WOODWARD

Technical Manual 03554
(Revision D)
Original Instructions

GECO™·& GECO Vista
Stoichiometric Gas Engine Controls

Air/Fuel Ratio Control
for Emissions-controlled, Stationary Gas Engines

Installation and Operation Manual

IMPORTANT

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DEFINITIONS

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

WARNING

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

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

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.

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, be sure to check the *publications page* on the Woodward website:

www.woodward.com/publications

The current revision and distribution restriction of all publications are shown in manual *26311*.

The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

NOTICE

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.

NOTICE

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*.

Revisions—Text changes are indicated by a black line alongside the text.

Contents

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Illustrations and Tables

Regulatory Compliance

North American Compliance:

These listings are limited only to GECO™ Stoichiometric models with CSA marking.

CSA: CSA Certified for Class I, Division 2, Groups A, B, C, & D, T5 at 70 °C Ambient. For use in Canada and the United States. Certificate 1214651

These listings are limited only to GECO Vista models with CSA marking.

CSA: CSA Certified for Class I, Division 2, Groups A, B, C, & D, T4A at 40 °C Ambient. For use in Canada and the United States. Certificate 1214651

Special Conditions for Safe Use:

The open-type units are certified as components to be used within a suitable enclosure. The final assembly is subject to acceptance by the authority having jurisdiction.

Wiring must be in accordance with North American Class I, Division 2 wiring methods as applicable, and in accordance with the authority having jurisdiction.

On GECO Vista models, input power must be supplied from an NEC or CEC class 2 power source.

⚠WARNING	**EXPLOSION HAZARD—Do not disconnect equipment while circuit is live unless the area is known to be non-hazardous.** **Substitution of components may impair suitability for Class I, Division 2.**

⚠AVERTISSEMENT	**RISQUE D'EXPLOSION—Ne pas débrancher l'équipement tant que l'installation est sous tension, sauf en cas l'ambiance est décidément non dangereuse.** **La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, Division 2.**

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.

NOTICE

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*.

Chapter 1.
General Information

Welcome!

This manual describes the GECO™·and GECO Vista Stoichiometric controls. The GECO·Stoichiometric control provides precise air/fuel ratio control for engines using three way catalytic converters to reduce exhaust emissions. It is a more sophisticated exhaust oxygen feedback control system because it includes continuous oxygen sensor diagnostics, catalyst over-temperature & differential pressure protection, and failsafe operating modes.

Available Woodward Stoichiometric Controls		
Woodward Control P/N	**Enclosure Type**	**Touch Display / Handheld**
9907-865 – GECO Stoichiometric	Hoffman Enclosure	Handheld
9907-867 – GECO Stoichiometric	Panel Assembly	Handheld
9907-879 – GECO Vista	Hoffman Enclosure	Touch Display

GECO·Stoichiometric System Features

- Microprocessor-based
  - 9–30 Vdc supply operation voltage for GECO Stoichiometric
  - 19.2–28.8 Vdc supply operation voltage for GECO Vista
- Pre-catalyst, closed loop, exhaust oxygen feedback control
- Post-catalyst, exhaust oxygen feedback, cascade control allowing adaptation to changing catalyst performance
- Post-catalyst exhaust oxygen control set point variable with engine load
- Adjustable fuel valve dithering algorithm for better catalyst control
- Catalyst temperature monitoring to protect the catalyst from engine fueling malfunctions (2 K-type thermocouples)
- Catalyst differential pressure monitoring to indicate ash build-up and help meet regulatory requirements
- Open loop valve positioning in event of critical oxygen sensor malfunction or large transient load changes
- Self-learning capability that “remembers” appropriate fuel valve positions over engine load range providing near-perfect failsafe operation
  - Capable of driving up to two fuel metering valves for “V” engine configurations
- Utilizes low-cost L-Series fuel trim valves capable of “Full-flow’ fuel trim strategy that extends the AFR adjustment range
- RS-485/Modbus® * communications support for data transmission
- Full color HMI screen, enabling monitoring without hand-held terminal (available on the GECO Vista model)
- Comprehensive diagnostics including continuous oxygen sensor health monitoring
- Manual closed loop enable switch
- Alarm relay
- Shutdown relay
- LED Driver for Power Indication, Alarm & Shutdown

- Plug-in terminal strip connectors for ease of installation
- CSA Listed for Class I, Division 2, Groups A, B, C, and D in Canada and US

*—Modbus is a registered trademark of Schneider Automation Inc.

Definitions of Terms and Abbreviations

atm	Atmosphere (pressure), 14.7 psia at sea-level (101 kPa, 1.01 bar)
°C	Degree Celsius
catalyst	Also known as a catalytic converter, a flow-through chemical reactor mounted in the exhaust stream to decrease harmful emissions; three-way refers to simultaneous oxidation of carbon monoxide (CO) and hydrocarbon (HC) along with reduction of oxides of nitrogen (NO x) at fuel mixtures close to stoichiometry
CLE	Closed Loop Enable (switch)
closed loop (CL)	Control using feedback signals from the controlled parameter
duty cycle	Percent of on time per total on/off cycle time
ECU	Electronic Control Unit
EGO sensor	Exhaust Gas Oxygen sensor
EGT sensor	Exhaust Gas Temperature sensor (K-type thermocouple)
equivalence ratio	Normalized air/fuel ratio used to compare different fuels relative to stoichiometry phi (φ) = $(A/F)_{stoich}$ / $(A/F)_{actual}$ lambda (λ) = 1/phi
°F	Degree Fahrenheit
GECO	Gas Engine Control
G-lead	Ignition pulse output signal (high voltage) used for engine speed measurement
HEGO sensor	Heated Exhaust Gas Oxygen Sensor
kPa	kilopascal (pressure)
kW	kilowatt (power)
kW transducer	A transducer that measures the output power of the electrical generator and converts that measurement to a proportional 4–20 mA signal
lambda (λ)	See equivalence ratio
lb-ft	Pound-feet (torque)
lbm/hr/l	Pounds per hour per liter (mass flow rate per liter of engine displacement)
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MAP	Intake Manifold Absolute Pressure—an indicator of engine load
MAT	Intake Manifold Absolute Temperature—used to determine mixture density
Mdot	Mass flow rate
MPU	Magnetic Pickup speed sensor
N·m	Newton-meter (torque)
open loop	Control without feedback from any controlled parameters
PC	Personal Computer
psi	Pounds per square inch (pressure)
psia	psi absolute pressure
psig	psi gauge pressure (over ambient)
RPM	Revolutions Per Minute (rotational speed)
RTV	Room Temperature Vulcanizing (silicone sealers)
stereo	Two separate fuel systems for each bank of cylinders including intake manifolds, throttles, and carburetors
stoichiometric	Chemically balanced mixtures (all reactants mutually consumed)—in the case of engine air/fuel mixtures, just enough air to theoretically burn all the fuel
TC	Thermocouple (see EGT)
W	Watt (power)

GECO·Stoichiometric Control Specifications

Power Supply	
Power Supply Operating Voltage:	19.2–28.8 Vdc (24 Vdc nominal) (GECO Vista model) 9.0–30.0 Vdc (12 Vdc or 24 Vdc nominal) (GECO Stoichiometric model)
Power Supply Rated Voltage:	19.2–28.8 Vdc (class 2) (GECO Vista model) 8–32 Vdc (GECO Stoichiometric model)
Power Consumption:	83 W maximum (application specific) (GECO Vista model) 70 W maximum (application specific) (GECO Stoichiometric model)
Inputs:	2 Unheated Zirconia Exhaust Oxygen Sensors (EGO) (0–1 Vdc), p/n 6910-315 or equivalent 1 Heated Zirconia Exhaust Oxygen Sensor (HEGO) (0–1 Vdc), p/n 6910-316 or equivalent 2 K-type Thermocouples, p/n 1736-919 or equivalent 1 Intake Manifold Absolute Pressure Sensor (0–5 Vdc; 0–3 bar absolute), p/n 6910-314 1 Differential Pressure Sensor(1–5 Vdc; 0–15“ H_2O) 1 Magnetic Pickup, p/n 5430-929 or equivalent (0.20–100 Vrms; 8–10 000 Hz) 1 “G-lead” pulse from ignition system (±250 V max)
Outputs:	2 PWM Fuel Metering Valves, p/n 1310-923 1 Alarm Relay (Solid State relay Form C; 250 V @ 75 mA max non-inductive load) 1 Shutdown Relay (Solid State relay Form C; 250 V @ 75 mA max non-inductive load)
Diagnostics:	Power Supply Voltage Oxygen Sensor Health Oxygen Sensor Heater Circuits Manifold Pressure Sensor Closed-Loop Functions Catalyst Differential Pressure Catalyst Temperature
Control Failsafe Operating Modes:	Pre-catalyst exhaust oxygen closed loop control on failure of post-catalyst oxygen sensor Open loop valve positioning mode on failure of pre-catalyst exhaust oxygen sensor Valve default position on failure of manifold pressure sensor
Communications:	RS-232 Hand-Held Interface 6-Pin RJ-12 RS-232 PC Interface DB9F RS-485/Modbus Slave Data Transmission

