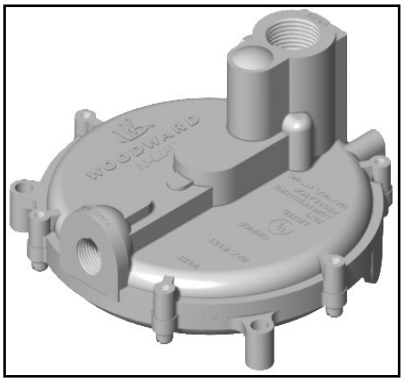


Figure 4. N-LPR Regulator

L-Series Air-fuel Ratio Trim Valve

The L-Series trim valve is a microprocessor-based PWM positioned control valve. The SECM sends a PWM signal to the L-Series controller to provide precise N-LPR regulator outlet pressure. This precise closed-loop control of the output regulator pressure allows the fixed-speed, four-stroke, gaseous-fueled engine to operate at a near-stoichiometric air-fuel ratio. The advantages of running a generator set at near-stoichiometric air-fuel ratio are improved fuel efficiency and reduced wear of engine components.

The L-Series trim valve software is not a customer-serviceable item. However, customers can monitor trim valve performance and diagnose and troubleshoot the valve via the Mototune software service tool.

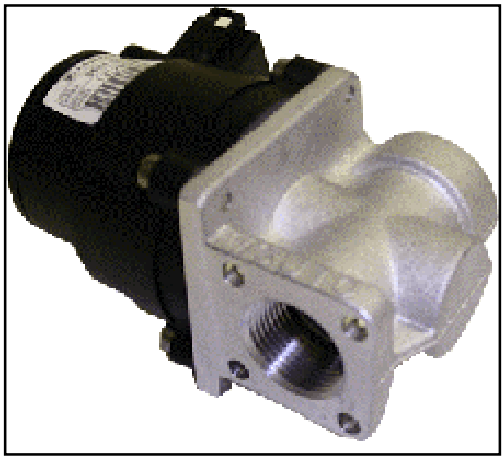


Figure 5. L-Series AFR Trim Valve

Venturi Mixer

The PG-04 control system utilizes a fixed venturi mixer to accomplish complete fuel and air mixing prior to the electronic throttle. The fixed venturi mixers are the preferred mixers for stationary applications. However, air valve mixers could provide uniform, reliable mixing as well. Fuel from the pressure regulator is delivered at the required pressures to the venturi mixer due to the L-Series trim valve. Fuel in the appropriate pre-determined amounts then mixes with the inlet air prior to entering the throttle body assembly.

It should be noted that the venturi mixer for the PG-04 control system is part of the throttle body-venturi mixer-trim valve assembly called a *throttle sub-assembly* and will be shipped already assembled as one unit (see **Figure 6**). There is a repair kit available for the L-Series trim valve (see Parts Catalog section of this manual).

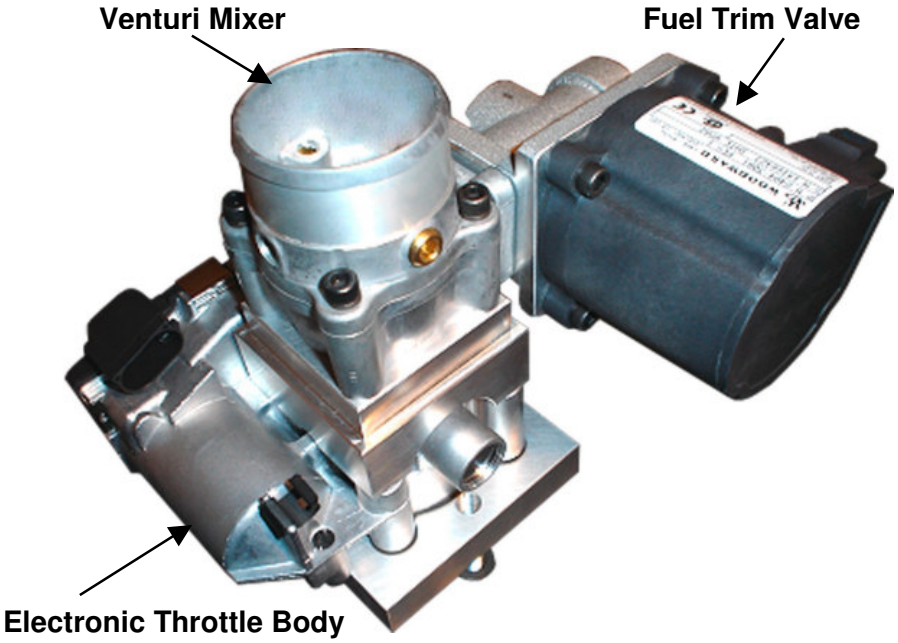


Figure 6. Throttle Sub-assembly

Electronic Throttle

Conventional throttle systems rely on a mechanical linkage to control the throttle valve. To meet fluctuating engine demands, a conventional system will typically include throttle valve actuators designed to readjust the throttle valve opening in response to engine demand, together with idle control actuators or idle air bypass valves.

In contrast, the PG-04 system uses electronic throttle control (ETC). The SECM controls the throttle valve based on engine rpm, engine load, and information received from the speed sensor.

The electronic throttle used in the PG-04 system is a Bosch DV-E5 32 mm electronic throttle body (**Figure 7**). The DV-E5 is a single unit assembly, which includes the throttle valve, throttle-valve actuator (DC motor) and the throttle position sensor (TPS). The SECM calculates the correct throttle valve opening that corresponds to the equipment power demand, makes any adjustments needed for adaptation to the engine's current operating conditions and then generates a corresponding electrical (driver) signal to the throttle-valve actuator.

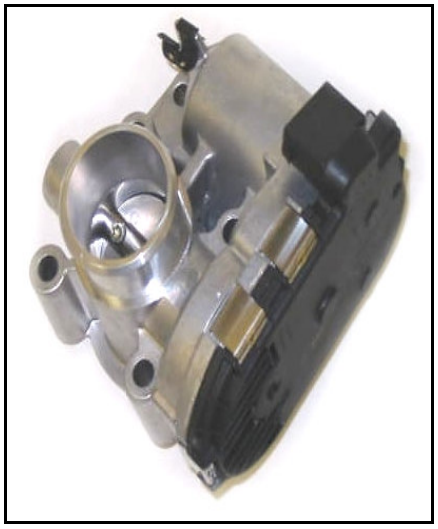


Figure 7. Electronic Throttle

NOTE
The DV-E5 throttle is NOT a serviceable assembly. If the TPS sensor fails, the entire assembly should be replaced.

Heated Exhaust Gas Oxygen Sensor (HEGO)

The HEGO sensor (**Figure 8**) is installed in the exhaust manifold before the catalytic muffler. This sensor detects the amount of oxygen in the exhaust stream. Once the HEGO reaches approximately 600° F (316° C), it becomes electrically conductive. The concentration of oxygen in the exhaust stream determines the voltage produced. If the engine is running rich, little oxygen will be present in the exhaust and voltage output will be relatively high. Conversely, in a lean situation, more oxygen will be present and a smaller electrical potential will be noticed.

Figure 8. HEGO Sensor

In order for the sensor to conduct and create an electrical signal below 600° F (316° C) a heated element is added to the sensor housing. Two wires provide the necessary 12 VDC and ground signal for the heater element. A fourth wire provides an independent ground for the sensor.

The HEGO stoichiometric air-fuel ratio voltage target is approximately 500 mV and changes slightly as a function of speed and load. When the HEGO sensor sends a voltage signal less than 500 mV the SECM interprets the air-fuel mixture to be lean. The SECM then decreases the PWM duty cycle sent to the L-Series trim valve in order to increase the fuel pressure to the venturi mixer inlet; thus richening air-fuel mixture. The opposite is true if the SECM receives a voltage signal above 500 mV from the HEGO. The air-fuel mixture would then be interpreted as being too rich and the SECM would increase the duty cycle of the trim valve.

CAUTION
The HEGO sensor used is calibrated to work with the PG-04 control system. Using alternate sensors may impact performance and the ability of the system to diagnose rich and lean conditions.

Ignition Coil

The Woodward “smart” ignition coils (**Figure 9**) are inductive type coils. The SECM controls the smart coil with a 5 VDC TTL signal. The smart coil contains the current driver necessary to energize the primary spark coil. The SECM controls dwell time and spark discharge time. The coil supply voltage can range from 8 VDC to 16 VDC. Maximum coil dwell time is two milliseconds.

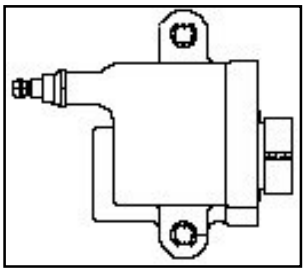


Figure 9. “Smart” Ignition Coil

SECM (General Description)

The Woodward Small Engine Control Module (SECM) controller has full authority over spark, fuel and air. Utilizing Motorola's HCS12 micro controller, the SECM has 24 pins of I/O and is fully waterproof and shock hardened (**Figure 10**). In order to optimize engine performance, the SECM uses several sensors for closed-loop feedback information. These sensors are used by the SECM for closed-loop control in three main categories:

- Fuel Management
- Load/Speed Management
- Ignition Management

The SECM monitors system parameters and stores any out-of-range conditions or malfunctions as faults in SECM memory. Engine run hours are also stored in memory. Stored fault codes can be displayed as flash codes on the customer-supplied Malfunction Indicator Light (MIL) or read by the PG-04 Service Tool.

Figure 10. SECM-24 Engine Controller

Battery power (12 VDC) is supplied through the fuse block to the main power relay. The ignition key switch is used to energize the main power relay. A main power relay supplies 12 VDC power to the SECM, the heated element of the oxygen sensor, fuel lock-off, L-Series fuel trim valve and the smart coils.

The SECM supplies 12 VDC and ground to the electronic throttle actuator. Also, the SECM supplies 5 VDC to oil pressure switch, manifold temperature sensor and the coolant temperature sensor via pull-up resistors. Last, the SECM supplies 5 VDC reference voltage to the throttle position sensor in the electronic throttle body and to the manifold pressure sensor.

SECM (Fuel Management)

During engine cranking at startup, the SECM provides a signal to open the fuel lock-off, which allows fuel (vapor propane or natural gas) to flow to the regulator. A stall safety shut-off feature is built into the SECM to close the lock-off in case of a stall condition. The SECM monitors three engine states:

Crank, when the speed sensor detects any engine revolutions;

Stall, when the key is in the ON position but the speed sensor detects no engine revolutions;

Run state, when the engine reaches pre-idle RPM.

When an operator turns on the key switch, the lock-off is opened, but if the operator fails to crank the engine, the SECM will close the lock-off after 5 seconds.

In order to maintain proper performance, the SECM uses a heated exhaust gas oxygen sensor (HEGO) mounted before the catalyst to measure exhaust gas content. Engine speed is monitored by the SECM through a variable reluctance (VR) sensor with a flywheel-mounted encoder. Intake manifold air temperature and absolute pressure are monitored with a TMAP sensor. The HEGO voltage is converted to an air-fuel ratio value and is compared to a target value in the SECM.

The target value is based on optimizing performance for a given load and speed. The SECM then calculates any corrections that need to be made to the air-fuel ratio.

The system operates in open-loop fuel control until the engine has done a certain amount of work. This ensures that the engine and HEGO are sufficiently warmed up to stay in control. In open-loop control, the L-Series trim valve duty cycle is based on engine speed and load. Once the HEGO reaches operating temperature, the fuel management is in closed-loop control for all steady-state conditions for the pre-programmed speeds. In closed-loop mode, the L-Series trim valve duty cycle is based on feedback from the HEGO sensor. The SECM then makes any necessary corrections to the air-fuel ratio by controlling the inlet fuel pressure to the air-fuel mixer. Reducing the fuel pressure leans the air-fuel mixture and increasing the fuel pressure enriches the air-fuel mixture. Control is achieved by modulating the L-Series fuel trim valve.

SECM (Speed Management)

The PG-04 control system performs speed governing through the SECM and electronic throttle. The desired fixed speed values for the generator set or fixed-speed pump must be pre-programmed. Some applications such as stand-by generators require that the speed be constant from start-up to full-load operation. The SECM controls the engine's constant speed by receiving and processing information from a speed sensor such as magnetic pickup (see Speed Sensing section below) and utilizes additional information from the HEGO, TMAP sensor (**Figure 11**), coolant temperature sensor, and throttle position sensor (located in the electronic throttle body).

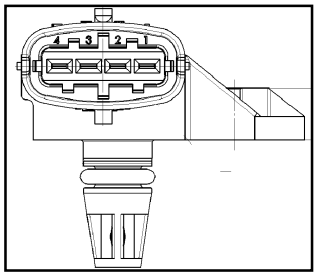


Figure 11. TMAP Sensor

The transient performance is controlled through the PID parameters in the SECM software. The software also contains safety features such as over-speed protection and shutdowns and alarms, which become active as a result of repeated faults.

Speed Sensing
(Customer-Supplied Component)

The PG-04 control system requires a specific encoder pattern and a specific location for the speed sensor. The recommended encoder must be flywheel mounted and must have a 30-5 pattern.

NOTE: Using any other encoder pattern will result in inaccurate SECM operation.

The recommended speed sensor for the PG-04 system is a magnetic pick-up. For optimal resolution, the magnetic pick-up should be installed on the flywheel housing and must be installed 90° CCW from the bore centerline. (Left bank side when viewing the flywheel.) The 30-5 encoder must be aligned correctly with respect to engine TDC position as well.

SECM (Ignition Management)

The PG-04 control system provides accurate control of spark timing and spark energy for efficient combustion. The system consists of the SECM, smart coils, crank position sensor (customer provided), secondary lead wires to the spark plugs (customer provided), and timing wheel/encoder (customer provided).

The SECM, through use of embedded control algorithms and calibration variables, determines the proper time to start energizing the coil and fire the spark plugs. This requires accurate crankshaft position information, an engine speed calculation, coil dwell information, and target spark timing.

The SECM controls the smart coil with a 5-volt TTL signal. The smart coil contains the current driver necessary to energize the primary spark coil. The SECM controls dwell time and spark discharge time. The system also performs diagnostics on the spark channel outputs.

In addition, the PG-04's SECM can interface with customer-supplied ignition modules in order to drive customer-provided ignition systems. For instance, if required, the PG-04 system can provide spark management via the smart coils and a distributor.

Auto-Start Feature

The PG-04 control system is capable of automatic starting based on inputs from external or local contact switches. The system receives the run command and verifies that all the engine parameters are within appropriate ranges to proceed with the start-up sequence. The auto-start sequence triggers an auxiliary relay that will engage the starter and initiate fuel flow. The system then monitors for successful starts. If the engine does not achieve the pre-programmed start-up speed within 30 seconds, then the system will declare a shutdown. The system is programmed to provide three consecutive start attempts prior to logging a start failure fault.

Malfunction Indicator Light (MIL) (Optional Feature)

The PG-04 control system is capable of driving a malfunction indicator light (MIL) instead of the Auto-Start feature. However, the PG-04 system cannot drive both the auto-start and the MIL due to the limited number of SECM outputs. The MIL can be programmed to flash different programmable fault codes.

Please contact Woodward for application engineering assistance with the MIL.

Speed Select Feature

The PG-04 control system is capable of running at a maximum of four pre-determined speed points. These speed values are programmed in the SECM software prior to shipment to the customer. In order to make the switching of speeds easier, PG-04 has a speed select switch input. This input enables the operator to select two speeds for the engine to run. For instance, the speed select switch input can be configured to provide two speed set points: 1800 rpm for 60 Hz applications and 1500 rpm for 50 Hz applications.

It should be noted that the speed switch could be changed while the engine is running. The SECM will not generate a shutdown when the engine speed is changed; however, operators should exercise caution when making this change.

Fuel Select Feature

The PG-04 control system is configured to run on LPG vapor or natural gas. The system can be modified to work on gasoline-fueled engines. The two types of fuel typically used on an industrial, fixed-speed application are natural gas and LPG vapor. In some cold weather generator applications, the fuel utilized for starting the engine is LPG (stored in vapor or liquid phase), and once the engine is warmed up, the generator set's main operating fuel is natural gas.