Environmental Specifications

Temperature Ranges:	
Ambient Operating Temperature:	0 to +40 °C (+32 to +104 °F) (GECO Vista model) –40 to +70 °C (–40 to +158 °F) (GECO Stoichiometric model)
Storage Temperature:	–40 to +105 °C (–40 to +221 °F)
Enclosure:	305 x 254 X 127 mm (12 x 10 x 5 in) NEMA 12/13, IP55, Quick-Release Latches
Regulatory Compliance:	
	GECO Stoichiometric CSA Certified for Class I, Division 2, Groups A, B, C, & D, T5 at 70 °C Ambient. For use in Canada and the United States. CSA Certificate 1214651
	GECO Vista CSA Certified for Class I, Division 2, Groups A, B, C, & D, T4A at 40 °C Ambient. For use in Canada and the United States. CSA Certificate 1214651

Tecknocraft Trim Valve Environmental Specifications

Operating Temperature:	–40 to +125 °C (–40 to +257 °F) housing temperature
Vibration:	Sine Sweep—10-2000 Hz at 10 g's peak-to-peak

L-Series Trim Valve Environmental Specifications

Operating Temperature:	–40 to +125 °C (–40 to +257 °F) housing temperature
Vibration:	Sine Sweep—10-2000 Hz at 10 g's peak-to-peak

Chapter 2.
System Description and Application

GECO™·Stoichiometric Air/Fuel Ratio Control

The GECO™·Stoichiometric gas engine control is a microprocessor-based air/fuel ratio control for carbureted, four-stroke, gaseous-fueled engines operating with a near-stoichiometric air/fuel ratio. It is designed to work in conjunction with a three-way catalytic converter to efficiently reduce exhaust emissions. By automatically maintaining an optimum air/fuel mixture, emissions compliance is achieved and catalyst life is maximized without operator supervision.

Figure 2-1. System Components

In supplementary mode, the carburetor remains in place on the engine, adjusted slightly lean. During operation, the GECO·Stoichiometric control adds fuel through a supplementary fuelling system to bring the air/fuel mixture to the precise value that will make the catalytic converter most efficient. In full-flow mode, the carburetor remains in place on the engine, adjusted slightly rich. During operation, the GECO stoichiometric control restricts flow using a full-flow trim valve located inline upstream of the carburetor to bring the air/fuel mixture to the required precise value that will make the catalytic converter most efficient.

A catalyst that simultaneously eliminates hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x) is referred to as a “three-way” catalyst. The use of a three-way catalyst will reduce the emissions of a stoichiometric engine. However, for these reductions to be reliable and maximized and to protect the catalyst element from premature aging or damage, a very precisely controlled air/fuel ratio is required.

If a three-way catalyst receives exhaust gas containing emissions in the proportions shown in the “Stoich” window of Figure 2-2, the resulting emissions exiting the catalyst will be reduced to the levels shown in Figure 2-3.

The exhaust gas oxygen sensor (EGO) will generate a voltage signal that is characteristic of this ideal stoichiometric window. The GECO control will use this voltage value to keep the engine at this correct air/fuel ratio. For natural gas this voltage is usually around 0.780 V.

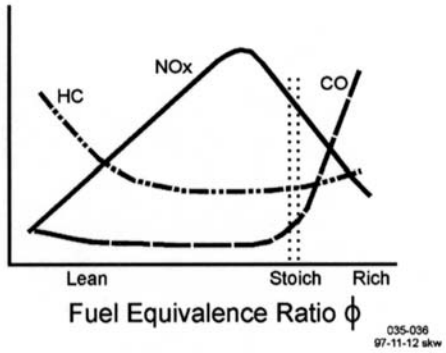


Figure 2-2. Pre-Catalyst Emissions

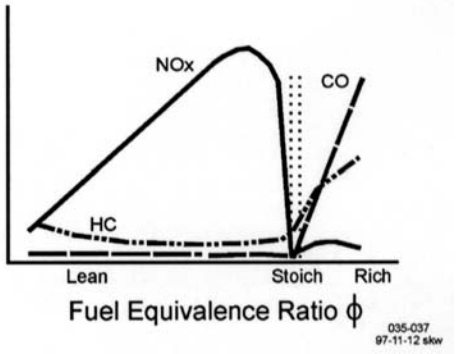


Figure 2-3. Post-Catalyst Emissions

Pre-Catalyst Exhaust Oxygen Control

The GECO control increases or decreases the fuel flowing through the supplementary fuel system to hold the EGO1 (and EGO2 if present) sensor voltage at this target value.

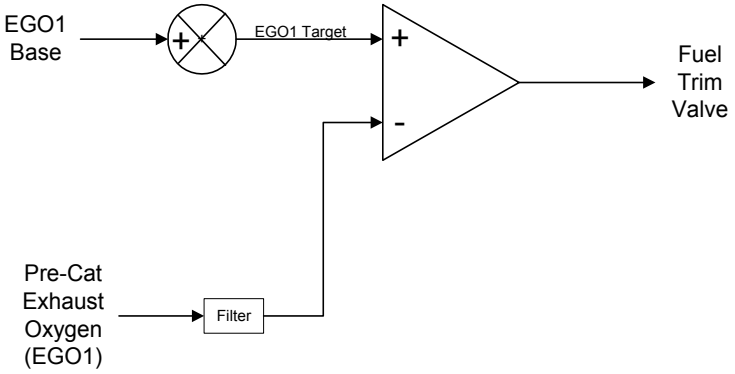


Figure 2-4. Basic Control Logic for Pre-catalyst EGO Control

Post-Catalyst Exhaust Oxygen Control

In order to assure optimal catalyst performance over time as conditions vary and the catalyst element ages, the GECO·Stoichiometric control has an “Adaptive Control” loop that uses feedback from a second oxygen sensor in the exhaust downstream of the catalyst element.

This post-catalyst control loop “adapts” the primary pre-catalyst control to changes in fuel, catalyst, and environmental conditions that are reflected in the post-catalyst oxygen concentration. A post-catalyst oxygen sensor voltage of 0.720 V is a typical post-catalyst control loop set point (or EGO3 Base value).

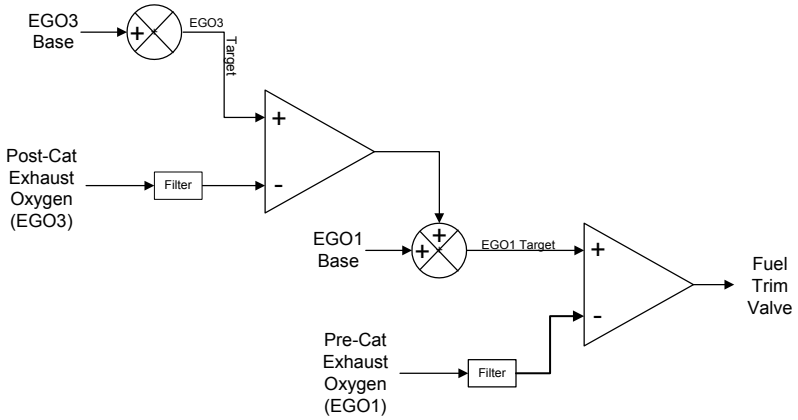


Figure 2-5. Basic Control Logic for Post-catalyst EGO Control

EGO3 Offset

This EGO3 Base value may vary several millivolts from engine to engine, catalyst to catalyst, and load to load. Some engines operate with varying loads. In order to keep such an engine and catalyst at optimum performance, the EGO3 Base value may need to be adjusted. The required adjustment can be entered into the EGO3 Offset table in the GECO control so that it can adjust the EGO3 Base value by adding the offset to the base value at different loads. The GECO control keeps track of engine load by monitoring the intake manifold pressure (MAP) and engine speed (MPU). The intake manifold pressure and engine speed are used to calculate an approximate engine fuel flow is then used as a load indicator. The load range of the engine is divided into eight segments. An EGO3 Offset value can be manually entered for each of these load levels with this feature. The EGO3 Base value can be offset to provide the optimum EGO3 Target value over the entire operating range of the engine.

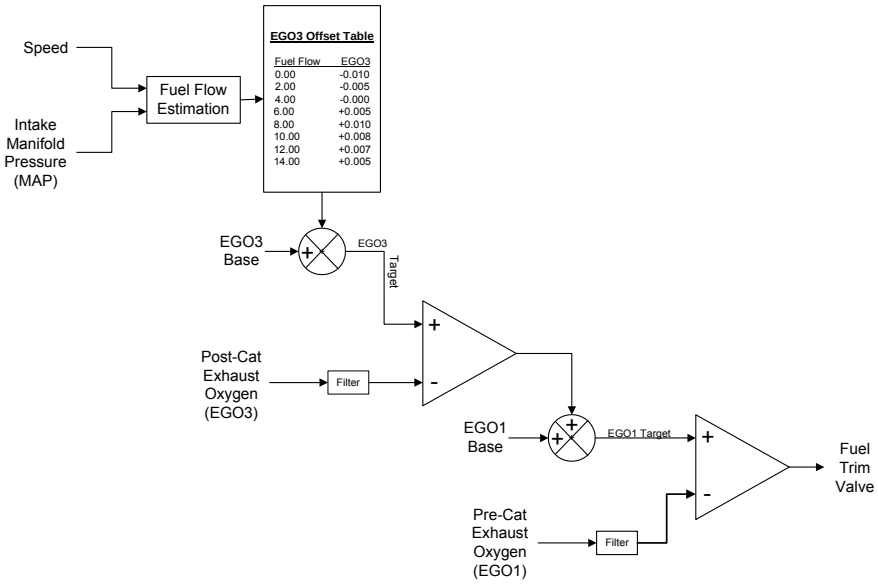


Figure 2-6. Control Logic with EGO3 Offset

Open Loop Control Mode

The open loop control mode will control the air/fuel ratio of the engine without the closed loop EGO measurement. This mode is less accurate than the closed loop mode but it is more accurate than the carburetor alone. This mode positions the fuel control valve to predetermined values based on the load of the engine. The control measures engine load by using the intake manifold pressure and engine speed to calculate fuel flow into the engine. This calculated fuel flow represents engine load. It is then used in a table of the control valve position versus fuel flow. This table is called the Valve-Learn table. The Valve Learn table stores valve operating positions at various points over the engine load range. The table has eight load points. Values in between load points are interpolated.