Unlike the speed select switch input, the fuel select switch must be positioned to the selected fuel prior to starting the engine. Should the operator select a different fuel type while the engine is running, an engine shutdown would occur.

Restrictor/Orifice

If the operating fuel is LPG, a restrictor/orifice (**Figure 12**) must be installed on the outlet of the N-LPR pressure regulator. This restrictor/orifice is not needed if the equipment will operate on natural gas.

This orifice is included on all of the PG-04 control system kits and should not be installed unless the system is running on LPG.

Each PG-04 control system configuration has a separate restrictor/orifice. (See the Parts Catalog section of this manual – Chapter 9)

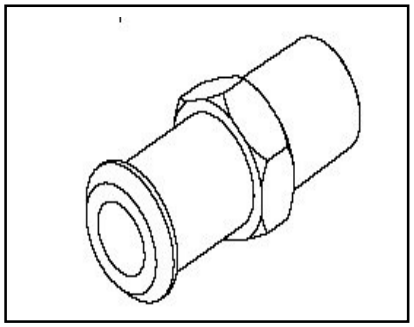


Figure 12. Restrictor/Orifice

The propane restrictor should be screwed into the outlet of the low-pressure regulator after the regulator to mixer hose is temporarily removed. Then, the regulator to mixer hose should be connected.

Coolant Temperature Sensor

The coolant temperature sensor included in the PG-04 control system is a fully validated component for industrial applications. The coolant sensor has a 3/8"-NPT thread and should be mounted to sense/measure the hot coolant temperature prior to the radiator. The SECM utilizes the coolant temperature sensor input to adjust spark timing and duration as well as to switch between open-loop and closed-loop operation.

Oil Pressure Switch
(Customer-Supplied Component)

The oil pressure switch is used as an engine protection device on the PG-04 control system. The oil pressure switch is open during normal operating conditions and it closes when there is a loss of pressure condition; thus, the switch triggers a protection fault from the SECM.

Catalytic Muffler
(Customer-Supplied Component)

All exhaust gases pass through a catalytic converter that is mounted on the exhaust pipe. It filters these gases through a dense honeycomb structure coated with precious metals such as platinum, palladium, and rhodium. Chemical reactions occur on these surfaces to convert the pollutants into less harmful gases. Catalytic converters store oxygen on lean mixtures (less than optimal amount of fuel) and release oxygen on rich mixtures (more than optimal amount of fuel). The primary pollutant produced on the lean swing is nitrous oxide. Oxygen is removed from nitrous oxide by the converter, resulting in nitrogen gas, a harmless emission. On the rich cycle, the primary pollutant is carbon monoxide. By adding the oxygen that was stored on the lean cycle to the carbon monoxide, carbon dioxide is produced.

Inside the catalytic muffler is a three-way catalyst as well as sound dampening and spark arresting components. The three-way catalyst section consists of a honeycomb coated with a mixture of platinum, palladium and rhodium. As engine exhaust gases flow through the converter passageways they contact the coated surface, which initiates the catalytic process. The **reduction catalyst** is the first stage of the catalytic converter. It uses platinum and rhodium to help reduce the NOx emissions. The **oxidation catalyst** is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. Cerium is also used to promote oxygen storage and improve oxidation efficiency.

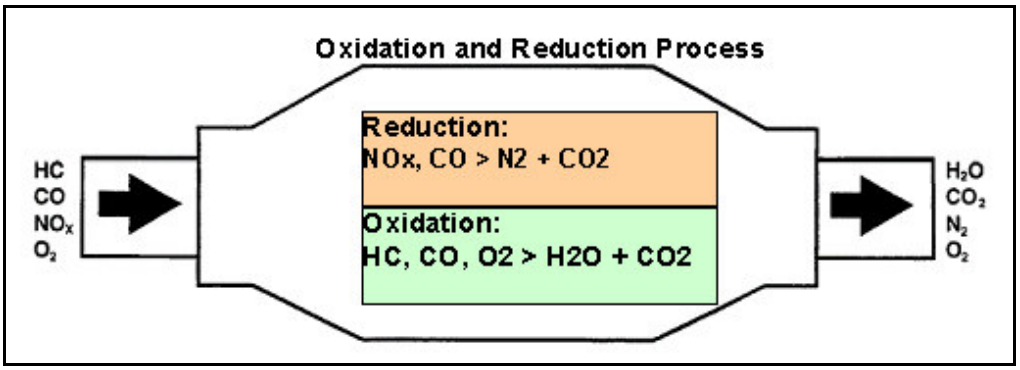


Figure 13. Three-Way Catalytic Converter

As exhaust and catalyst temperatures rise, the following reaction occurs:

- Oxides of nitrogen (NOx) are reduced into simple nitrogen (N2) and carbon dioxide (CO2).
- Hydrocarbons (HC) and carbon monoxide (CO) are oxidized to create water (H2O) and carbon dioxide (CO2).

The PG-04 control system monitors the exhaust stream and uses this information to control the air-fuel mixture. By using the signal from the HEGO, the SECM can increase or decrease the amount of oxygen in the exhaust by modulating the L-Series trim valve output and adjusting the air-fuel ratio. This control scheme allows the SECM to make sure that the engine is running at the stoichiometric point, and also to make sure that there is enough oxygen in the exhaust to allow the oxidization catalyst to eliminate any unburned hydrocarbons and CO.

NOTE: The catalytic muffler is a customer-supplied component.

Chapter 3.
Installation Guide

This section covers the installation recommendations for the major components of the PG-04 control system. These instructions are guidelines for the installation of these components.

The main items covered are:

1. **SECM** engine controller unit
2. **N-LPR** pressure regulator
3. **Smart Coils** ignition coils
4. **Trim Valve Sub-Assembly**
   (Electronic throttle, L-Series trim valve and venturi mixer)
5. **Oxygen Sensor**

In addition to component installation, this section contains general guidelines for the installation of connectors, fittings and hoses. It also covers torque standards for bolts, screws and other fittings.

It should be mentioned that hoses, fittings and connectors are customer-supplied items.

SECM Installation Instructions

The engine controller (SECM), main power relay and auto-start relay should be mounted on the engine. Typically, a single mounting bracket or plate is used to accommodate both the SECM and relays. The SECM must be bolted on the mounting plate with rubber shock mounts in order to withstand engine vibration. The vibration absorption hardware includes fasteners, washers, aluminum guides and rubber grommets. Since the mounting plate is a customer-supplied item, it is left to the customer's discretion to select a mounting location for the relays.

Note: The mounting plate is a customer-supplied component.

To Mount the SECM:

1. Insert the grommet into the SECM flange.
2. Insert the aluminum mounting guide into the grommet.
3. Place a flat washer on top of the grommet; then insert the bolt and tighten to the mounting plate using the specified torque values, which are located at the end of this chapter in Tables 3 and Table 4.

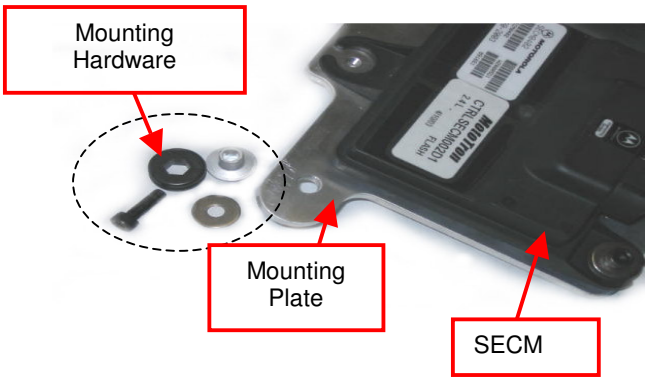


Figure 14. SECM and Mounting Hardware

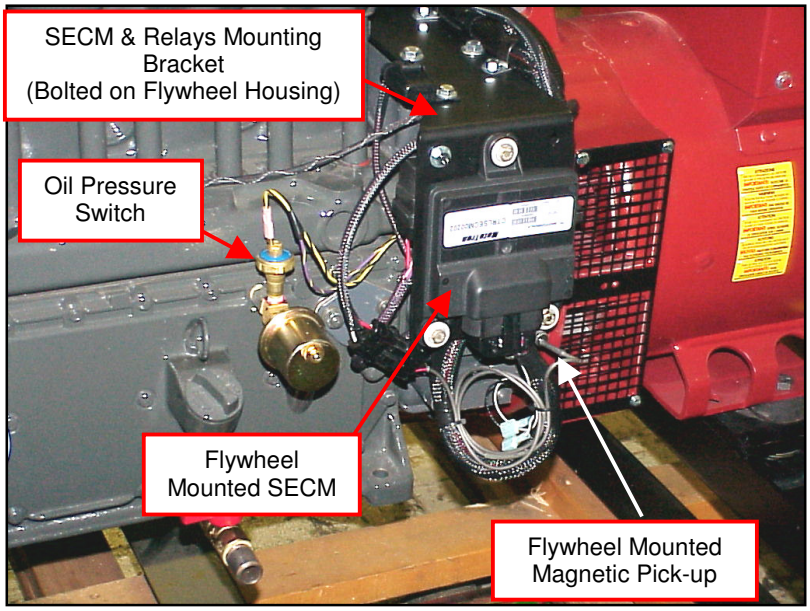


Figure 15. Recommended SECM Mounting Location and Orientation

NOTE
It is recommended that the SECM be mounted so that the electrical connection is not facing upward in order to reduce the chances of fluid penetration.

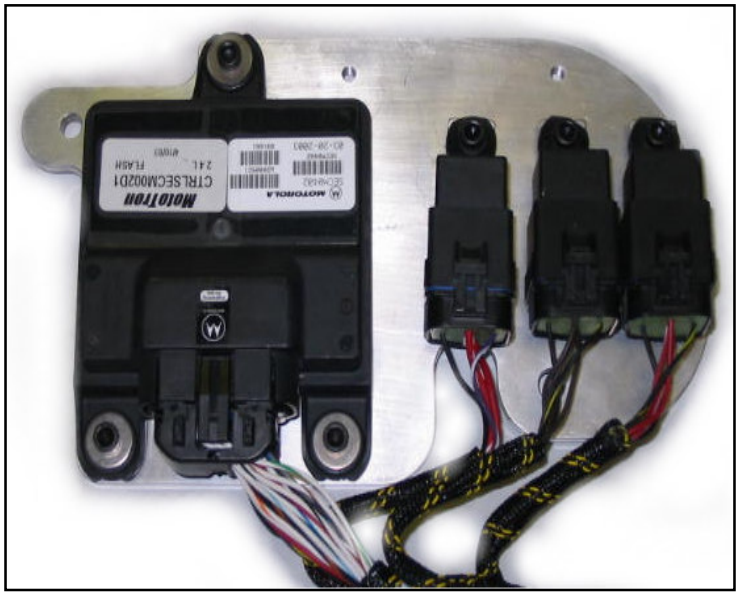


Figure 16. SECM and Relays on a Customer-Designed Mounting Plate

N-LPR Pressure Regulator Installation

The N-LPR should be mounted as close to the trim valve sub-assembly as possible with the outlet on top (the arrow on the cover pointing up) and the diaphragm in a vertical orientation. This helps to minimize the effects of gravity on diaphragm travel. The unit should also be placed for easy access to the primer if provided.

There are two sets of mounting holes provided. Either set of mounts will adequately support the N-LPR. The bottom set of holes has a 1-3/4"(44.5 mm) bolt spacing. The mounting bosses on cover are spaced 5-3/4" (146.1 mm) apart for use with 5/16" (7.9 mm) bolts.

Before installing the fuel supply line, be sure that the gas pressure is no more than the maximum inlet pressure shown on the front of the N-LPR. If the pressure is greater, leakage could result in a fire hazard and/or hard starting. The piping to the inlet should be of sufficient size to allow full fuel flow to the N-LPR. This is very important in natural gas installations, as any restrictions can affect engine performance.

If a solenoid is used ahead of the N-LPR in the low-pressure line, it should have an orifice at least 7/16" (11.1 mm) in diameter. Flexible piping to the inlet should be used to prevent cracking from vibration if the N-LPR is mounted on the engine or other vibrating surface.

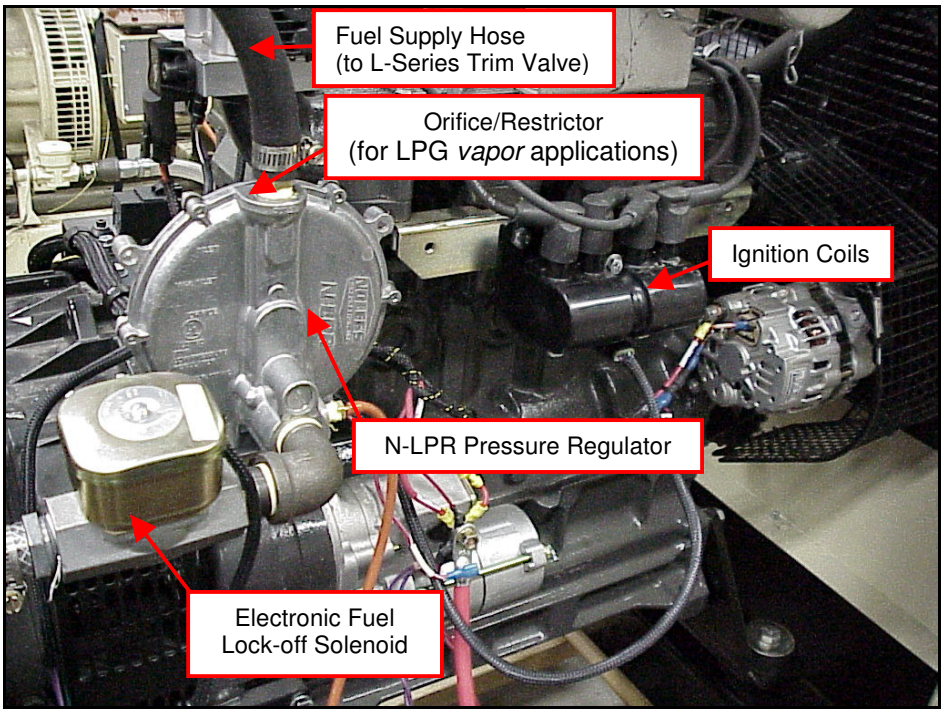


Figure 17. Correctly Oriented N-LPR Installed on an Engine

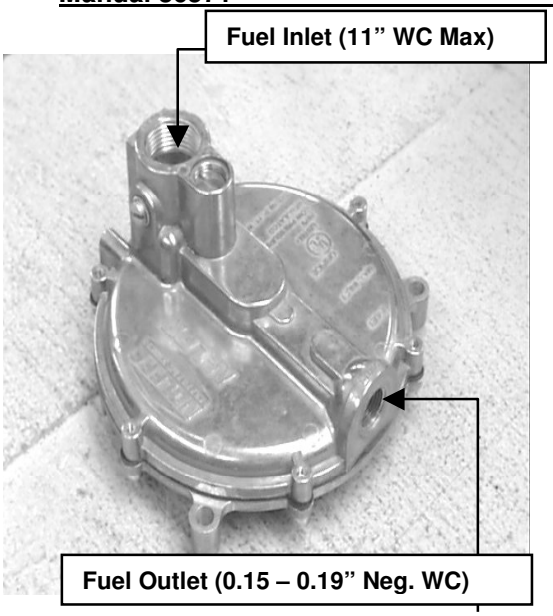


Figure 18. Fuel I/O Ports

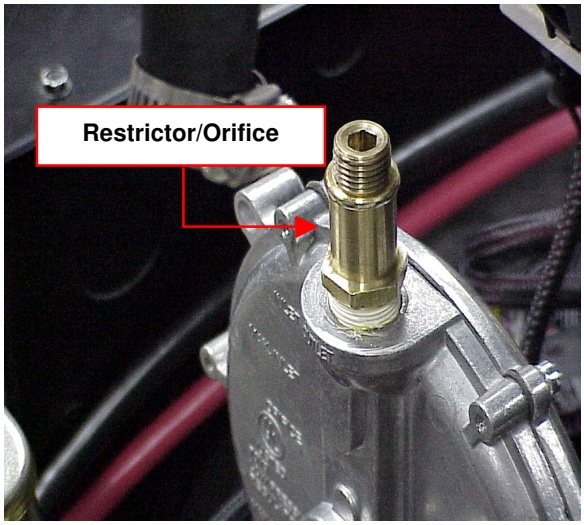


Figure 19. Restrictor Orifice Connected on the Pressure Regulator Outlet

REGULATOR SPECIFICATIONS

A. Overall Width……6-1/4” (158.8 mm)

B. Overall Depth…… 3 5/8” (92.1 mm)

C. Overall Height……..6-1/2” (165.1 mm)

D, E Mounting Holes
Center to Center…….5-3/4” 1 3/4” (146.1mm; 44.5 mm)

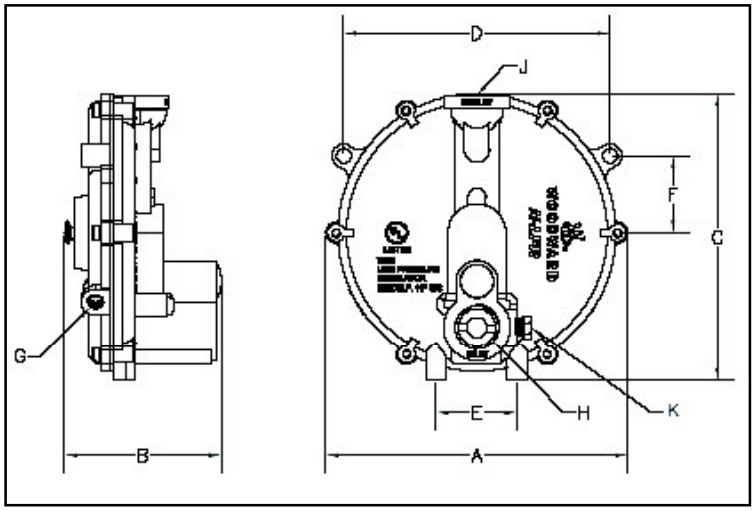
F. Mounting Holes
Distance from Center…..1-21/32" (42.1 mm)

G. Air Vent ……1/8" NPT (3.2 mm)

H. Vapor Fuel Inlet ……3/4" NPT (19.1 mm)

J. Vapor Fuel Outlet …….3/8" NPT (9.5 mm)

K. Test Port ……1/8" NPT (3.2 mm)



Smart Coil Installation

The smart coils are installed on a customer-supplied mounting bracket. **Figure 20** shows the recommended installation and orientation for the coils.