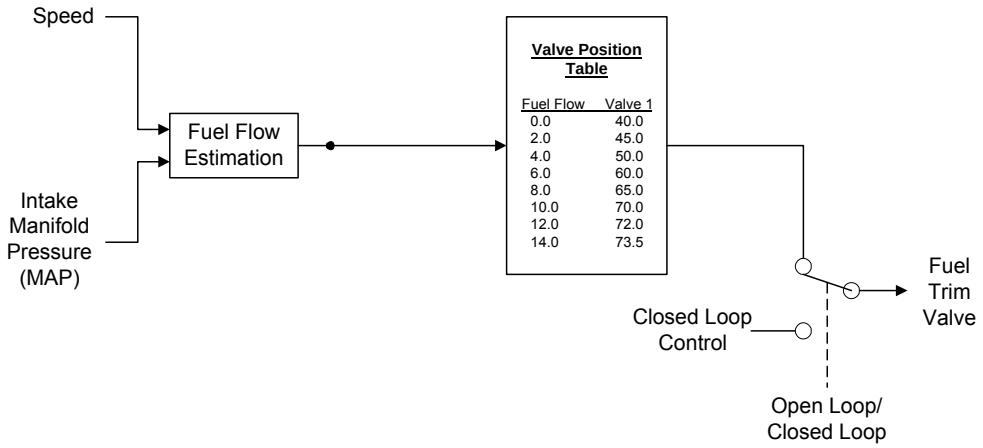


Figure 2-7. Control Logic for Open Loop Control

The open loop control mode can be used as the primary control mode, but it mainly serves as a backup to the pre-catalyst closed loop control mode. If the EGO1 or 2 sensor fails, the control automatically defaults to the open loop mode. The values in this table are normally entered manually during initial control calibration. In some situations they can be entered automatically. This is called the Valve-Learn function, it is not initially active. It must be activated in the control if this feature is required.

Valve-Learn Function

Over time, if fuel BTU content changes or environment conditions change, normal “Closed Loop” or “Closed Loop - Adaptive” control operation will maintain the fuel control valve at the optimum position for the current operating conditions. However, in Open Loop mode, the Valve-Learn table will lose its accuracy if it is not kept up-to-date. To prevent this, the Valve-Learn function can continuously learn new optimum control valve positions. As long as the “Closed Loop” function is active the current optimum valve position is re-entered into the table whenever conditions are stable and closed loop accuracy is maintained. If a problem should develop with the EGO1 or EGO2 sensors, the “Open Loop” control mode will then select from the table the valve positions that match current conditions.

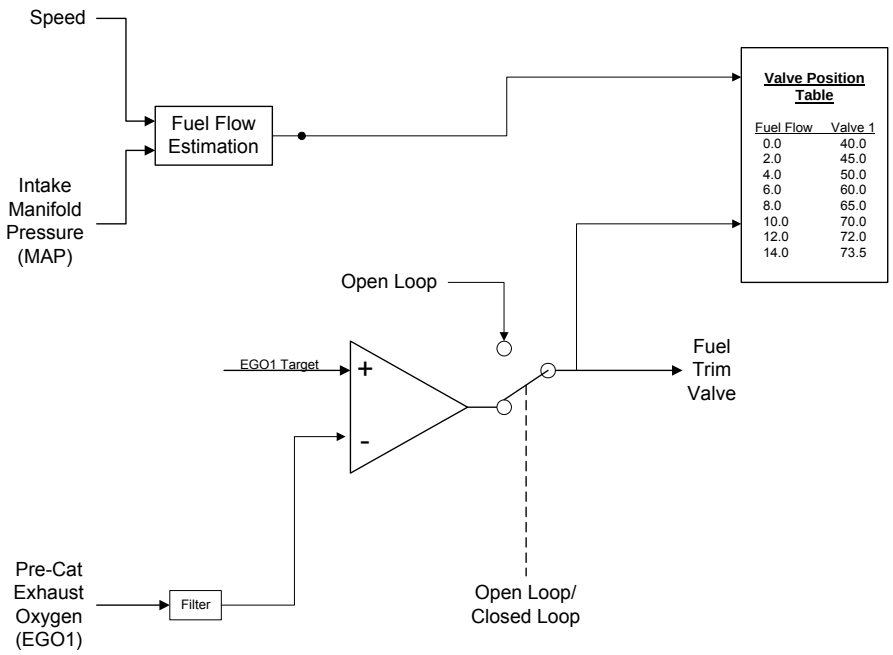


Figure 2-8. Control Logic for Valve-Learn Function

Fuel Valve Dithering

It has been shown that “dithering” the Air/fuel ratio into the catalyst increases the window of air/fuel ratio variation to enhance the performance of the catalyst. The GECO includes parameters to adjust the amplitude and frequency of the dithering to optimize the oxygen storage capability of the catalyst. This strategy widens the window of operation and will allow the EGO sensors to drift more without reducing the efficiency of the catalyst.

Diagnostics and Monitoring

For system reliability the GECO control monitors sensor inputs and control outputs for high and low failure conditions as well as extensive self-diagnostics for system functionality. Alarm or shutdown control outputs are available to allow integration into an engine or system control panel for component failure or emissions compliance requirements. These alarms are configured in the software. There is an alarm and shutdown LED output as well as an alarm and shutdown relay.

In addition, the GECO control has oxygen sensor health monitoring. This function can assess the remaining activity of the oxygen sensors, and preventative maintenance can be planned before a sensor failure occurs.

Communications

Communication with the system is via a computer (PC) interface or by the hand-held terminal. Control setup and tuning is accomplished through the PC interface screens (see Figure 2-9).

The PC software also includes many helpful features for system troubleshooting, including status indicators and data monitoring, and real-time plotting and logging. The hand-held terminal allows only very limited access to settings and is generally not suitable for set-up and calibration.

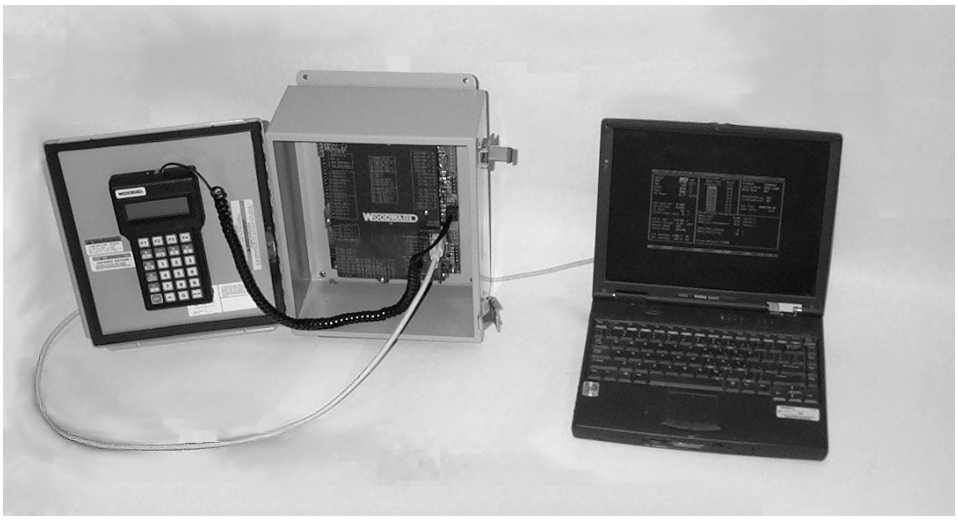


Figure 2-9. PC Communications

1 GECO Stoichiometric Air/Fuel Control Monitor ID:5455-111-NW 2001/05/15

Engine		Shutdowns		Fuel Control Alarms		
Speed	1200 rpm	ClearAll	High	ClearAll	High	Low
MAP	10.00 psia	TC Upstream	OK	Valve1 Limit	OK	OK
TC Upstream	1013 °F	TC Dnstream	OK	Valve2 Limit	OK	OK
TC Dnstream	1091 °F		Misc	Adapt Limit	OK	OK
Control1	OPEN LOOP	Controller	OK	Valve1 Currt	OK	OK
Control2	OPEN LOOP	**Status/Control**		Valve2 Currt	OK	OK
RunMode	RUNNING	Valve State	HOLDING	DC Power	OK	OK
Run Time	0073:19:01	ShutdownRelay	OFF	MAP Sensor	OK	OK
Hour Meter	120.8	ClsdLoopSwtch	ON		Open	LowExp
DC Power	23.9 volts	ManualControl	OFF	TC Upstream	OK	OK
				TC Dnstream	OK	OK
				CJC sensor	OK	OK
					Misc	
				ECU Processor	OK	
				Trigger	OK	
					High	Health
				EGO1	OK	OK
				EGO2	OK	OK
				EGO3	OK	OK

Oxygen Sensors

	Engine-Out		Cat-Out	
	Bank1	Bank2	Bank1+2(EGO3)	
EGO unfilt	0.791	0.749	0.725	volts
EGO filter	0.783	0.782	0.723	volts
EGO target	0.782	0.782	0.721	volts
EGO health	100	98	95	%
Adaptive			+0.00	%
Valve Cmd	+55.16	+52.91		%
Valve Cur	0.61	0.66		amps

Figure 2-10. PC Software Tool Display Screen Example

Modbus Communication

The GECO control is also capable of sending information to a supervisory control or SCADA system. The communication protocol is Modbus, ASCII or RTU. This function is for information distribution and is not intended or capable of remote configuration or tuning.

System Diagram Examples

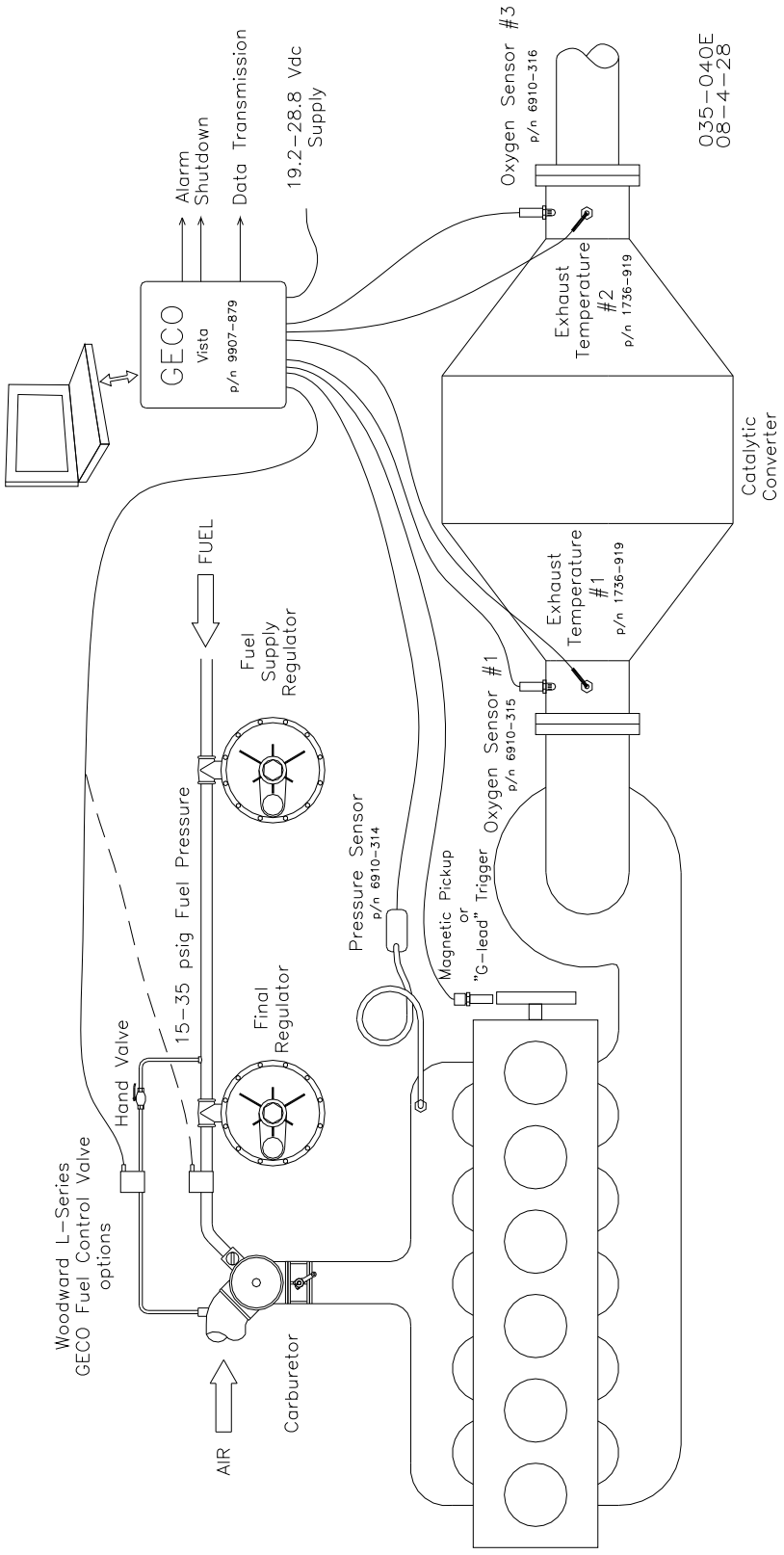


Figure 2-11. GECO System for Single Carburetor Engine

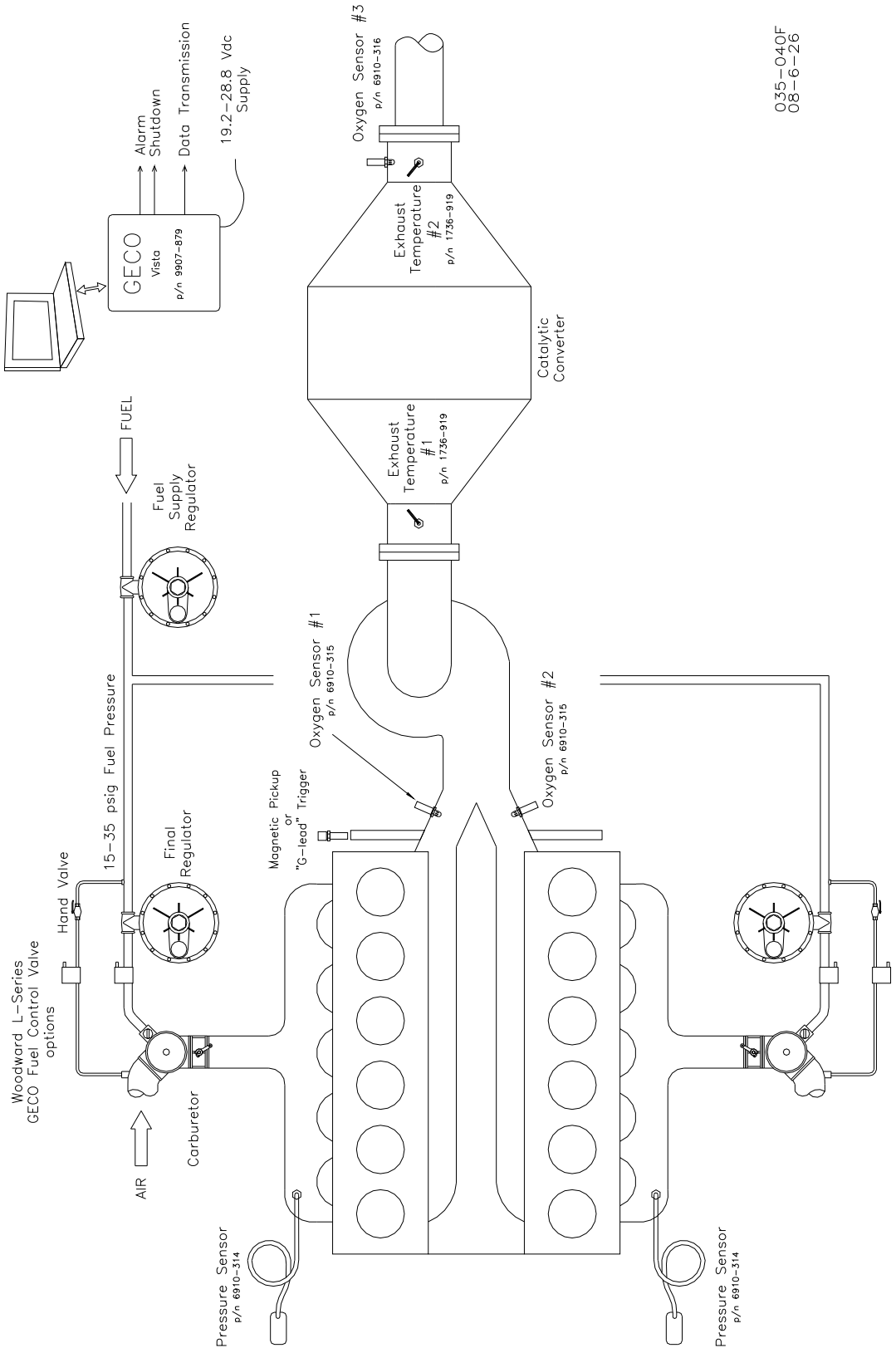


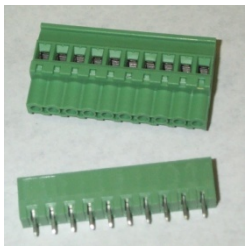
Figure 2-12. GECO System for Dual Carburetor Engine

Chapter 3.
System Components

Circuit Board Panel Assembly

[P/N 9907-867] The circuit board includes the microprocessor control and all associated electronics for power regulation, signal inputs and filtering, controlled outputs, and communications. All system connections are made directly to the board through plug-in terminal strips and connectors. The board also includes a status indicator light and a control mode switch.

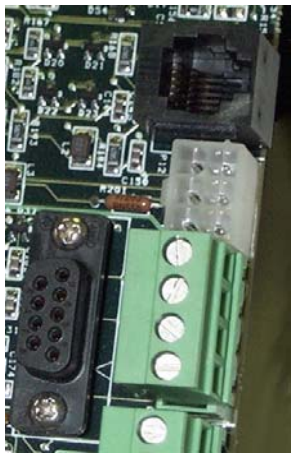
Mounting
There are four mounting holes in the circuit board. One 6.35 mm (0.250 inch) hole is located at each corner.