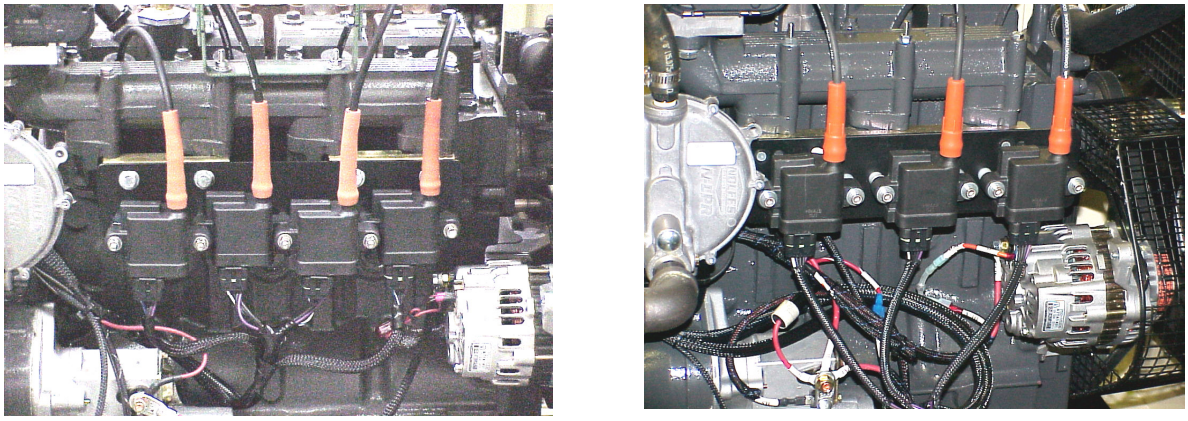


Figure 20. Ignition Coils Mounted on 4-Cylinder and 3-Cylinder Engines (Mounting plate is customer-supplied.)

The ignition coil (Smart Coil) used with the PG-04 control system is normally mounted on the engine block. The coil can either be bolted directly to the engine block under the intake manifold or on the rear of the SECM mounting plate that is bolted to the engine block.

1. Connect the high-tension cable from the coil to the center of the distributor rotor cap.
2. Connect the 5-pin ignition coil connector to the rear of the Smart Coil.

NOTE
Be sure that the ground terminal ring of this harness is securely mounted to a ground point on the engine block or the SECM mounting plate.

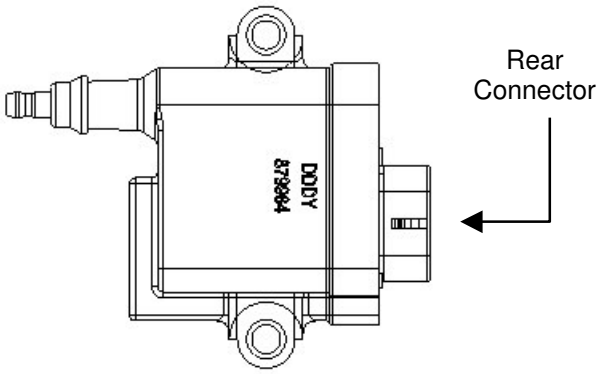


Figure 21. Rear Connector of Smart Coil

Sub-assembly Installation
(Electronic Throttle, L-Series Trim Valve, & Fixed Venturi Mixer)

Refer to **Figures 22-25**.

The entire sub-assembly of the L-Series trim valve, venturi mixer, and electronic throttle will be shipped to the customers as an assembly. Customers must then ensure that they design and build (or source) an adapter plate to the intake manifold. This adapter plate must be able to accommodate the electronic throttle bolt pattern as well as the TMAP sensor installation.

The fuel supply fitting must be installed to the L-Series trim valve prior to bolting the sub-assembly onto the intake manifold mounting plate. This fitting will also accommodate the fuel supply hose connecting the pressure regulator outlet to the trim valve inlet.

The engine crankcase breather hose must be connected from the rocker cover to one of the four available ports on the fixed venturi mixer assembly. The hose should not be kinked or twisted. This hose and its fittings are customer-supplied items.

The recommended installation orientation for all electrical connectors is downward. In this manner, the operators minimize the risk of water/moisture penetrating and damaging the electrical connections.

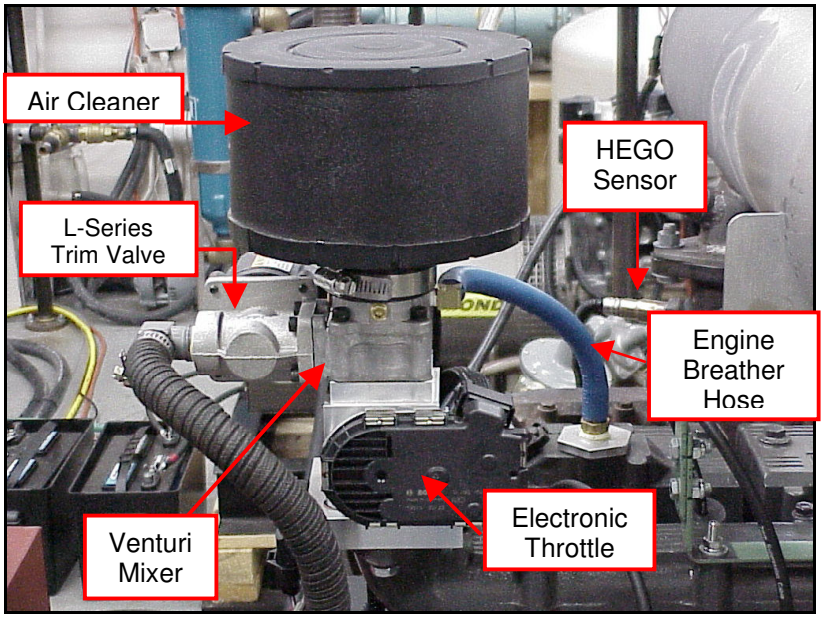


Figure 22. Sub-assembly Properly Installed on an Engine (Viewed from the Right Bank of the engine)

Sub-Assembly Installation (Cont'd.)

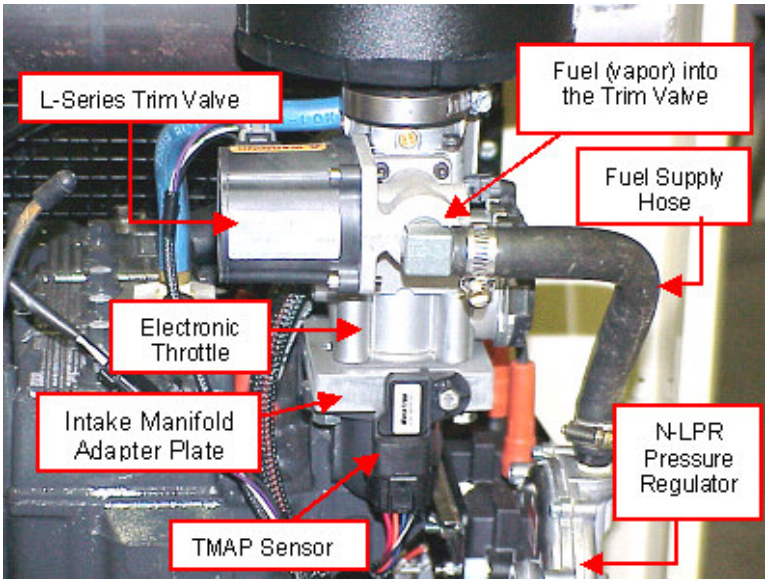


Figure 23. View Standing Facing Flywheel at Rear of Engine

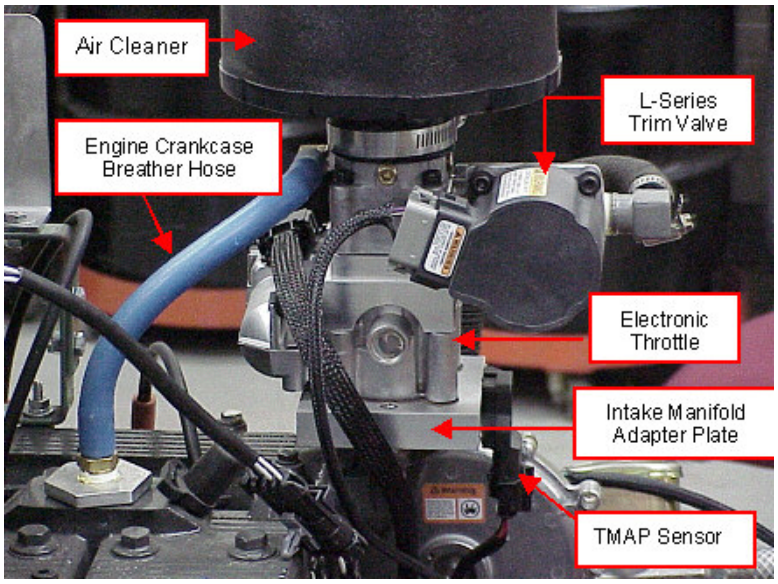


Figure 24. View Standing on Left Bank of Engine

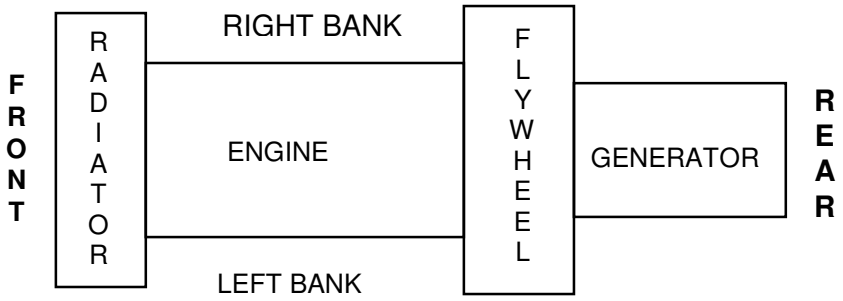


Figure 25. Top View of Generator Set

Oxygen Sensor Installation

The oxygen sensor must be installed in the exhaust stream. **Figure 26** shows the typical installation of the O_2 sensor. The oxygen sensor should be installed in a location where it receives a representative sample of the exhaust gases from all the cylinders.

Proper care should be taken to prevent the wires from coming in contact with the exhaust manifold.

1. Apply an adequate amount of anti-seize compound to the threads of the oxygen sensor and install the sensor in the O_2 sensor bung located on the exhaust manifold.
2. Tighten the sensor to 40 to 60 Newton-meters (30 –44 lbf-ft).

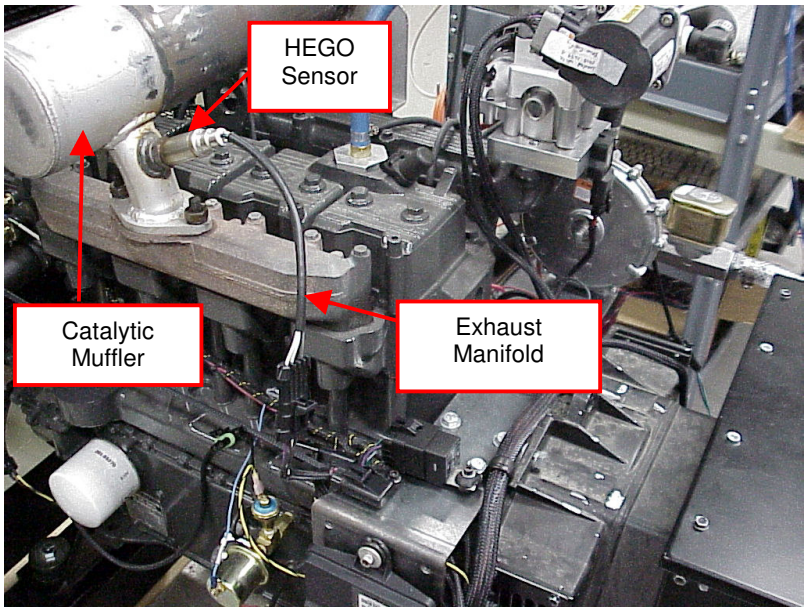


Figure 26. Typical Installation of Oxygen Sensor

Fittings Installation

If threads on the fitting are badly nicked or galled, replace the fitting. If port threads are damaged, re-tap, if possible, or replace the component. If the port is cracked, replace the component. Normally, the total number of threads engaged should be between 3-1/2 and 6. Any number outside of this range indicates either under- or over-tightening of the joint or out of tolerance threads.

If the joint is under-tightened, tighten it further but no more than one full turn. If it is over-tightened, check both threads, and replace the part, which has out-of-tolerance threads.

NOTE
Teflon tape or PTFE thread sealant should be applied to the threaded male fittings in the PG-04 control system in order to minimize the risk of fuel leakage.

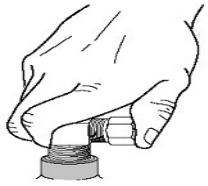
Elbow or Tee

1. Tighten external thread into the internal thread.
2. Tighten an additional 1 to 1.5 revolutions with a wrench.
3. Tighten fitting to align with tubing (never counterclockwise).

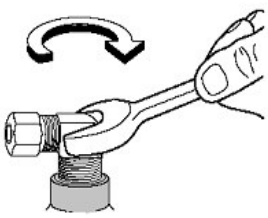
NOTE
To minimize the possibility of a leaking threaded joint after assembling male to female pipe threads, neither end should be backed out (loosened) once the assembly has been made.