Connectors
The terminal strips around the edge of the circuit board are the connections for the analog and discrete I/O. There are 45 terminals total, but not all of them will be used for a typical application.

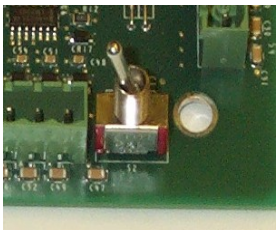
The RJ-12 modular “telephone jack” connects the hand-held terminal to the circuit board. See the section in this chapter titled “Hand-Held Terminal”.

The 6-pin Molex connector next to the RJ12 connector provides a connection to a panel or remotely mounted LED display of power, alarm, and shutdown status. See the section in this chapter titled “LED Status Indicators”.



The “DB9F” Subminiature 9-pin D connector is the RS-232C connector for communications with the PC Service Tool software running on a laptop or desktop computer. A DB9 “straight-through” male-to-DB9 female RS-232C cable is required to link the control to the computer. See the section in this chapter titled “PC Service Tool Software”. A null modem adapter is NOT required.

Power Indicator LED
The LED at the top of the circuit board indicates that power is currently applied to the circuit. Terminals 33 and 34 are the connection locations where 19.2–28.8 Vdc power is applied.



Toggle Switch
The toggle switch at the lower right corner of the circuit board provides a means to manually switch between Open Loop and Closed Loop control modes. When the switch handle is to the right, it is in Closed Loop mode.

Hand-Held Terminal

[P/N 8928-395] A weather-resistant hand-held terminal can be used for monitoring of the GECO™·Stoichiometric control. Data monitoring, oxygen sensor health, and fault checking and clearing can all be performed with this tool. Note that this hand-held terminal is not interchangeable or compatible with other Woodward hand-held programmers. See Chapter 4 for instructions on how to use the terminal.

The terminal features a 4-line by 20-character LCD display and a 24-key sealed membrane keypad. Communication with the control is through an RS-232, 6-pin RJ-12 connector (6-wire modular telephone jack). The specifications for this data terminal are as follows:

Operating Voltage:	4.8–5.3 Vdc (supplied by control)
Power Consumption:	150 mW, 470 mW with backlight
Communications:	RS-232 6-pin modular RJ-12 connector
Temperature Ratings—	
Ambient Operating Temperature:	0 to 50 °C (32 to 122 °F)
Storage Temperature:	–40 to +85 °C (–40 to +185 °F)

⚠WARNING

EXPLOSION HAZARD—The GECO enclosure should not be opened when a hazardous atmosphere is present. Wiring connections which could cause sparks are available inside the cabinet.

Do not disconnect while circuit is live unless area is known to be non-hazardous.

The GECO control must not be operated with the hand-held terminal connected to the control when a hazardous atmosphere is present.

Enclosure

[P/N 1627-101] The circuit board is enclosed in a rugged, powder-coated steel box. The enclosure is 305 x 254 x 127 mm (12 x 10 x 5 inches) with quick-release latches for easy access.

The environmental rating on this enclosure meets NEMA 12, NEMA 13, UL 50, IEC 60529, IP 65, and JIC standard EGP-1-1967. This means that the enclosure is designed to provide protection from dust, dirt, oil, and water.

There are no knockouts or pre-cut conduit openings in the enclosure. All four sides of the box are free of obstruction and available for conduit entry. We recommend locating knockouts in the bottom of the box. It is highly recommended that the circuit board be removed from the enclosure before conduit openings are added—this can be accomplished by removing the four slotted screws in the mounting plate at the back of the box.

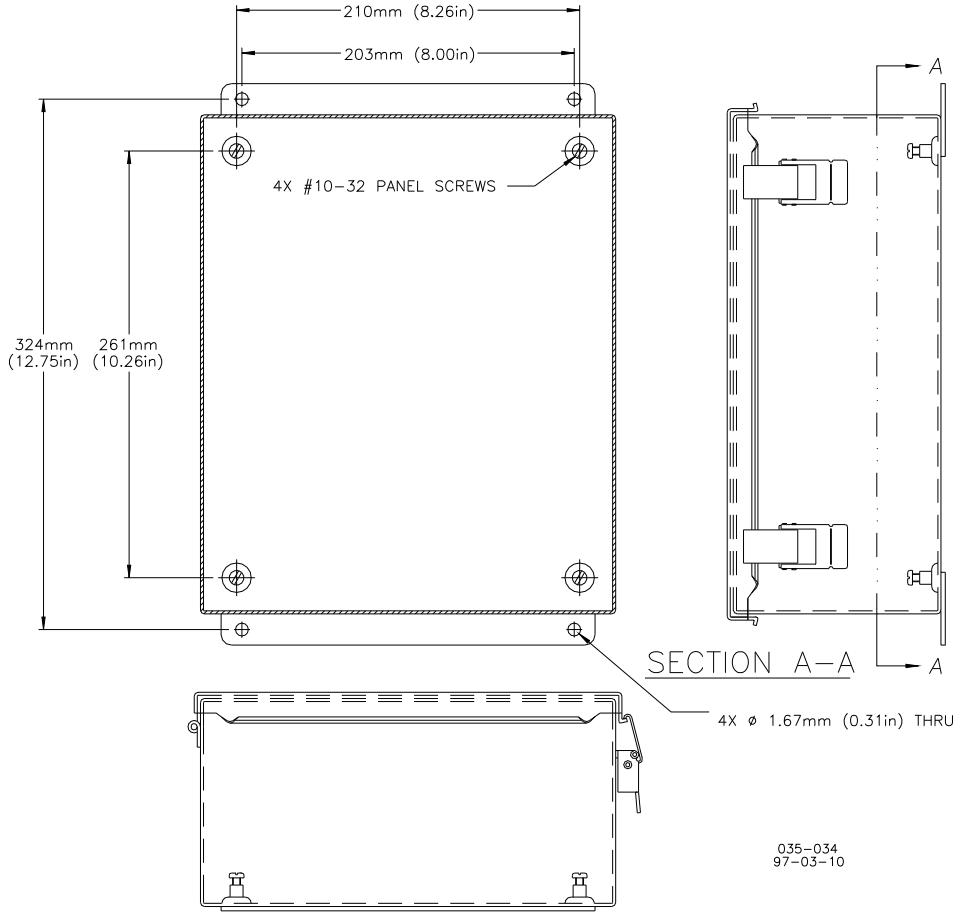


Figure 3-1. Mounting Dimensions

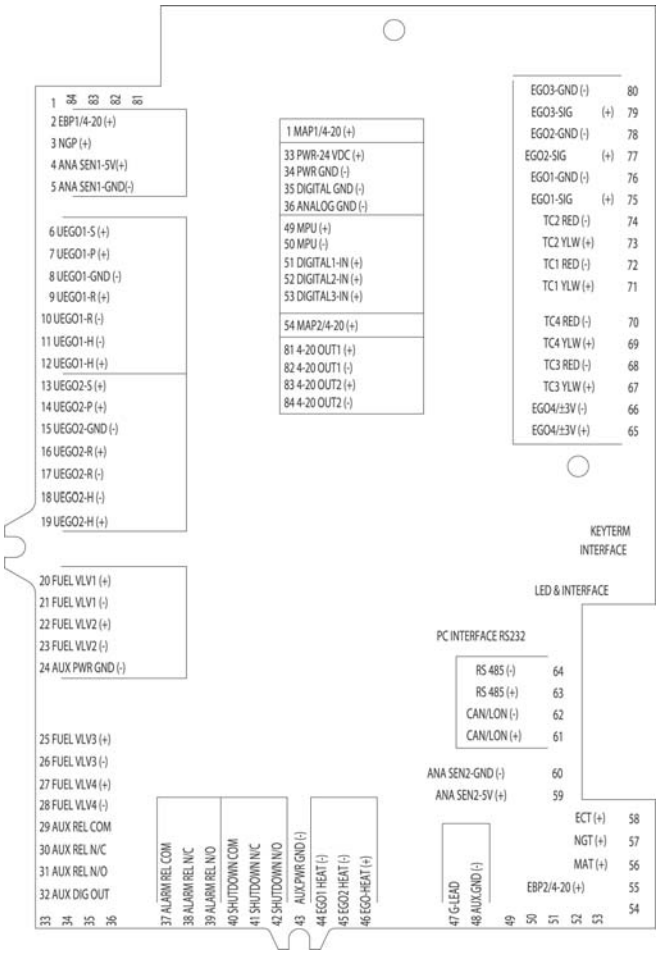


Figure 3-2. Circuit Board Cover (wiring legend plate)
[P/N 4903-101]

Fuel Control Valve for Supplementary Applications

[P/N 1310-923] In supplementary fuel applications, the GECO·Stoichiometric system controls the air/fuel ratio by adding a small amount of fuel to the intake air stream that is independent of the carburetor. This supplemental fuel represents approximately 5–10% of the total fuel flow to the engine. The GECO system adjusts this supplemental fuel with a proportional solenoid valve command and powered from the GECO circuit board. The valve position is proportional to the command signal. With loss of power the valve closes. Fuel supply pressure to the valve should be 103 to 241 kPa (15 to 35 psig). This fuel is added to the intake air a few centimeters/inches upstream of the carburetor.

Connector

The valve has a 0.5 inch (13 mm) conduit fitting with 12” long (300 mm) 22 AWG (0.3 mm²) lead wires: red is positive, black is negative.

Command

The position command from the GECO control is a 500 Hz, 0–20 V, pulse width modulated signal (PWM).