TABLE 1.
Assembly Turns from Finger Tight Values for Steel, Stainless Steel and Brass Fittings

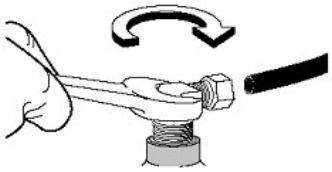
PIPE THREAD SIZE NPTF	TURNS FROM FINGER TIGHT (T.F.F.T)
1/8 - 27	2 -3
1/4 - 18	2 -3
3/8 - 18	2 -3
1/2 - 14	2 -3
3/4 - 14	2 -3
1-11-1/2	1.5 – 2.5
1-1/4 -11-1/2	1.5 – 2.5
1-1/2 -11-1/2	1.5 – 2.5
2 -11-1/2	1.5 – 2.5



FINGER TIGHT



WRENCH TIGHT

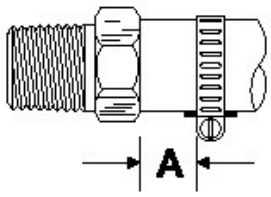


CLOCKWISE TO ALIGN

Connecting Hose to Hose Barb Fittings

1. Cut hose cleanly and squarely to length.
2. Slide clamp on hose.
3. Lubricate hose with light lubricant (oil). Push hose on fitting until hose bottoms against stop ring or hex.
4. Position hose clamp as shown below and secure with a screwdriver or wrench. Maintain “A” dimension noted below for proper clamp positioning.

HOSE SIZE	HOSE CLAMP	A
3/16"	97 HC-3	1/4"
1/4"	97 HC-3	1/4"
5/16"	97 HC-6	1/4"
3/8"	97 HC-6	1/8"
1/2"	97 HC-8	1/8"
5/8"	97 HC-12	1/8"
3/4"	97 HC-12	1/8"



Installing SAE Straight Threaded Fittings

1. Inspect components to ensure that male and female port threads and sealing surfaces are free of burrs, nicks, and scratches or any foreign material.
2. If O-ring is not pre-installed to fitting port end, install proper size O-ring.
3. Lubricate O-ring with light coating of system lubricant or compatible oil.
4. Screw fitting into port until the hex flat contacts the port face. Light wrenching may be necessary.
5. Tighten to given torque for the size from appropriate table.

NOTE: For brass fittings, decrease torque by multiplying value given in **Table 2** by 0.65.

TABLE 2
Assembly Torque for SAE Threaded Fittings

SAE Dash Size	Thread Size (UN/UNF)	Assembly Torque (+10% -0)					
		Hollow Hex Head (HP5ON)			Hex Head (P5ON)		
		in. lbs.	ft. lbs.	N-m	in. lbs.	ft. lbs.	N-m
2	5/16 - 24	30	2.5	3.5	85	7	9.5
3	3/8 - 24	55	4.5	6	155	13	17.5
4	7/16 - 20	120	10	13.5	300	25	35
5	1/2 - 20	170	14	19	360	30	40
6	9/16 - 18	410	34	46	410	34	46
8	3/4 - 16		60	80		60	80
10	7/8 - 14		100	135		100	135
12	1 1/16 - 12		135	185		135	185
14	1 3/16 - 12		175	235		175	235
16	1 5/16 - 12		200	270		200	270
20	1 5/8 - 12		250	340		250	340
24	1 7/8 - 12		305	415		305	415
32	2 1/2 - 12		375	510		375	510

TABLE 3
Standard Torque Values for Metric Fasteners

METRIC NUTS AND BOLTS		
THREAD SIZE (mm)	STANDARD TORQUE	
	(N • m)	(lb • ft)
M6	12 ± 3	9 ± 2
M8	28 ± 7	20 ± 5
M10	55 ± 10	40 ± 7
M12	100 ± 20	75 ± 15
M14	160 ± 30	120 ± 22
M16	240 ± 40	175 ± 30
M20	460 ± 60	340 ± 44
M24	800 ± 100	600 ± 75
M30	1600 ± 200	1200 ± 150
M36	2700 ± 300	2000 ± 225

METRIC TAPERLOCK STUDS		
THREAD SIZE (mm)	STANDARD TORQUE	
	(N • m)	(lb • ft)
M6	8 ± 3	6 ± 2
M8	17 ± 5	13 ± 4
M10	35 ± 5	26 ± 4
M12	65 ± 10	48 ± 7
M16	110 ± 20	80 ± 15
M20	170 ± 30	125 ± 22
M24	400 ± 60	300 ± 45
M30	650 ± 80	480 ± 60
M36	870 ± 100	640 ± 75

TABLE 4
Standard Torque Values for Inch Fasteners

INCH NUTS AND BOLTS		
THREAD SIZE inch	STANDARD TORQUE	
	(N • m)	(lb • ft)
1/4	12 ± 3	9 ± 2
5/16	25 ± 6	18.0 ± 4.5
3/8	47 ± 9	35 ± 7
7/16	70 ± 15	50 ± 11
1/2	105 ± 20	75 ± 15
9/16	160 ± 30	120 ± 20
5/8	215 ± 40	160 ± 30
3/4	370 ± 50	275 ± 35
7/8	620 ± 80	460 ± 60
1	900 ± 100	660 ± 75
1-1/8	1300 ± 150	950 ± 100
1-1/4	1800 ± 200	1325 ± 150
1-3/8	2400 ± 300	1800 ± 225
1-1/2	3100 ± 350	2300 ± 250

INCH TAPERLOCK STUDS		
THREAD SIZE inch	STANDARD TORQUE	
	(N • m)	(lb • ft)
1/4	8 ± 3	6 ± 2
5/16	17 ± 5	13 ± 4
3/8	35 ± 5	26 ± 4
7/16	45 ± 10	33 ± 7
1/2	65 ± 10	48 ± 7
5/8	110 ± 20	80 ± 15
3/4	170 ± 30	125 ± 22
7/8	260 ± 40	190 ± 30
1	400 ± 60	300 ± 45
1-1/8	500 ± 70	370 ± 50
1-1/4	650 ± 80	480 ± 60
1-3/8	750 ± 90	550 ± 65
1-1/2	870 ± 100	640 ± 75

Band-Type Hose Clamps

TABLE 5
Torque Values for Band-Type Hose Clamps

CLAMP WIDTH	TORQUE ON NEW HOSE	RETIGHTENING TORQUE
7.9 mm (.312 in)	0.9 ± 0.2 N • m 8 ± 2 lb • in	0.7 ± 0.2 N • m 6 ± 2 lb • in
13.5 mm (.531 in)	4.5 ± 0.5 N • m 40 ± 5 lb • in	3.0 ± 0.5 N • m 25 ± 5 lb • in
15.9 mm (.625 in)	7.5 ± 0.5 N • m 65 ± 5 lb • in	4.5 ± 0.5 N • m 40 ± 5 lb • in

45° Flared and Inverted Fittings

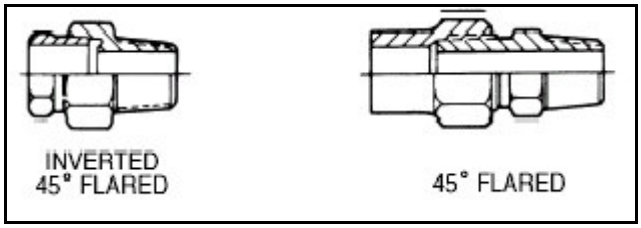


TABLE 6
Torque Values for 45° Flared and Inverted Fittings

45° FLARED AND 45° INVERTED FLARE FITTINGS				
NOMINAL TUBE O.D.		THREAD SIZE inch	STANDARD TORQUE	
METRIC	INCH		(N • m)	(lb • ft)
3.18	.125	5/16	5.0 ± 1.5	4 ± 1
4.76	.188	3/8	8.0 ± 1.5	6 ± 1
6.35	.250	7/16	11 ± 2	8 ± 1
7.94	.312	1/2	17 ± 3	13 ± 2
9.52	.375	5/8	30 ± 3	22 ± 2
11.11	.438	11/16	30 ± 3	22 ± 2
12.70	.500	3/4	38 ± 4	28 ± 3
15.88	.625	7/8	50 ± 5	37 ± 4
19.05	.750	1-1/16	90 ± 8	65 ± 6
22.22	.875	1-1/4	100 ± 10	75 ± 7

Chapter 4.
Electrical Connections

The following schematics illustrate the typical electrical connections for the PG-04 control system components. A wiring harness is not supplied with this control system.

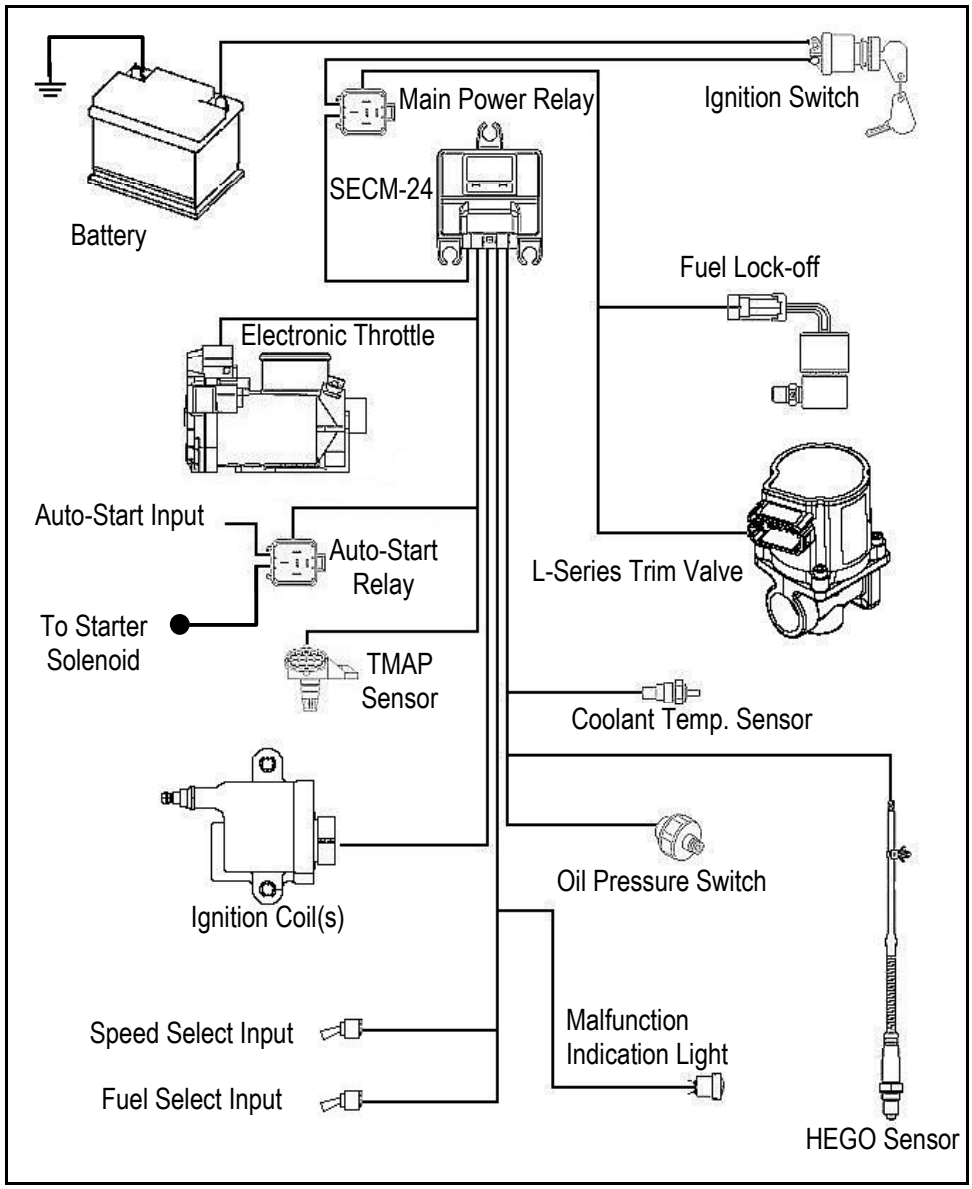


Figure 27. Typical PG-04 Control System Electrical Connections

NOTE
The battery power should be disconnected from the harness when making these connections.

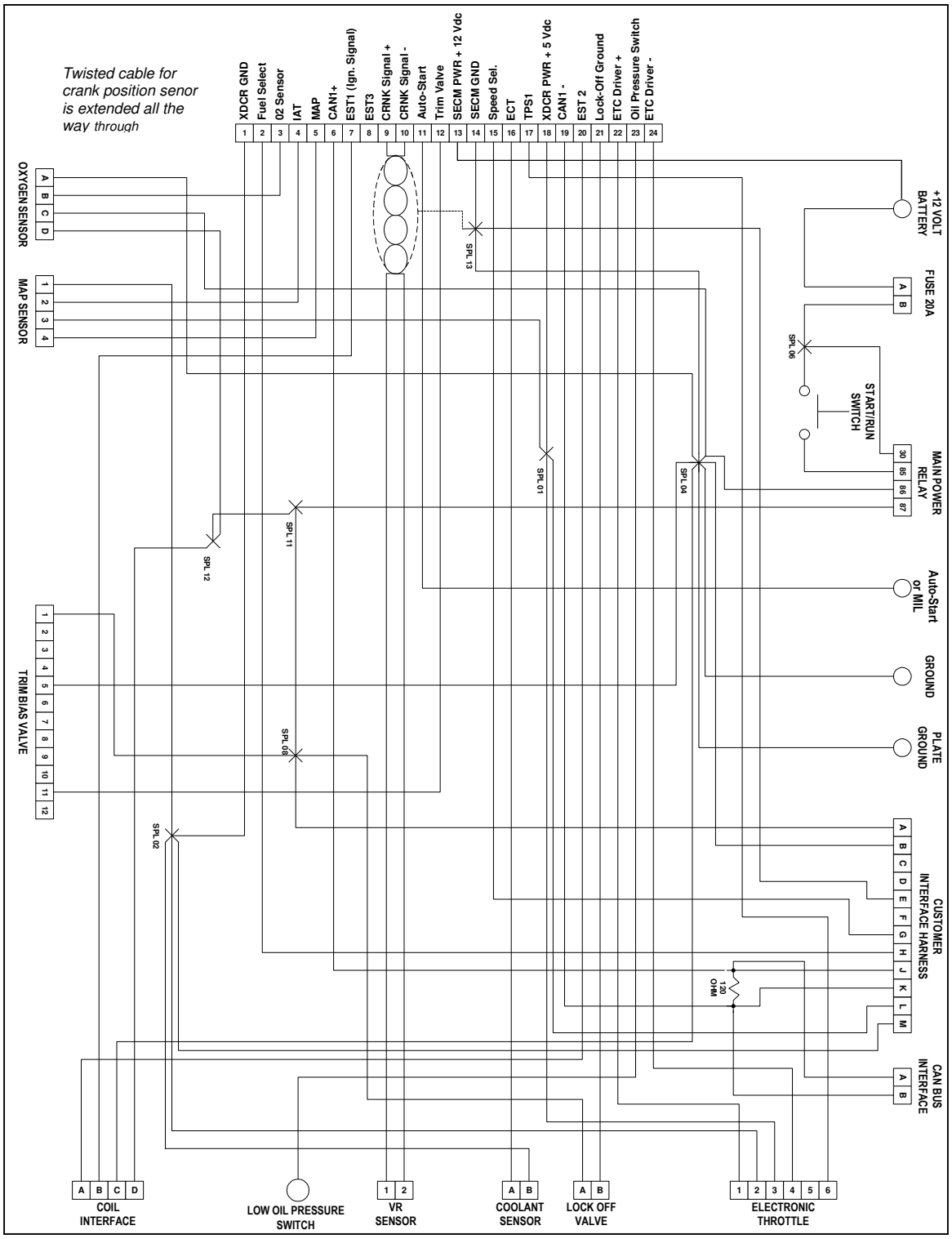


Figure 28. PG-04 Wiring Harness

NOTE
The wire harness is a customer-supplied item.

SECM Electrical Mounting Recommendations

In order to prevent the possibility of any SECM malfunctions due to EMI/RFI emissions, engine packagers and OEMs should follow industry “best practices” and the SECM mounting and harness recommendations listed below.

- The SECM should be mounted in a location that minimizes the amount of EMI exposure by locating it as far as practical from all high tension components such as ignition coils, distributors, spark plug wires, etc. It is recommended that the SECM be mounted at least 29.5” (749 mm) away from the distributor and ignition coil, and at least 20” (508 mm) from the nearest plug wire.