Mounting

The valve housing has four 6.9 mm (0.27 inch) through-holes in a square 41.1 mm (1.62 inch) pattern for mounting.

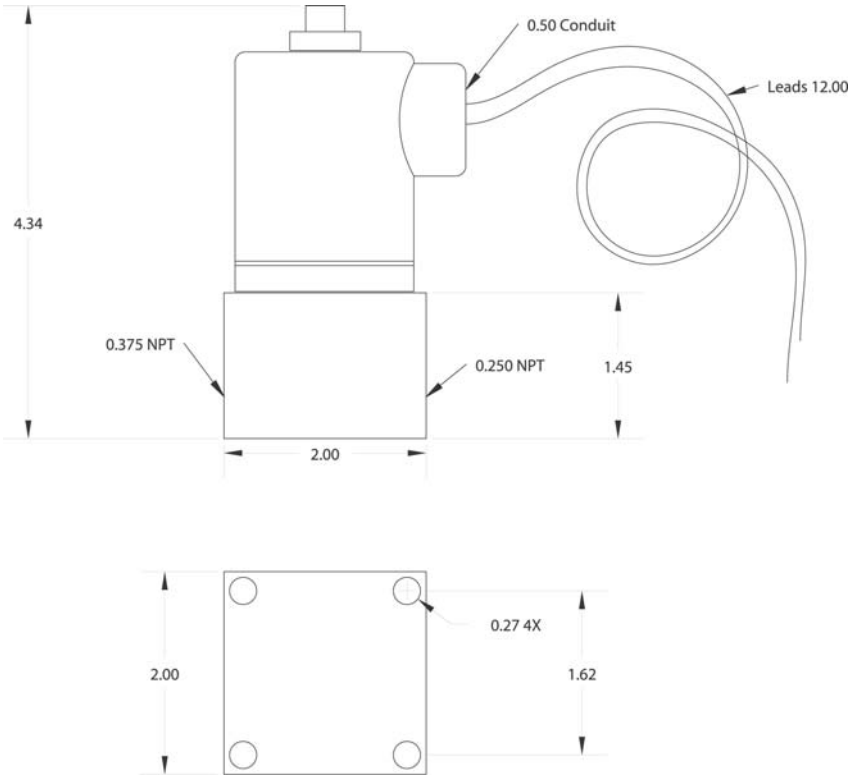


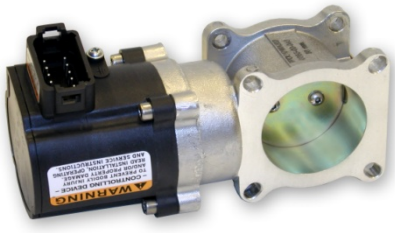
Figure 3-3. Valve Outline Drawing

The gas inlet is a 0.25 inch (6.4 mm) NPT threaded fitting and the outlet is 3/8 inch (9.5 mm) NPT.

Environmental Specifications

Temperature:	–40 to +70 °C (–40 to +158 °F)
Proof pressure:	1379 kPa (200 psig)
Coil Resistance:	14 Ω

Fuel Control Valve for Full-flow Applications



In Full-flow fuel applications, the GECO·Stoichiometric system controls the air/fuel ratio by restricting the fuel to the carburetor. The GECO system adjusts this restriction using the L-series 'Smart-Valve' to vary the pressure input to the carburetor that is adjusted slightly rich. The GECO sends a low-current PWM signal to the L-Series, which uses an integrated driver to position its butterfly valve. The valve flow is proportional to the duty cycle command signal. The L-series needs a separate 10–32 V power supply to power its onboard driver circuitry. Different L-Series models are available in five sizes ranging from 25–50 mm and also to open or close the valve upon loss of power. The L-Series valve is configured to operate with the GECO out of the box, and a PC Service Tool is included to configure the valve for additional fault and positioning features. Fuel supply pressure to the valve can be 0–30 psia. This valve is placed in between the final cut regulator and the carburetor fuel inlet.

Connector
The following Deutsch connector components are recommended for harness designs:

	Recommended	**Optional**
Mating Connector	DT06-12SA-P012	DT06-12SA
Secondary Lock	W12S-P012	N/A
Sockets	0462-201-16141	0462-201-16141

Woodward part number 8928-396 is a kit that provides all the necessary Deutsch components.

Command
The position command from the GECO control is a 500 Hz, 0–24 V, pulse-width-modulated signal (PWM).

Manual
Please refer to Woodward manual 26237 for more detailed information.

Environmental Specifications
Temperature: –40 to +105 °C (–40 to +221 °F)

Oxygen Sensors
The GECO·Stoichiometric system uses inexpensive, readily available automotive exhaust gas oxygen sensors. The two-wire unheated sensor (EGO) upstream of the catalyst is for air/fuel control feedback. A four-wire heated sensor (HEGO) downstream of the catalyst provides adaptive control for engine, catalyst, and fuel variations. The sensors are threaded for 18 mm x 1.5 ports, and high-temperature anti-seize thread lubricant must be used to facilitate sensor replacement.

Lubricants and sealants of any kind must be checked for oxygen sensor compatibility—even for use on the intake or crankcase ventilation system. Small amounts of silicone and other contaminants can poison Zirconia-based sensors.

Exhaust Gas Oxygen (EGO) Sensor

[P/N 6910-315] In locations with relatively high exhaust temperature, such as just after the exhaust manifold (pre-catalyst), an unheated oxygen sensor may be used. The minimum operating temperature is 660 °F (350 °C) for proper signal output from this sensor. Zirconia-type sensors basically give a switch signal at 450 mV and a relatively linear signal from approximately 600 mV to 800 mV. The slope of the output is very steep with small air/fuel changes at stoichiometry. This characteristic makes this type of sensor very useful for catalyst applications, where the air/fuel ratio must be held within very precise limits for effective emissions reduction. This type of sensor will generally have two leads—one for the sensor signal and the other for signal ground. The Woodward part number for the mating connector is 8928-399.

Connector Wiring:

Terminal	Wire Color	Function	GECO Terminal
1	gray	signal	75/77
2	black	signal ground	76/78

Heated Exhaust Gas Oxygen (HEGO) Sensor

[P/N 1680-6005, 6910-316] For cooler locations where exhaust temperature may be below 660 °F (350 °C), such as just after the catalyst, a heated oxygen sensor is required. The operation of the HEGO is identical to the EGO described above, however an integral electric heater applies the additional heat necessary to reach proper operating temperature. These sensors will have four leads, two wires for the sensor signal and signal ground and two for the heater circuit. The heater circuit is polarity insensitive.

Connector Wiring:

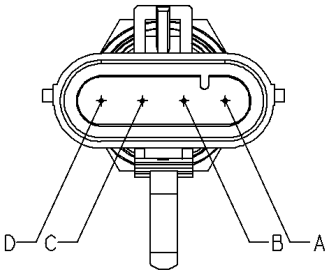
Terminal	Wire Color	Function	GECO Terminal
1	gray	signal	79
2	black	signal ground	80
3	white	heater, 12 V	46
4	white	heater, ground	44

The sensor mounts in the exhaust with an M18x1.5 thread. Any gas leakage through the threaded fitting will cause erroneous measurements. These threads should be torqued to 41 ±5 N·m (30 ±4 lb-ft).

The following Packard Connector components are recommended for HEGO harness designs:

	Recommended
Mating Connector	12162144
Secondary Lock	12047948
Crimp Terminals	12048074
Cable Seals	12048086

For convenience, Woodward part number 8928-427 is a kit that provides all the necessary Packard components.

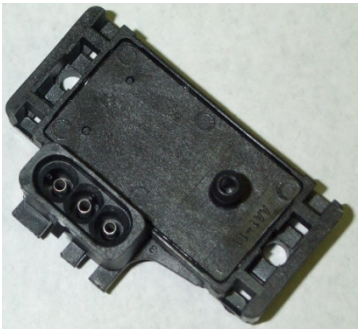


PIN A: SENSOR GROUND (GREY WIRE)
PIN B: SENSOR SIGNAL (BLACK WIRE)
PIN C: SENSOR HEATER (WHITE WIRE)
PIN D: SENSOR HEATER (WHITE WIRE)

View shown is looking into HEGO connector

Figure 3-4. HEGO Sensor Connector Pin Arrangement

MAP Sensor



[P/N 6910-314] The Manifold Absolute Pressure sensor (MAP) is used by the control to measure the intake manifold pressure. It is an absolute pressure sensor with a 300 kPa (43.5 psia) range and a 0–5 Vdc output signal. Like the EGO and HEGO sensors, it was developed for the automotive industry. This sensor is manufactured by Delphi Automotive Systems for General Motors Corporation.

The intake manifold pressure is connected to the MAP sensor via a 0.25 inch (6.4 mm) hose.

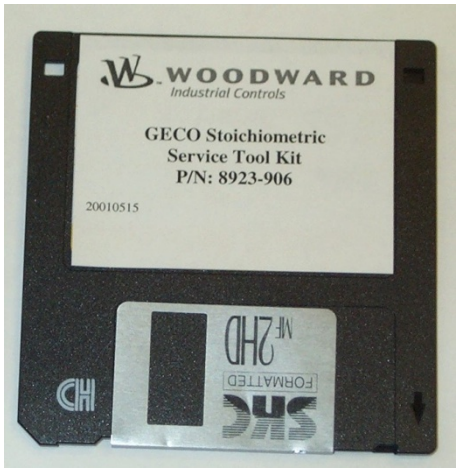
The mating connector is a Packard Electric “Weatherpack” and is available from Woodward as part number 8928-397.