- All wiring harnesses should be routed to minimize coupling (both radiated and conducted), and be securely fastened to minimize movement and maintain proper clearance between the SECM and all ignition system components.

- The OEM must ensure that a high quality ground connection between the SECM and battery negative (–) is provided and can be maintained for the useful life of the vehicle. This may require the use of star-type washers on all ground lug connections between the SECM and the battery and/or special preparation of all mating surfaces that complete the ground connection in order to ensure that the connection is sound.

Engineering judgment must be exercised on all applications to determine if appropriate measures have been implemented to minimize EMI exposure to the SECM and associated cabling. The above recommendations do not provide any guarantee of proper system performance.

Chapter 5.
Tests and Adjustments

This section covers the recommended tests and adjustments that must be made on an engine equipped with the PG-04 control system.

Additional tests can be performed at the discretion of the packager.

SECM Fault Archive Test

The SECM controller creates and retains a fault history archive. The fault history archive can be accessed via the laptop or the maintenance diagnostic tools. Operators need only to provide battery power to the SECM to access the fault archive. If no major faults are active in the fault history archive, then operators may proceed with the remaining control system checks and tests.

Fuel System Leak Test

Before starting the engine for the first time after a new installation, the fuel system should be checked for leaks. The correct fuel supply connections (to natural gas line or LPG vapor cylinder) must be made. If the system is installed on an engine not yet in its final location, make sure the correct fuel connections are made before opening the manual shutoff valve.

1. Connect the main fuel line to the inlet of the fuel lock-off.
2. Obtain a leak check squirt bottle or pump spray bottle filled with approved leak check solution.
3. Completely open the manual shutoff valve on the fuel.
4. Spray a generous amount of the solution on the fuel system fuel lines and connections, starting at the main connections.
5. Wait approximately 15-60 seconds, and then perform a visual inspection of the fuel system. Leaks will cause the solution to bubble.
6. Repair any leaks before continuing.
7. Crank the engine through several revolutions. This will energize the fuel lock-off and allow fuel to flow to the pressure regulator.
8. Apply additional leak check solution to the pressure regulator fuel connections and housing.
9. Repeat leak inspection as listed above.
10. Repair any fuel leaks before continuing.

11. If at any time escaping fuel is heard or smelled, immediately shut down the fuel. The leak must be found and replaced before proceeding.

Inspect Engine for Fluid Leaks

1. Turn the ignition key to the ON position.
2. Start the engine and allow it to reach operating temperatures.
3. Turn the engine off.
4. Inspect the entire engine for oil and/or coolant leaks.
5. Repair as necessary before continuing.

Electronic Fuel Lock-off Solenoid Test

There are two tests that help confirm proper operation of the electronic lock-off solenoid. The first test consists of disconnecting the connector to the fuel lock-off prior to starting the engine. Then the operator should attempt to start the engine. The engine should not start.

The second test consists of disconnecting the fuel lock-off connector as the engine is running at idle speed with no load. As soon as the operator removes the connection to the fuel lock-off, the engine should shut down.

Faults will be logged and archived for both of these shutdown conditions.

CAUTION
Operators should exercise caution when conducting this test with a running engine.

Fuel Feed Pressure into the Pressure Regulator Test

The N-LPR pressure regulator has a fuel inlet pressure test port (**Figure 29**). The fuel supply pressures to the N-LPR should not exceed 11" of WC. This pressure can be checked using a water manometer. The operator should install a 1/8" NPT threaded fitting into the test port and connect the fitting with a hose to a water manometer. Then, the electronic fuel lock-off solenoid should be powered in order for the fuel to flow into the N-LPR pressure regulator.

NOTE
Pressure regulators are calibrated and tested prior to shipment from Woodward to the customer. Consequently, the outlet pressures do not require adjustments.

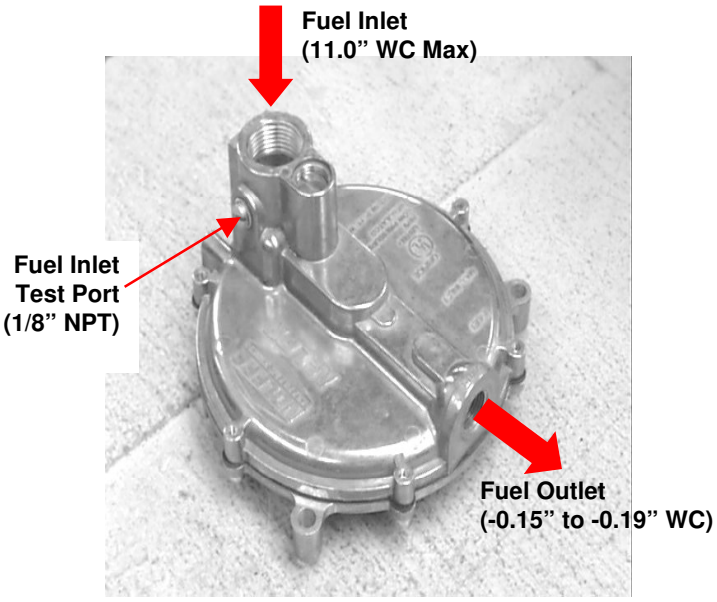


Figure 29. Fuel Inlet Test Port on LPR Regulator

Final Timing and Idle Mixture Adjustment

To make the final timing adjustment to a running engine, it is necessary to connect a laptop computer to the SECM and use the Service Tool software. A USB (Universal Serial Bus) to CAN (Controller Area Network) communication adapter manufactured by Kvaser is required (**Figure 30**) along with a Crypt Token (**Figure 31**). The Crypt Token acts as a security key allowing the laptop to access data from the SECM. Also, the latest Mototune software version is needed in order to access and support the calibration files in the controller.

NOTE
Follow engine manufacturer's guidelines for checking spark timing. Different procedures exist for checking the spark timing between engines equipped with distributors and distributor-less engines.

Figure 30. USB to CAN Adapter

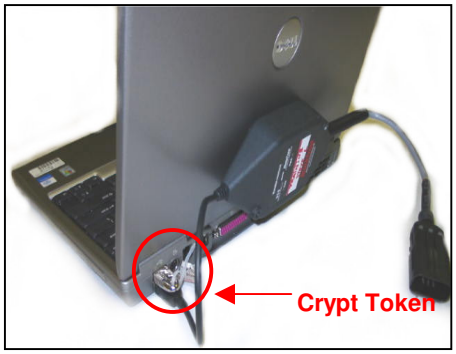


Figure 31. Crypt Token

1. Install the Crypt Token into a USB port in the computer (**Figure 31**).
2. With the ignition key in the OFF position, connect the Kvaser communication cable from a second USB port on the computer to the CAN communications cable on the engine. *(If your laptop computer does not have a second USB port an appropriate USB hub will need to be used).*
3. Connect a timing light to the engine to Cylinder # 1 high-tension lead.
4. Turn the ignition key to the ON position ***(Do Not Start the Engine).***
5. Launch the Mototune program on your computer and open the Service Tool display.
6. Start the engine. The operator should now see the engine RPM on the Service Tool display screen.
7. Start the engine. Use the timing light to check the engine timing. The timing should be at 10 degrees BTDC. If it is not, and the engine is equipped with a distributor, then loosen the distributor-retaining nut and rotate the distributor until the timing light shows an engine timing of 10 degrees BTDC.
8. Tighten the distributor-retaining nut and verify the timing is still 10 degrees BTDC.
9. Unlock the Spark Control Lock bit; the field should now read unlocked.
10. While on the Advanced Screen adjust the idle mixture screw on the mixer until a reading between 20-80% is reached for the FTV Duty Cycle.
11. If the engine is not equipped with a distributor, then all spark-timing changes must be made via the software tool (Mototune).
12. Turn the ignition key to the OFF position to shut down the engine.
13. Close the manual shutoff valve of the fuel supply main or tank.

14. Purge the fuel system by starting the engine and continue to run the engine until all of the trapped fuel is consumed and the engine shuts down.
15. Turn the ignition key to the OFF position.

The service test screen below (**Figure 32**) shows the Mototune screen used for various tests for the PG-04 control system. The Ignition Timing Test, Fuel Trim Valve (FTV) Test, and Throttle Position Test can all be conducted via this screen.

ADDITIONAL TEST

The service test screen also shows the Engine State (STALL, CRANK, RUN) and the ARF (Air-Fuel Ratio) Control Mode (Open-Loop or Closed-Loop).

The *Engine State* parameter allows the operator to monitor when the engine transitions from STALL to RUN during start-up. And, it could help the operator troubleshoot any startability issues.

The *Air-Fuel Ratio (AFR)* parameter is a useful feature that enables the operator to monitor how the control system transitions from open-loop operation to closed-loop operation. This transition is important because during open loop operation, the engine performance is strictly governed by the default fuel and spark tables in the software. Once the HEGO sensor warms up, then the control system is able to manage engine spark and fuel based on the HEGO input in order to achieve stoichiometric air-fuel ratio performance.

Lastly, via the service test screen, the operator is able to access the fault archive, and after analyzing the archives, the operator can clear and/or reset all faults.

The **Advance Diagnostics** section of this manual covers these topics in more detail.

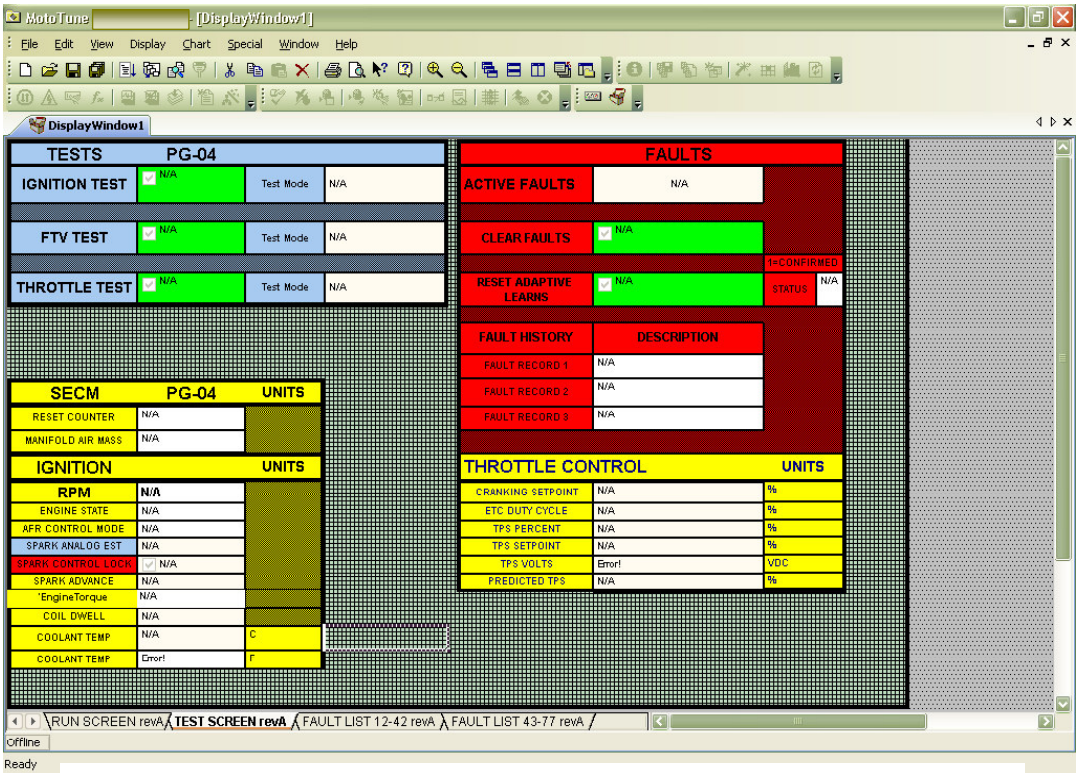


Figure 32. Mototune Service Test Screen

Chapter 6.
Basic Troubleshooting

PG-04 systems are equipped with built-in fault diagnostics. Detected system faults are displayed and logged in the Mototune software service tool. Access and manipulation of the system faults are covered in the Advanced Diagnostics section. Items such as fuel level, plugged fuel lines and malfunctioning pressure regulators may not set a fault code by the Small Engine Control Module (SECM). Below are basic checks that should be made before referring to the Advanced Diagnostics section, if engine or performance problems are encountered.

Consider all parts of the ignition and mechanical systems as well as the fuel system. The following troubleshooting guidelines were developed for LPG systems; however, a similar approach can be followed for troubleshooting Natural Gas systems.

PROBLEM	PROBABLE CAUSE	CORRECTIVE ACTION
ENGINE CRANKING BUT WILL NOT START	Fuel container empty	Fill fuel container • Do not exceed 80% of liquid capacity
	Liquid valve closed	Slowly open liquid valve
	Excess flow valve closed	Reset excess flow valve • Close liquid valve • Wait for a “click” sound; Slowly open liquid valve
	Plugged fuel line	Remove obstruction from the fuel line • Close liquid fuel valve • Using caution, disconnect the fuel line (some propane may escape) • Clear obstruction with compressed air • Re-connect fuel line • Slowly open liquid fuel valve • Leak test
	Clogged fuel filter	Repair/replace as required Follow filter manufacturer’s recommendations.
	Faulty vapor connection between the pressure regulator/converter and the mixer	Check connection • Verify no holes in hose • Clamps must be tight • Look for kinked, pinched and/or collapsed hose
	Fuel lock-off malfunction	Repair/replace fuel lock-off
	Pressure regulator/converter malfunction	Test pressure regulator/converter operation
	Incorrect air-fuel or ignition/spark control	*See Advanced Diagnostics*
	No VR sensor signal	Verify the VR signal is present *See Advanced Diagnostics*

Basic Troubleshooting (Cont'd.)

PROBLEM	PROBABLE CAUSE	CORRECTIVE ACTION
DIFFICULT TO START	Fuel container almost empty	LPG vapor from liquid outlet • Fill fuel container • Do not exceed 80% of liquid capacity
	Excess flow valve closed	Reset excess flow valve • Close liquid valve • Wait for a "click" sound; slowly open liquid valve
	Clogged fuel filter	Repair/replace as required
	Plugged fuel line	Remove obstruction from the fuel line • Close liquid fuel valve • Using caution, disconnect the fuel line (some propane may escape) • Clear obstruction with compressed air • Re-connect fuel line • Slowly open liquid fuel valve • Leak test
	Faulty vapor connection between the pressure regulator/converter and the mixer	Check connection • Verify no holes in hose • Clamps must be tight • Look for kinked, pinched and/or collapsed hose
	Pressure regulator/converter malfunction	Test pressure regulator/converter operation
	Fuel container almost empty	LPG vapor from liquid outlet • Fill fuel container • Do not exceed 80% of liquid capacity
	Air filter clogged	Check air filter • Clean/replace as required
	Incorrect air-fuel or ignition control	*See Advanced Diagnostics*
	Engine mechanical	*See Engine Manufacturer's Service Manual*
	Electronic Throttle Controller Problem	Run the Throttle Test in the Test Screen on the Mototune service tool and open the display screen.
	SECM active faults	Run the Mototune service tool and check the display screen for active faults.

Basic Troubleshooting (Cont'd.)

PROBLEM	PROBABLE CAUSE	CORRECTIVE ACTION
WILL NOT RUN CONTINUOUSLY	Fuel container almost empty	LPG vapor from liquid outlet • Fill fuel container • Do not exceed 80% of liquid capacity
	Excess flow valve closed	Reset excess flow valve • Close liquid valve • Wait for a "click" sound. Slowly open liquid valve
	Clogged fuel filter	Repair/replace as required based on filter manufacturer's guidelines.
	Plugged fuel line	Remove obstruction from fuel line • Close liquid fuel valve • Using caution, disconnect the fuel line (some propane may escape) • Clear obstruction with compressed air • Re-connect fuel line • Slowly open liquid fuel valve & leak test
	Pressure regulator freezes	Check level in cooling system • Must be full, check coolant strength • -35°F (-37°C) minimum Check coolant hoses • Watch for kinks and/or pinched hoses • Verify one pressure hose and one return hose
	Fuel lock-off malfunction	Repair/replace fuel lock-off
	SECM active faults or incorrect software installed on the controller.	*See Advanced Diagnostics*
	Engine mechanical	*See Engine Manufacturer's Service Manual*

Basic Troubleshooting (Cont'd.)