A crimping tool, such as the Packard Electric 12014254 or similar, is needed for the best connections.

Connector wiring:

Terminal	Function	GECO Terminal
A	Ground	5
B	Signal	1
C	Power, 5 Vdc	4

PC Service Tool Software



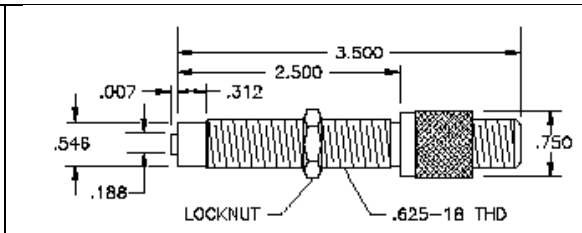
[P/N 8928-1162 (CD) or 8447-1009 (floppy disk)] The PC service tool software is executed on a Windows compatible PC. When the COM port of the PC is connected to the RS-232C port of the GECO·Stoichiometric control (DB9 connector), the service tool software will provide monitoring and display of the set-up and tuning parameters of the GECO control application software.

The RS-232C connection is made with a straight-through (no null modem adapter) cable, 9-pin “DB9” male to 9-pin “DB9” female.

Minimum PC requirements are:

- Pentium processor
- 32 MB of RAM memory
- Windows NT®, Windows® 2000/XP, Windows Vista®
- [This software will NOT run on DOS or Windows 9x.]

[P/N 202-816, 1680-622, or 1680-631] The speed sensor can be either a Magnetic Pick Up (MPU) or a signal from the ignition system “G-lead”. The control software must be configured for the speed signal source. Terminal 47 is for the “G-lead” input; terminals 49 and 50 are the MPU inputs.

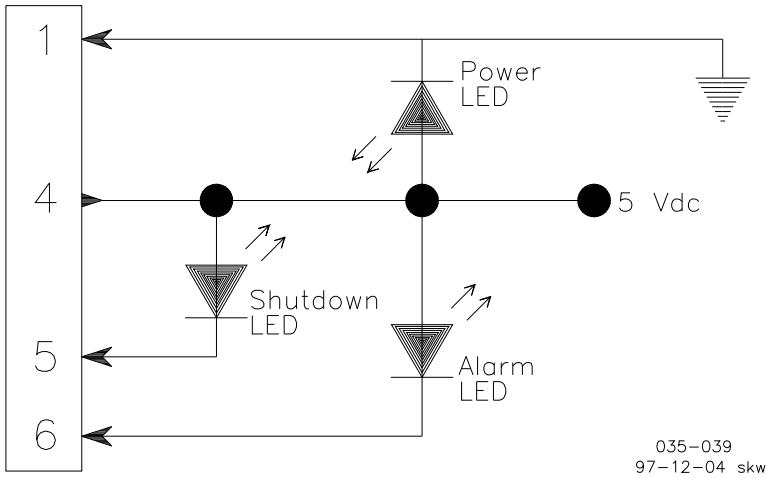


Status Indicator LEDs

If the operator wishes to install LED lights for GECO control power, alarm, and shutdown (with or without the alarm and shutdown relay outputs), the circuit board also includes a 6-pin connector specifically for indicator LEDs.

LED Wiring Diagram

The LEDs can be connected as in the wiring diagram above. Also, you can check with your GECO distributor for availability of pre-wired, panel-mounted LED modules that include a DB9 connector for a PC, or an RS12 connector for the hand-held terminal.



Chapter 4.
Control Operation

Although the GECO™·Stoichiometric control has many features, its core function is stoichiometric air/fuel ratio control. As described in the System Description and Application, the purpose for precise fuel delivery is to maximize the efficiency and performance of the three-way exhaust catalyst.

Closed Loop Strategy

The GECO·Stoichiometric control uses exhaust oxygen feedback from both upstream and downstream of the catalytic converter. This feedback comes from an automotive-style exhaust gas oxygen (EGO) or “lambda” sensor. This EGO sensor provides a very “steep” voltage versus air/fuel ratio signal in the vicinity of stoichiometry for precise fuel control feedback.

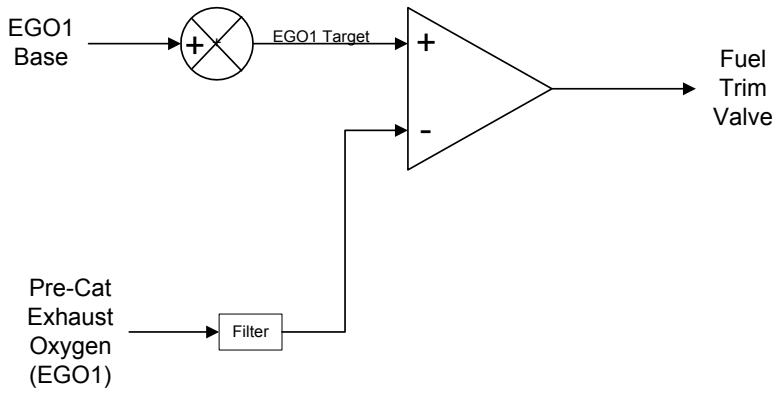


Figure 4-1. Pre-Catalyst EGO Closed Loop Control Mode Diagram

The GECO PC Tool will display the EGO feedback value in the form of a DC voltage between 0 and 1 V. This value is labeled “EGO unfiltered”. It is a “noisy” signal because of the quick response of the sensor and the high ratio of volts-to-air/fuel ratio. For this reason a filter is included to help stabilize this signal. The “EGO1/2 filter tau” value increases or decreases the amount of filtering and the “EGO filtered” value shows the results of the filtered voltage signal.

This filtered signal is compared to the “EGO target” value and the fuel trim valve command, “Valve Cmd”, is increased or decreased to make the EGO filtered value match the EGO target.

The actual pre-catalyst EGO voltage, which provides the lowest emissions, varies a little depending on many parameters, including fuel composition, ambient conditions, catalyst activity, etc. To compensate for these variations, an oxygen sensor downstream of the catalyst provides a feedback signal that correlates more consistently with actual emissions. In other words, emissions are more tightly regulated by maintaining a constant downstream EGO signal. Unfortunately, the increased feedback delay from a downstream sensor alone would make the response of the fuel control too slow. The GECO system solves these limitations with the use of both upstream and downstream oxygen sensor feedback. The upstream sensor (EGO1 and EGO2), mounted close to the engine, provides quick response to fuel control changes and allows precise control at a specific oxygen sensor target. The control then modifies this upstream EGO target based on information from the downstream EGO3 sensor—the system adaptively learns the optimum control target for the current engine operating conditions.

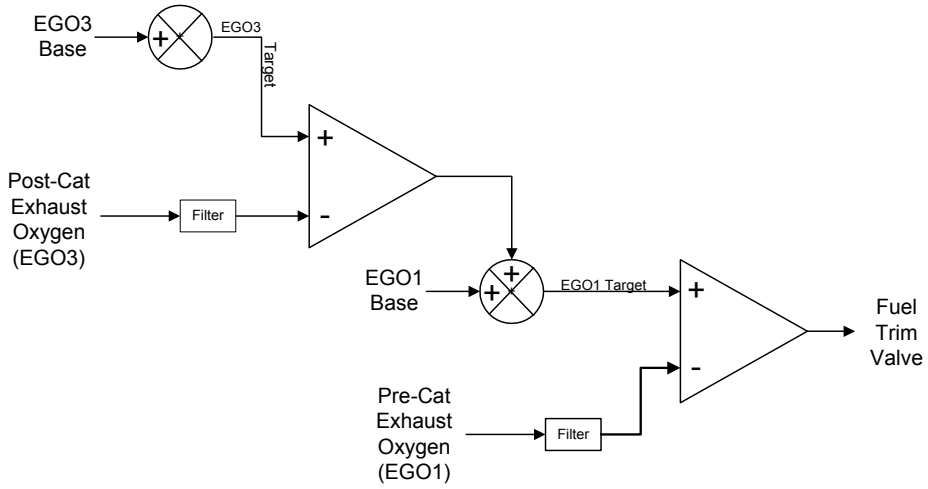


Figure 4-2. Adaptive EGO Closed Loop Control Mode Diagram

The most common upstream EGO target value is entered as the “EGO1 Base” and the “EGO2 Base” values. These values automatically become the EGO target value until the post-catalyst control modifies the EGO1/2 Base values with the “Adaptive” signal.

EGO1 Base + Adapt = EGO1 Target

The EGO1/2 Base adjusted by the Adaptive value becomes the EGO target. The Adaptive signal is the output of the post-catalyst EGO3 control. In the event that the EGO3 sensor signal is lost, the EGO target reverts back to the EGO1/2 Base value.

The “EGO3 Base” value is the “EGO3 target” value after it has been modified by the “EGO3 Offset.”

EGO3 Base + EGO3 Offset = EGO3 Target

Normally, the EGO3 Base is the optimum post-catalyst exhaust oxygen sensor voltage at engine full power. The EGO3 Offset is an adjustment to this EGO3 Base value for operating conditions at less than full power.

Dynamic adjustment of the pre-catalyst control loop is made with the closed loop gain called “K_CL” and the EGO1/2 filter tau. Adjustment of the post-catalyst control loop is with the Adaptive gain called the “K_Adapt” and the EGO3/4 filter tau.

Open Loop Strategy

Open loop means that the closed loop feedback signal is not used or is not available. In the case of the GECO·Stoichiometric control, if the EGO1 or EGO2 feedback signals are not available, the control operates in open loop mode.