PROBLEM	PROBABLE CAUSE	CORRECTIVE ACTION
ENGINE STALLS	Fuel container almost empty	LPG vapor from liquid outlet • Fill fuel container • Do not exceed 80% of liquid capacity
	Excess flow valve closed	Reset excess flow valve • Close liquid valve • Wait for a "click" sound. Slowly open liquid valve
	Clogged fuel filter	Repair/replace as required based on filter manufacturer's guidelines.
	Plugged fuel line	Remove obstruction from the fuel line • Close liquid fuel valve • Using caution, disconnect the fuel line (some propane may escape) • Clear obstruction with compressed air • Re-connect fuel line • Slowly open liquid fuel valve & leak test
	Fuel lock-off malfunction	Repair/replace fuel lock-off per lock-off Manufacturer's recommendations.
	Faulty vapor connection between the pressure regulator/converter and the mixer	Check connection • Verify no holes in hose • Clamps must be tight • Look for kinked, pinched and/or collapsed hose
	Pressure regulator freezes	Check level in cooling system • Must be full, check coolant strength • -35°F (-37°C) minimum Check coolant hoses • Watch for kinks and/or pinched hoses • Verify one pressure hose and one return hose
	Pressure regulator malfunction	Test pressure regulator operation *See Tests and Adjustments*
	Vacuum leak	Check for vacuum leaks • Between mixer and throttle body • Between throttle body and intake manifold • Between intake manifold and cylinder head
	Fixed venturi mixer malfunction	Clogged or plugged venturi mixer Check for foreign objects in the air passages.
	Engine mechanical	*See Engine Manufacturer's Service Manual*
	SECM faults	*Check Mototune service software tool.* *See Advanced Diagnostics section of this manual.*

Basic Troubleshooting (Cont'd.)

PROBLEM	PROBABLE CAUSE	CORRECTIVE ACTION
UNSTABLE SPEED	Faulty vapor connection between the pressure regulator/converter and the mixer	Check connection • Verify no holes in hose • Clamps must be tight • Look for kinked, pinched and/or collapsed hose
	Pressure regulator malfunction	Test pressure regulator operation *See Tests and Adjustments*
	Vacuum leak	Check for vacuum leaks between . . . • Mixer and throttle body • Throttle body and intake manifold • Intake manifold and cylinder head
	Fixed Venturi mixer malfunction	Clogged or plugged venturi mixer Check for foreign objects in the air passages
	SECM faults	*See Advanced Diagnostics & Tests and Adjustments*
	Incorrect timing or spark control	
	Engine mechanical	*See Engine Manufacturer's Service Manual*
EXCESSIVE FUEL CONSUMPTION / LPG EXHAUST SMELL	Air-fuel mixer malfunction	Check mixer *See Air-fuel Mixer*
	Air filter clogged	Check air filter • Clean/replace as required
	Vacuum leak	Check system vacuum hoses and mixer • Repair/replace as necessary
	Pressure regulator malfunction/fuel pressure too high	Test pressure regulator operation *See Tests and Adjustments*
	Faulty L-Series trim valve	Check L-Series trim valve for housing cracks or obstructions • Advanced Diagnostics & Operation • Repair and/or replace as necessary
	Weak ignition and/or spark control	*See Advanced Diagnostics*
	Incorrect air-fuel control	*See Advanced Diagnostics*
	Exhaust system leaks	Repair exhaust system
	Oxygen sensor failure	Replace as necessary *See Advanced Diagnostics*

Basic Troubleshooting (Cont'd.)

PROBLEM	PROBABLE CAUSE	CORRECTIVE ACTION
POOR HIGH SPEED PERFORMANCE	Clogged fuel filter	Repair/replace as required *See Filter Manufacturer's recommendations for replacements*
	Plugged fuel line	Remove obstruction from the fuel line • Close liquid fuel valve • Using caution, disconnect the fuel line (some propane may escape) • Clear obstruction with compressed air • Re-connect fuel line • Slowly open liquid fuel valve & leak test
	Air filter clogged	Check air filter • Clean/replace as required
	Faulty vapor connection between the pressure regulator/converter and the mixer	Check connection • Verify no holes in hose • Clamps must be tight • Look for kinked, pinched and/or collapsed hose
	Pressure regulator malfunction	Test pressure regulator operation *See Tests and Adjustments*
	Fixed Venturi mixer malfunction	Clogged or plugged venturi mixer Check for foreign objects in the air passages
	Restricted exhaust system	Check exhaust system • Measure exhaust back pressure
	Incorrect ignition control	*See Advanced Diagnostics & Tests and Adjustments*
	Incorrect air-fuel control	
	Incorrect throttle position	

Resistance Checks

NOTE
All resistive checks are made with the sensor or device disconnected from the harness.

SENSOR	POINT TO POINT	EXPECTED RANGE
TMAP	TMAP Pin 1 (GND) to Pin 4 (pressure signal KPA)	2.4kΩ - 8.2kΩ
	TMAP Pin 3 (PWR) to Pin 4 (pressure signal KPA)	3.4kΩ - 8.2kΩ
	TMAP Pin 1 (GND) to Pin 2 (temperature signal)	See Table 7 for proper range

SENSOR	POINT TO POINT	EXPECTED RANGE
TPS (ELECTRONIC THROTTLE)	TPS PIN 2 (GND) TO PIN 6 (TPS1 SIGNAL)	1.25KΩ +/-30%
	TPS PIN 3 (PWR) TO PIN 6 (TPS1 SIGNAL)	1.25KΩ +/-30%
	TPS PIN 1 (+DRIVER) TO PIN 4 (-DRIVER)	~3.0Ω +/-30%

SENSOR	POINT TO POINT	EXPECTED RANGE
ECT (COOLANT TEMPERATURE)	ECT PIN A (SIGNAL) TO PIN B (GND)	2.8KΩ AT 25 C (77 F) +/- 8 C

SENSOR	POINT TO POINT	EXPECTED RANGE
O_2 (OXYGEN SENSOR)	O_2 PIN C (HEATER GND) TO PIN D (HEATER PWR)	2.1 +/- 0.4 ohms

CONNECTOR	POINT TO POINT	EXPECTED RANGE
IGNITION MODULE (4-PIN CONNECTOR)	COIL PIN A (GND) TO PIN B (PWR)	~5.5KΩ
	COIL PIN A (GND) TO PIN C (CRANK SIGNAL)	~4MEGΩ
	COIL PIN A (GND) TO PIN D (DRIVER SIGNAL)	~5.2KΩ
	COIL PIN B (PWR) TO PIN C	~4MEGΩ
	COIL PIN B (PWR) TO PIN D	~10.5KΩ
	COIL PIN C TO PIN D	~5MEGΩ

CONNECTOR	POINT TO POINT	EXPECTED RANGE
FUEL LOCK-OFF	LOCK-OFF PIN A (PWR) TO PIN B (GND SIGNAL)	~20-25Ω

TABLE 7
TMAP SENSOR IAT

TEMPERATURE IN F +/-1	TEMPERATURE IN C +/-1	RESISTANCE IN Ω (OHMS)		
		MINIMUM	NOMINAL	MAXIMUM
-40	-40	43.6K	48.2K	54.2K
-31	-35	32.1K	36.6K	40.1K
-22	-30	24.7K	27.5k	30.0k
-13	-25	18.3K	20.4K	22.7K
-4	-20	14.0K	15.6K	17.3K
5	-15	11.0K	12.1K	13.4K
14	-10	8.5K	9.4K	10.4K
23	-5	6.7K	7.4K	8.2K
32	0	5.4K	5.9K	6.5K
41	5	4.3K	4.7K	5.2K
50	10	3.5K	3.8K	4.2K
59	15	2.8K	3.0K	3.5K
68	20	2.3K	3.0K	3.3K
77	25	1.9K	2.0K	2.2K
86	30	1.6K	1.7K	1.9K
95	35	1.3K	1.4K	1.5K
104	40	1.1K	1.2K	1.3K
113	45	937	1.0K	1.1K
122	50	792	851	913
131	55	672	721	772
140	60	572	612	655
149	65	488	522	558
158	70	418	446	476
167	75	359	383	408
176	80	309	329	351
185	85	267	284	302
194	90	232	246	261
203	95	201	214	227
212	100	176	186	197
221	105	153	162	172
230	110	134	142	150
239	115	118	125	132
248	120	103	110	116
257	125	91	97	102
266	130	81	85	91

Chapter 7.
Advanced Diagnostics

This section covers the advanced diagnostics options for the PG-04 control system. In order to access the SECM monitoring and diagnostics screens, operators must use a laptop computer in addition to the Woodward Service Tool, which consists of:

1. **Dongle** – Crypt Token, which is inserted on an available USB port (required) The Crypt Token acts as a security key allowing the laptop to access data from the SECM.
2. **USB-to-CAN Cables** – communication adapter, which enables access to the CAN communication from the SECM (required)
3. **Mototron Software Program** – computer program for communicating between the SECM and the operator's laptop (required).
4. **Extension Cable** – 10-ft long extension cable (optional)

The Mototron program must be installed on a laptop computer prior to beginning the troubleshooting/diagnosing session since the program, along with the Crypt Token and USB-to-CAN cables, allows customers to access the fault archives as well as the monitoring screens. (See Chapter 9 for Service Tool part numbers).

Figure 33. USB-to-CAN Adapter and Dongle (shown uninstalled)

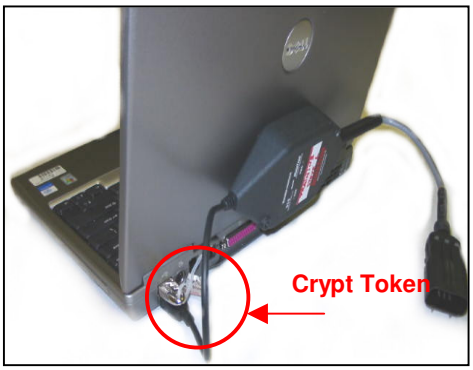


Figure 34. Crypt Token and USB-to-CAN Adapter (shown installed on a laptop)

Computer Requirements:

The Mototune software is a Microsoft Windows® based GUI (graphic user interface). The Service Tool Software is compatible with Windows 95/98/NT/2000/Me/XP and gives the user the ability to:

- Tune the control with the engine running during application development
- Create configuration files for downloading into multiple controls
- Upload and Download configuration files
- Extract and view fault codes for field diagnosis
- Update control dynamics during field service
- Troubleshoot and Diagnose engine parameters
- Run PG-04 control system specific Ignition Test, L-Series Trim Valve Test and Electronic Throttle test.

In addition, the Service Tool can be configured to incorporate security to limit access to and protect application settings where needed.

Communication Setup:

1. Install the Crypt Token (**Figure 33**) into a USB port in the computer (**Figure 34**).
2. With the ignition key in the OFF position, connect the communication cable from a second USB port on the computer to the CAN communications cable on the engine. *(If your laptop computer does not have a second USB port an appropriate USB Hub will need to be used).*
3. Connect the extension cable (if needed).
4. Connect to the customer interface connector on the engine harness.
5. Turn the Ignition key to the ON position (do not start the engine yet).
6. Launch the Mototron program.

   At this point, communication with the SECM should be established and a blank Mototune screen should be visible.

7. The operator must now select File, Open, Display and choose the following file:
   PG-4 Diagnostic_Display_rev1.dis

The Mototune interface is a Windows-based program. The Display feature contains pre-selected parameters that will enable operators to monitor, diagnose and troubleshoot engine performance. In addition, operators will have access to the fault archives via the Display screen.

Mototune Service Screens

RUN SCREEN

This is the most important service screen given that it allows the operator to monitor engine parameters and fault archives. The operator should access this screen first in order to check for active faults. Further investigation of active faults and the fault archive can be done via both fault list screens. See **Figure 35**.

The run screen enables the operator to check the FUEL TYPE the controller is expecting since the PG-04 control system is able to run on LPG vapor, natural gas or gasoline. GASEOUS FUEL 1 is the default NATURAL GAS and GASEOUS FUEL 2 is LPG vapor.

The run screen allows the operator to monitor whether or not the control system is operating in closed-loop mode. The HEGO sensor temperature must increase to a predetermined value (non-programmable) for the transition to occur. Also, the FTV (Fuel Trim Valve) DUTY CYCLE is an important parameter to monitor given that inappropriate operation of the L-Series trim valve would make the air-fuel mixture either too rich or too lean. Operation of this parameter should be between 20-80%.

Lastly, the RUN SCREEN enables the operator to monitor the operation of the electronic throttle body. The higher the TPS (Throttle Position Sensor) percentage, the wider the throttle is opened.

TEST SCREEN

The test screen enables the operator to conduct IGNITION Test, FTV (Fuel Trim Valve) Tests, and Throttle Test. In addition, the operator can analyze the active faults and clear and/or reset faults. See **Figure 36**.

FAULT LIST (12-42) & FAULT LIST (43-77):

These two screens contain a list of the possible system faults. See **Figures 37** & **38**.

Sample Service and Test Screens

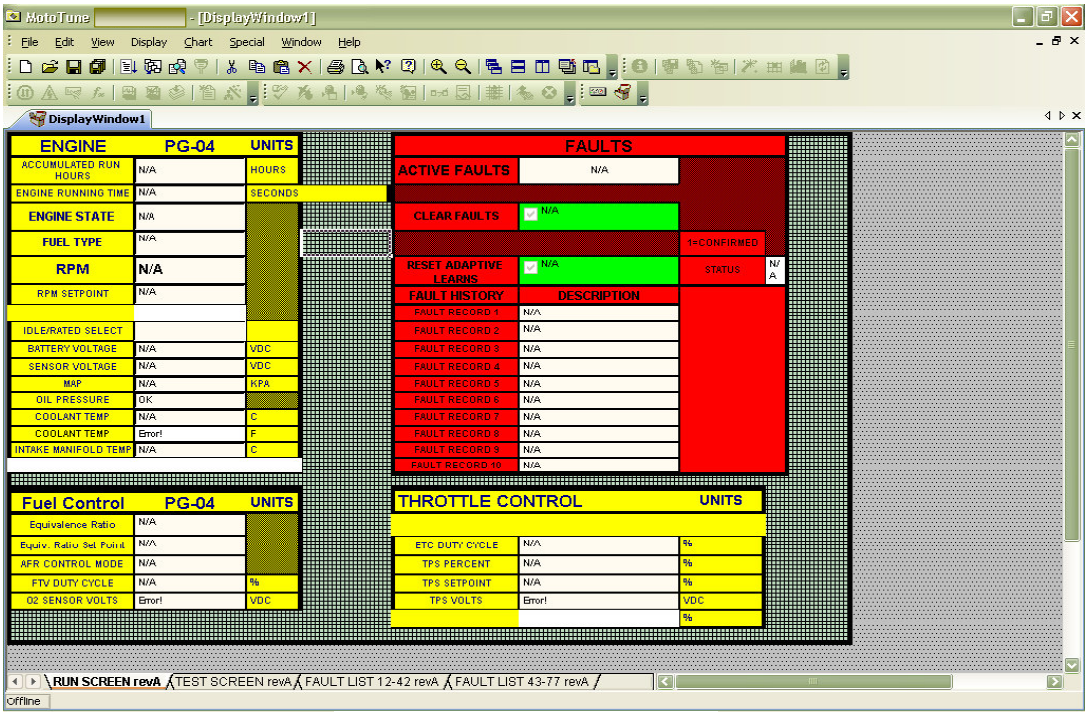


Figure 35. RUN Screen

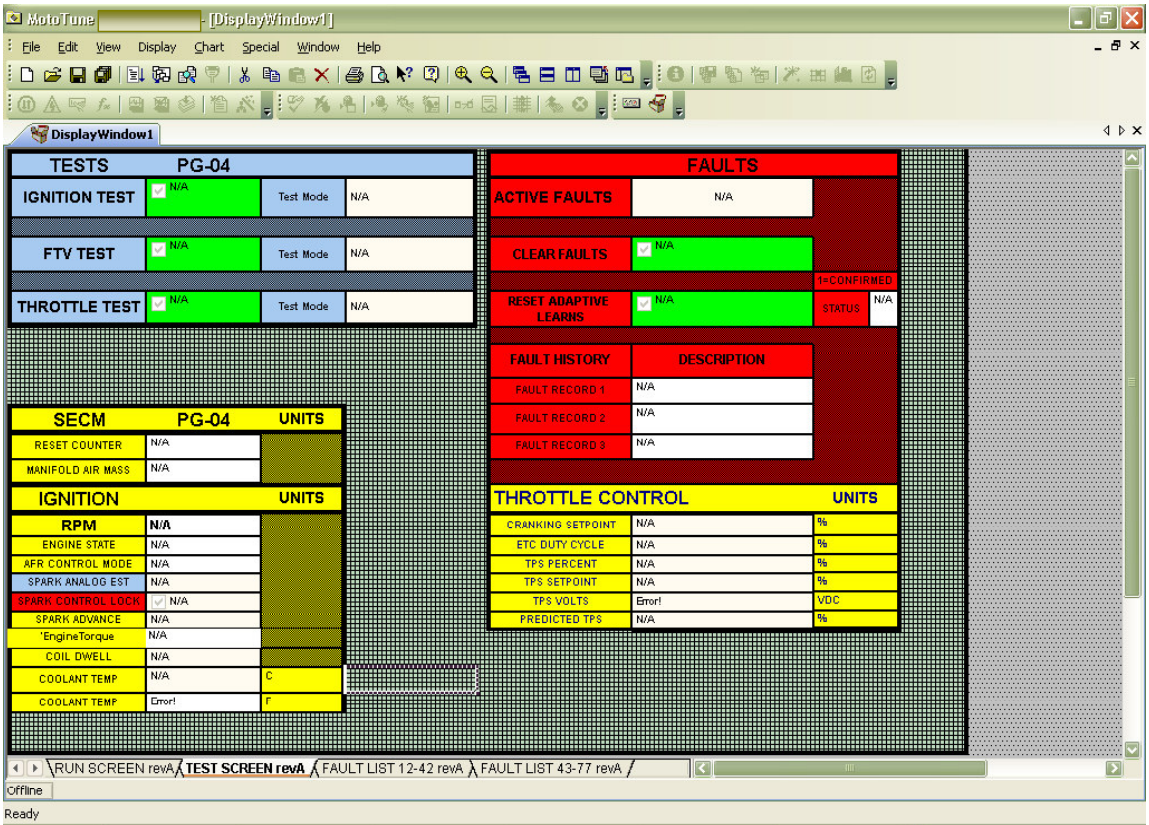


Figure 36. TEST Screen

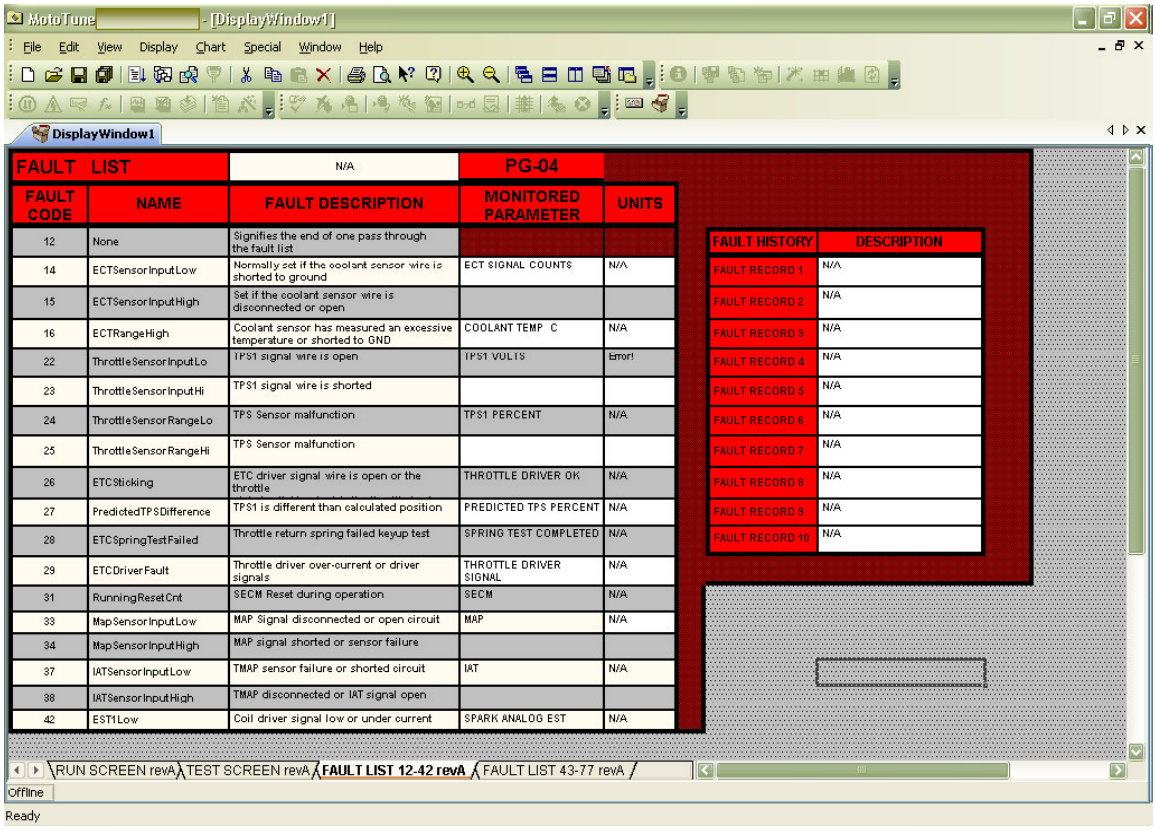


Figure 37. Fault List (12 –42)

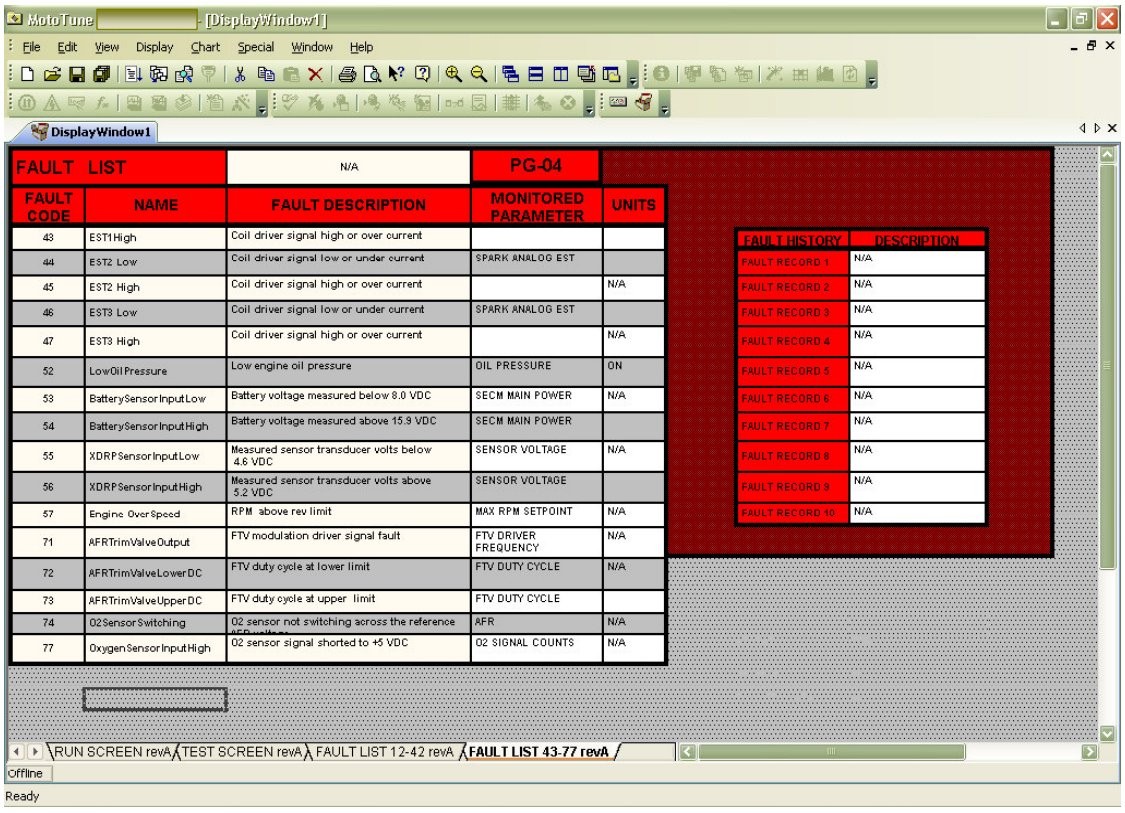


Figure 38. Fault List (43 –77)

Chapter 8.
Maintenance Schedule

Recommended Maintenance Schedule

Suggested maintenance requirements for an engine equipped with a PG-04 control system are contained in this section. Operators should, however, develop their own maintenance schedule using the requirements listed in this section and any other requirements listed by the engine manufacturer.

Test Fuel System for Leaks

- Obtain a leak check squirt bottle or pump spray bottle.
- Fill the bottle with an approved leak check solution.
- Spray a generous amount of the solution on the fuel system fuel lines and connections, starting at the storage container.
- Wait approximately 15–60 seconds, and then perform a visual inspection of the fuel system. Leaks will cause the solution to bubble.
- Repair any leaks before continuing.
- Crank the engine through several revolutions. This will energize the fuel lock-off and allow fuel to flow to the pressure regulator/converter. Apply additional leak check solution to the regulator/ converter fuel connections and housing. Repeat leak inspection as listed above.
- Repair any fuel leaks before continuing.
- Listen and smell for escaping fuels and repair as needed.

Inspect Engine for Fluid Leaks

- Start the engine and allow it to reach operating temperatures.
- Turn the engine off.
- Inspect the entire engine for oil and/or coolant leaks.
- Repair as necessary before continuing.

Inspect Electrical System

- Check for loose, dirty or damaged connectors and wires on the harness including: fuel lock-off, TMAP sensor, O_2 sensor, electronic throttle, control relays, L-Series trim valve, and smart coils.
- Check for broken or cracked wires and replace as necessary.
- Repair and/or replace as necessary.

Check Coolant Level

- The items below are a general guideline for system checks. Refer to the engine manufacturer's specific recommendations for proper procedures.
- Engine must be off and cold.

WARNING
Never remove the pressure cap on a hot engine.

- The coolant level should be equal to the "COLD" mark on the coolant recovery tank.
- Add approve coolant to the specified level if the system is low.

Inspect Coolant Hoses

- Visually inspect coolant hoses and clamps. Remember to check the two coolant lines that connect to the pressure regulator/converter if the system uses LPG liquid.
- Replace any hose that shows signs of swelling, cracking, abrasion or deterioration.

Inspect Battery System

- Clean battery outer surfaces with a mixture of baking soda and water.
- Inspect battery outer surfaces for damage and replace as necessary.
- Remove battery cable and clean, repair and/or replace as necessary.

Inspect Ignition System

- Remove and inspect the spark plugs. Replace as required.
- Test secondary wires with an ohmmeter. If maximum resistance is exceeded, repair and/or replace. (See Resistance Checks section of Chapter 6 of this manual.)
- Inspect the ignition coils for cracks and heat deterioration. Visually inspect the coil heat sink fins. If any fins are broken replace as required.

Replace Spark Plugs

- Using a gentle twisting motion, remove the high voltage leads from the spark plugs. Replace any damaged leads.
- Remove the spark plugs.
- Gap the new spark plugs to the proper engine manufacturer specifications (See Engine Owner's Manual).
- Apply anti-seize compound to the spark plug threads and install.
- Re-install the high voltage leads.

CAUTION
Do not over tighten the spark plugs. Apply torque per engine manufacturer's recommendations.

Testing Electronic Fuel Lock-off Operation

- Start engine.
- Locate the electrical connector for the fuel lock.
- Disconnect the electrical connector.
- The engine should run out of fuel and stop within a short period of time.
- Turn the ignition key switch off and re-connect the fuel lock-off connector.

NOTE
The length of time the engine runs on trapped fuel vapor increases with any increase in distance between the fuel lock-off and the pressure regulator.

Pressure Regulator Testing and Inspection

- Visually inspect the pressure regulator housing for leaks. Refer to the pressure regulator section of this manual if maintenance is required.

> **NOTE**
> **For pressure testing and internal inspection of the pressure regulator, refer to the pressure regulator section of this manual.**

L-Series Fuel Trim Valve Inspection

- Visually inspect the fuel trim valve for abrasions or cracking. Replace entire sub-assembly as necessary.
- Check for broken or cracked wires and replace as necessary.

Inspect Venturi Mixer

- Visually inspect the outlet ports of the venturi mixer by removing/disconnecting the air cleaner. The venturi mixer should have no obstructions or residue on the ports given that they may obstruct fuel flow and/or may be ingested by the engine.

Inspect for Intake Leaks

- Visually inspect the intake manifold adapter, throttle assembly, for looseness and leaks. Repair as necessary.

Inspect Throttle Assembly

- Visually inspect the throttle assembly motor housing for coking, cracks and missing cover-retaining clips. Repair and/or replace as necessary.

> **NOTE**
> **Refer to the mixer and throttle section of this manual for procedures on removing the mixer and inspecting the throttle plate.**

Checking the TMAP Sensor

- Verify that the TMAP sensor is mounted tightly into the manifold adapter, with no leakage.
- If the TMAP is found to be loose, remove the TMAP retaining screw and the TMAP sensor from the manifold adapter.
- Visually inspect the TMAP o-ring seal for damage. Replace as necessary.
- Apply a thin coat of an approved silicon lubricant to the TMAP o-ring seal.
- Re-install the TMAP sensor into the manifold adapter and securely tighten the retaining screw.

Inspect Engine for Exhaust Leaks

- Start the engine and allow it to reach operating temperatures.
- Perform visual inspection of exhaust system. Repair any/all leaks found.

Maintenance Schedule

CHECK POINT	INTERVAL HOURS						
	Daily	Every 250 Hours or 1 month	Every 500 Hours or 3 months	Every 1000 Hours or 6 months	Every 1500 Hours or 9 months	Every 2600 Hours or 1 year	Every 4500 Hours or 18 months
General Maintenance							
Test fuel system for leaks	Prior to any service or maintenance activity						
Inspect engine for fluid leaks	X						
Inspect electrical system-check for loose, dirty, or damaged wires and connections			X				
Inspect all fuel fittings and hoses				X			
Engine Coolant							
Check coolant level	X						
Inspect coolant hoses and fittings for leaks, cracks, swelling, or deterioration				X			
Engine Ignition							
Inspect battery for damage and corroded cables						X	
Inspect ignition system					X		
Replace spark plugs					X		
Fuel Lock-Off/Filter							
Replace LP fuel filter element					X		
Inspect lock-off and fuel filter for leaks					X		
Ensure lock-off stops fuel flow when engine is off					X		
Pressure Regulator/Converter							
Test regulator pressures				X			
Inspect pressure regulator vapor hose for deposit build-up				X			
Inspect regulator assembly for fuel/coolant leaks				X			
L-Series Fuel Trim Valve							
Inspect valve housing for wear, cracks or deterioration			X				

Maintenance Schedule (Cont'd)

CHECK POINT	INTERVAL HOURS						
	Daily	Every 250 Hours or 1 month	Every 500 Hours or 3 months	Every 1000 Hours or 6 months	Every 1500 Hours or 9 months	Every 2600 Hours or 1 year	Every 4500 Hours or 18 months
Air-fuel Components							
Check air filter indicator	X						
Check for air leaks in the filter system				X			
Inspect venturi mixer (or air valve mixer assembly)			X				
Check for vacuum leaks in the intake system including manifold adapter and mixer to throttle adapter						X	
Inspect throttle assembly				X			
Inspect air filter			X				
Replace air filter element				X			
Check TMAP sensor for tightness and leaks						X	
Exhaust							
Inspect engine for exhaust leaks	X						
Replace oxygen sensor							X
Replace PCV valve and breather element						X	

Servicing the N-LPR Pressure Regulator

The N-LPR should be periodically checked for leakage. If the unit requires service, Woodward suggests that the N-LPR be taken/sent to a qualified service technician. If a technical is not available, Woodward will furnish a list of qualified repair facilities or provide service information.

Chapter 9.
Parts Catalog

The following section describes the three PG-04 control system configurations currently available.

PG-04 CONTROL SYSTEM CONFIGURATIONS	
8514-011	4-Cylinder 1800 rpm Engine Control System
8514-017	4-Cylinder 3600 rpm Engine Control System
8514-018	3-Cylinder 1800 rpm Engine Control System

The SECM and sensors kit *must* be ordered in addition to each of these systems.

8514-012 WOODWARD SECM, TMAP AND TEMP SENSOR KIT			
ITEM	**PART NUMBER**	**QTY**	**PART NAME**
1	ASM-SECM-011	1	Mototron SECM Controller and Mounting Kit
2	SENS-TEMP-002	1	Sensor, Temperature Fluid (Coolant)
3	SENS-TMAP-001A	1	Sensor, TMAP 1 Bar

Therefore, if a customer requires a PG-04 control system for a 4-cylinder fixed-speed engine application running at 1800 rpm, the customer would order 8514-011 **and** 8514-012 for the complete system.

The Service Tool kit components are listed below.

WOODWARD-MOTOTRON SERVICE TOOL PARTS			
ITEM	**PART NUMBER**	**QTY**	**PART NAME**
1	ASM-CASE-015-00	1	Mototron Kit for PG-04
	▪ ASM-CRPT-004G-00	1	Dongle, Mototune
	▪ ASM-CD-004-00	1	Assembly CD – Mototune Program Software
2	ASM-INTR-013-00	1	USB-CAN Interface Cable
OPTIONAL EXTENSION CABLE			
3	84-879981 A50 (Mercury Marine PN)	1	Extension Cable, 10’ Long, Mercury Marine (OPTIONAL)

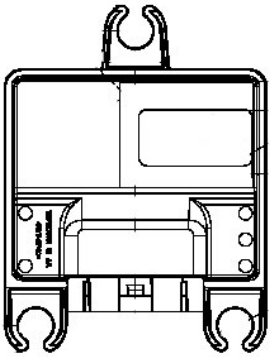
8514-011 WOODWARD 4-CYLINDER 1800 RPM PG-04 CONTROL SYSTEM			
NOTE	**PART NUMBER**	**QTY**	**PART NAME**
	879984	4	Coil – 12 V Smart-Coil
	N-LPR-1A	1	Regulator – N-LPR 6 oz/in^2 Tamper Resistant
	1295-1056	1	Fitting- Hose Barb 3/8” –18 NPTF, Restrictor, Orifice Size: 0.1875”
	1680-6005	1	Transducer – Exhaust Gas Oxygen, Heated 4-Wires
	5418-2515	1	Software – 4-Cylinder 1800 rpm
	6330-1016	1	Common Parts – LC50 Mixer Installation, 25-30-36 mm ITBS
	6945-1089	1	Valve – Sub-Asm, 32 mm Bosch Throttle Mixer

8514-017 WOODWARD 4-CYLINDER 3600 RPM PG-04 CONTROL SYSTEM			
NOTE	**PART NUMBER**	**QTY**	**PART NAME**
	879984	4	Coil – 12 V Smart-Coil
	N-LPR-1A	1	Regulator – N-LPR 6 oz/in^2 Tamper Resistant
	1295-1057	1	Fitting- Hose Barb 3/8” –18 NPTF, Restrictor, Orifice Size: 0.177”
	1680-6005	1	Transducer – Exhaust Gas Oxygen, Heated 4-Wires
	5418-2516	1	Software – 4-Cylinder 3600 rpm
	6330-1016	1	Common Parts – LC50 Mixer Installation, 25-30-36 mm ITBS
	6945-1089	1	Valve – Sub-Asm, 32 mm Bosch Throttle Mixer

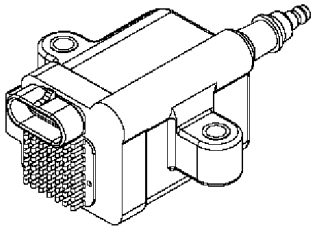
8514-018 WOODWARD 3-CYLINDER 1800 RPM PG-04 CONTROL SYSTEM			
NOTE	**PART NUMBER**	**QTY**	**PART NAME**
	879984	3	Coil – 12 V Smart-Coil
	N-LPR-1A	1	Regulator – N-LPR 6 oz/in^2 Tamper Resistant
	1295-1055	1	Fitting- Hose Barb 3/8” –18 NPTF, Restrictor, Orifice Size: 0.221”
	1680-6005	1	Transducer – Exhaust Gas Oxygen, Heated 4-Wires
	5418-2517	1	Software – 3-Cylinder 1800 rpm
	6330-1016	1	Common Parts – LC50 Mixer Installation, 25-30-36 mm ITBS
	6945-1089	1	Valve – Sub-Asm, 32 mm Bosch Throttle Mixer

REPAIR KIT FOR L-SERIES TRIM VALVE	**8923-1193**	Kit contains L-Series actuator and trim valve components

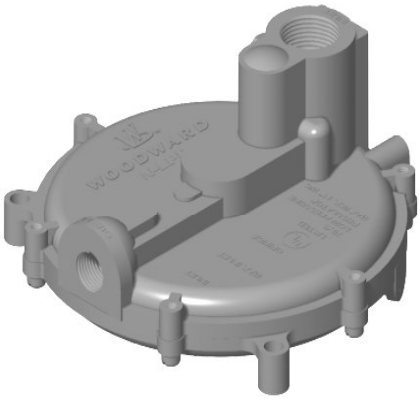
Key Components of PG-04 Control System



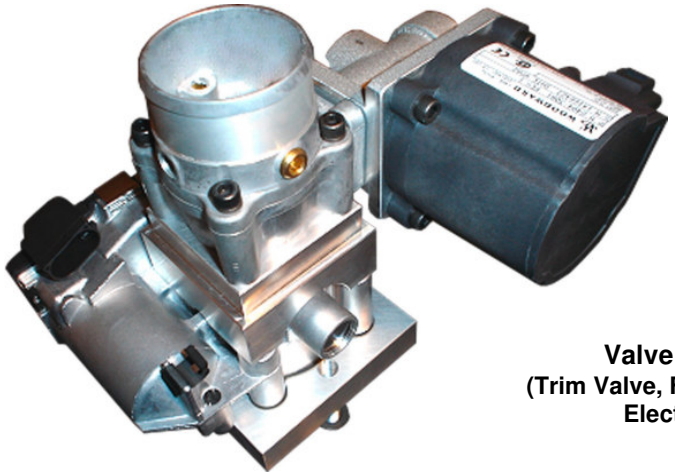
SECM-24
(Engine Controller)



Smart-Coil
(Ignition Coil)



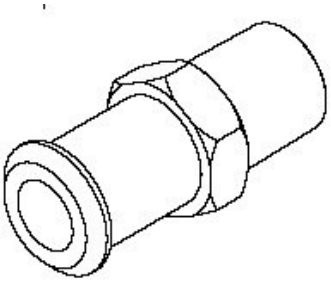
N-LPR-1A
(Pressure Regulator)



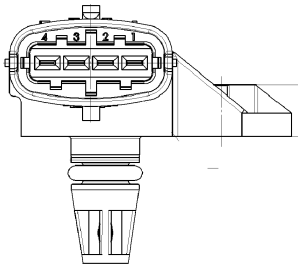
Valve Sub-Assembly
(Trim Valve, Fixed Venturi Mixer and Electronic Throttle)

Oxygen Sensor (HEGO)

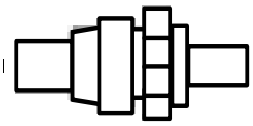
Orifice/Restrictor (Included with all configurations, but only used for LPG vapor)



TMAP Sensor (Manifold Absolute Pressure and Temperature Sensors)



Coolant Temperature Sensor



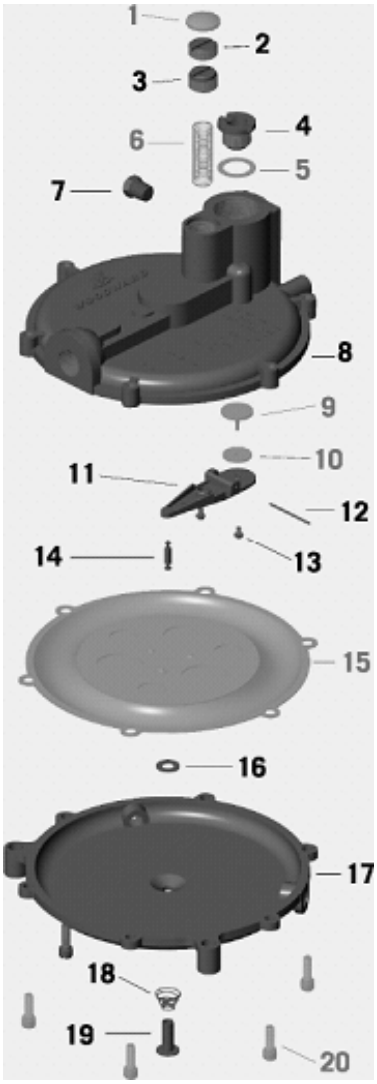
N-LPR Pressure Regulator Components

CAUTION
Only trained technicians should perform the installation of the N-LPR pressure regulator repair kits.

PART NUMBER	DESCRIPTION	QTY
N-LPR-1A	Pressure Regulator	1
N-RK-LPR	Repair Kit (See below for kit components listed in **boldface**.)	

ITEM	PART NO.	DESCRIPTION	QTY
1	**N-C11-1**	**CAP, ADJ. SCREW, TR**	**1**
2	N-S2-18	Screw, Lock, Adj. Spring	1
3	N-S2-11-LPR	Screw, Pressure Adjustment	1
4	N-J1-3	Jet	1
5	**N-W1-6**	**SEAL, JET**	**1**
6	**N-S3-14**	**SPRING**	**1**
7	N2-1011	Plug, 1/8” NPT, Slotted Head	1
8	N-B1-3-LPR	Standard Body	1
9	**N-S5-1**	**SEAT**	**1**
10	**N-W1-5-LPR**	**WASHER, SEAT BACKUP**	**1**
11	N-L1-5A	Lever Assembly	1
12	N-P1-11-LPR	Pin, Lever Fulcrum	1
13	N-S10-11	Screw, #4-40 x 1/4" Pan Head	2
14	N-P1-12	Pin, Connector	1
15	**N-D1-7A**	**DIAPHRAGM ASS’Y, SILICONE**	**1**
16	N00-7505	N-W1-27, Washer, Primer	1
17	N-C1-7-LPR	Cover, Back	1
18	N-S2-21-LPR	Spring, Primer	1
19	N-R11-2	Pin, Primer	1
20	**N00-6400**	**SCREW, 10-24 X 5/8" SLOTTED FILISTER HEAD WITH SPLIT LOCKWASHER, SEMS**	**6 (RK4)**

Boldface items are components of N-RK-LPR Repair Kit.



Grey shaded items are components of N-RK-LPR Repair Kit.

Chapter 10.
Service Options

Product Service Options

The following factory options are available for servicing Woodward equipment, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is purchased from Woodward or the service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

If you are experiencing problems with installation or unsatisfactory performance of an installed system, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact Woodward technical assistance (see “How to Contact Woodward” later in this chapter) and discuss your problem. In most cases, your problem can be resolved over the phone. If not, you can select which course of action you wish to pursue based on the available services listed in this section.

Replacement/Exchange

Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is also a flat rate structured program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

This option allows you to call in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Woodward facility as explained below (see “Returning Equipment for Repair” later in this chapter).

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned to Woodward within 60 days, Woodward will issue a credit for the core charge. [The core charge is the average difference between the flat rate replacement/exchange charge and the current list price of a new unit.]

Return Shipment Authorization Label. To ensure prompt receipt of the core, and avoid additional charges, the package must be properly marked. A return authorization label is included with every Replacement/Exchange unit that leaves Woodward. The core should be repackaged and the return authorization label affixed to the outside of the package. Without the authorization label, receipt of the returned core could be delayed and cause additional charges to be applied.

Flat Rate Repair

Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

Flat Rate Remanufacture

Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in “like-new” condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned to Woodward for repair, please contact Woodward in advance to obtain a Return Authorization Number. When shipping the item(s), attach a tag with the following information:

- Name and location where the control is installed;
- Name and phone number of contact person;
- Complete Woodward part number(s) and serial number(s);
- Description of the problem;
- Instructions describing the desired type of repair.

CAUTION

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Packing a Control

Use the following materials when returning a complete control:

- Protective caps on any connectors;
- Antistatic protective bags on all electronic modules;
- Packing materials that will not damage the surface of the unit;
- At least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- A packing carton with double walls;
- A strong tape around the outside of the carton for increased strength.

Return Authorization Number

When returning equipment to Woodward, please telephone and ask for the Customer Service Department [1 (800) 523-2831 in North America or +1 (970) 482-5811]. They will help expedite the processing of your order through our distributors or local service facility. To expedite the repair process, contact Woodward in advance to obtain a Return Authorization Number, and arrange for issue of a purchase order for the item(s) to be repaired. No work can be started until a purchase order is received.

NOTE

We highly recommend that you make arrangement in advance for return shipments. Contact a Woodward customer service representative at 1 (800) 523-2831 in North America or +1 (970) 482-5811 for instructions and for a Return Authorization Number.

Replacement Parts

When ordering replacement parts for controls, include the following information:

- The part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- The unit serial number, which is also on the nameplate.

How to Contact Woodward

In North America use the following address when shipping or corresponding:

Woodward Governor Company
PO Box 1519
1000 East Drake Rd
Fort Collins CO 80522-1519, USA

Telephone—+1 (970) 482-5811 (24 hours a day)
Toll-free Phone (in North America)—1 (800) 523-2831
Fax—+1 (970) 498-3058

For assistance outside North America, call one of the following international Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

Facility	Phone Number
Brazil	+55 (19) 3708 4800
India	+91 (129) 230 7111
Japan	+81 (476) 93-4661
The Netherlands	+31 (23) 5661111

You can also contact the Woodward Customer Service Department or consult our worldwide directory on Woodward's website (**www.woodward.com**) for the name of your nearest Woodward distributor or service facility.

Engineering Services

Woodward Industrial Controls Engineering Services offers the following after-sales support for Woodward products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

Contact information:

Telephone—+1 (970) 482-5811
Toll-free Phone (in North America)—1 (800) 523-2831
Email—icinfo@woodward.com
Website—**www.woodward.com**

Technical Support is available through our many worldwide locations or our authorized distributors, depending upon the product. This service can assist you with technical questions or problem solving during normal business hours. Emergency assistance is also available during non-business hours by phoning our toll-free number and stating the urgency of your problem. For technical support, please contact us via telephone, email us, or use our website and reference ***Customer Services*** and then ***Technical Support***.

Product Training is available at many of our worldwide locations (standard classes). We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability. For information concerning training, please contact us via telephone, email us, or use our website and reference ***Customer Services*** and then ***Product Training***.

Field Service engineering on-site support is available, depending on the product and location, from one of our many worldwide locations or from one of our authorized distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface. For field service engineering assistance, please contact us via telephone, email us, or use our website and reference ***Customer Services*** and then ***Technical Support***.

Technical Assistance

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

General

Your Name_____
Site Location_____
Phone Number_____
Fax Number_____

Prime Mover Information

Engine/Turbine Model Number_____
Manufacturer_____
Number of Cylinders (if applicable)_____
Type of Fuel (gas, gaseous, steam, etc)_____
Rating_____
Application_____

Control/Governor Information

Please list all Woodward governors, actuators, and electronic controls in your system:

Woodward Part Number and Revision Letter

_____

Control Description or Governor Type

_____

Serial Number _____

Woodward Part Number and Revision Letter

_____

Control Description or Governor Type

_____

Serial Number _____

Woodward Part Number and Revision Letter

_____

Control Description or Governor Type

_____

Serial Number _____

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please include the manual number from the front cover of this publication.

WOODWARD

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Email and Website—www.woodward.com

**Woodward has company-owned plants, subsidiaries, and branches,
as well as authorized distributors and other authorized service and sales facilities throughout the world.**

Complete address / phone / fax / email information for all locations is available on our website.

06/3/M