In open loop operation, the control commands the fuel trim valve to take a predetermined position stored in the control software. This position comes from what is called the “Valve-Learn” table. The table contains eight load levels, and each level can have a different valve position command. Valve positions between the table values are interpolated. The load levels are identified by a normalized fuel flow called “Mdot Fuel.” These load levels can be adjusted to match the engine. Mdot Fuel is calculated from intake manifold pressure (MAP) and engine speed. It is approximately equal to the pounds per hour of fuel flow per liter of engine displacement. It requires the MAP and MPU sensor values for its calculation.

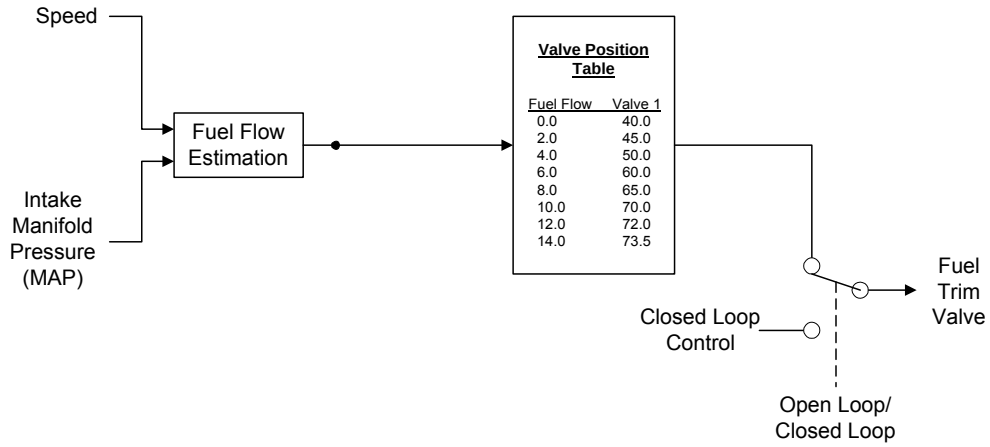


Figure 4-3. Open Loop Control Mode Diagram

These predetermined valve positions in the table are normally entered manually at the time of installation and setup. They can also be learned through an internal “Valve-Learn” function during normal closed loop operation. While the engine and control are operating in one of the closed loop modes, the control “reads” the correct valve position at the current load and enters it into the table for possible future use.

The control can be switched into open loop operation at any time by switching the open-loop/closed-loop toggle switch (the CLE switch) located on the bottom right corner of the circuit board.

Start-up Strategy

During engine start-up, the sensors do not provide useful information for engine air/fuel ratio control operation. The GECO·Stoichiometric control ignores most of these sensor readings and positions the fuel trim valve as a function of engine speed and air flow. When the engine reaches “run” speed, it enables open loop operation. When sufficient load has been added to increase air flow (called Mdot_air) to the engine to the minimum value (called Mdot_air Breakpoint) and the appropriate sensors are healthy (>40% health), it enables closed loop operation.

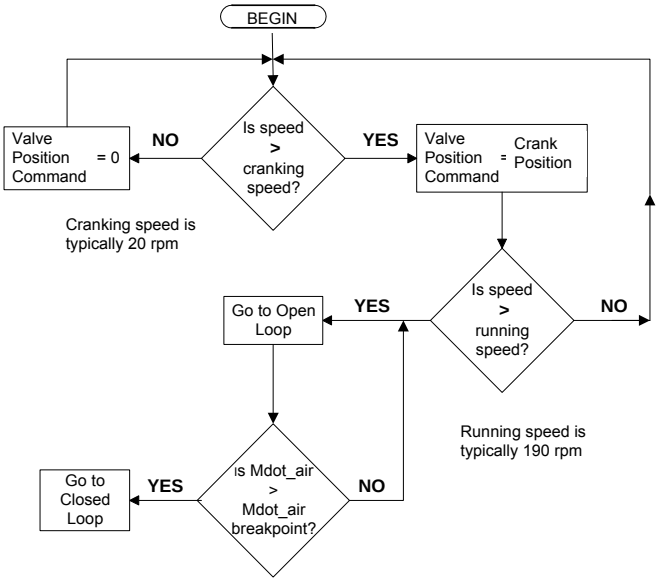


Figure 4-4. Start Sequence Flowchart

In more detail, when the engine is shut down, the speed signal reads 0 speed. At this time, the fuel valves are closed down to 0%. At cranking, the control looks for an engine speed of at least 50 rpm before opening the valves to the “Crank Default” position. The valves remain at this position until the engine accelerates to approximately 450 rpm. At 450, the valve position control passes to the Valve-Learn table. The valve position is taken from this table until the Mdot_air breakpoint is reached. This value will rise as the engine speeds up and load increases. The “Mdot_air breakpoint” is the value of “Mdot_air” at which the closed loop control is activated. This value can be set at any level but would typically be the value that represents approximately 50% load. At this time the control will move into closed loop operation.

Modbus Communication

The GECO·Stoichiometric control can serve as a Modbus “slave” unit and will respond to requests for information from a properly programmed “master.”

The table below gives some examples of the parameters available. A complete list is available in the Appendix. The register addresses in the proper Modbus format will provide the numerical or Boolean values. These values must then be scaled properly for meaningful information.

It is not necessary to read all of the information available. Modbus protocol allows you to read only the registers of interest.

This function is for information distribution and is not intended or capable of remote configuration or tuning.

RS-485
Terminals 63 and 64 on the edge of the circuit board are the RS-485 connection. This is the Modbus communication port.

Example of Modbus Register List

Address	Analog Description	Address	Boolean Description
1	Engine speed	1	MAP1 voltage high alarm
2	Intake manifold pressure	7	Battery voltage high alarm
12	Cold junction (control) temperature	9	MAP voltage low alarm
30	Closed loop control value - bank 1	15	Battery voltage low alarm
31	Closed loop control value - bank 2	35	TC2 lower than expected alarm
34	Fuel valve command - bank 1	36	TC1 lower than expected alarm
35	Fuel valve command - bank 2	39	TC2 open (high) alarm
39	Control supply voltage	40	TC1 open (high) alarm
45	Thermocouple 1 temperature	61	CL on bank 2 hit positive limit alarm
46	Thermocouple 2 temperature	62	CL on bank 2 hit negative limit alarm
		63	CL on bank 1 hit positive limit alarm
		64	CL on bank 1 hit negative limit alarm

Chapter 5.
Hand-Held Terminal Operation

Hand-Held Terminal Operation

The hand-held terminal is designed to accommodate the day-to-day monitoring functions for operation of the GECO™·Stoichiometric control. The main uses are to review current operating conditions and check for any previous faults. When a fault condition is corrected, the terminal can be used to clear the fault indication and restore normal operation (some faults will deactivate closed loop control, activate the alarm relay, or activate both alarm and shutdown relays). More extensive control and fault configuration ability is available with access code through the PC interface software.

⚠WARNING

EXPLOSION HAZARD—The GECO enclosure should not be opened when a hazardous atmosphere is present. Wiring connections which could cause sparks are available inside the cabinet.

Do not disconnect while circuit is live unless area is known to be non-hazardous.

The GECO control shall not be operated with the hand-held terminal connected to the control when a hazardous atmosphere is present.

The active keys and functions are described below. The control screens are described in the following section.

Hand-Held Navigation and Control Keys

F4

This key is used to turn on the LCD screen backlight for 60 seconds. The backlight will make the screen readable in low-light conditions.

>
ESC

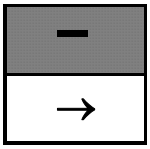
This key is used to skip to the next screen. Use of the shift key is not necessary.

<
SPACE

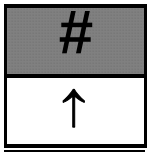
This key is used to skip to the previous screen. Use of the shift key is not necessary.

+
←

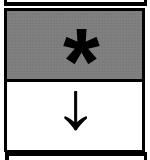
This key is used to move the blinking cursor to the next field left.



This key is used to move the blinking cursor to the next field right.



This key is used to move the blinking cursor to the next field up.



This key is used to move the blinking cursor to the next field down.

This key is used to select the current field in order to change values or control parameters. Once a new value has been typed, press the key again to enter. Control parameter options are toggled by repeatedly pressing the key. This key is also used to clear a fault or shutdown status. If the fault condition is still present, the fault indication will immediately return.

Hand-Held Terminal Control Screens

```
GECO Stoichiometric
   Air/Fuel Ratio
     Controller
5418-111-NW  05/15/01
```

1.) On system power-up, the red power indicator light on the GECO circuit board will illuminate and the hand-held terminal will boot up with the title screen. The model number for the control software, along with the revision and revision date, will be displayed.

```
   CLEAR ALL CODES
(review codes first)
   SHUTDOWNS: CLR
     ALARMS: CLR
```

2.) If fault codes need to be cleared quickly to resume normal operation, all alarm and shutdown codes can be cleared from this screen. However, for maintenance, and documentation, the individual codes should be reviewed and recorded first. If the cause for any fault has not been fixed, the fault will reactivate immediately. Press the ENTER key when a CLR field is blinking to clear all faults. Individual faults can be cleared one at a time on other screens as well.

```
SHUTDOWNS      LIMITS
Tcupstrm:OK    1300 F
TCdnstrm:SD    1400 F
Control:OK
```

3.) A fault on the thermocouple screen indicates that an overtemperature condition has occurred on one of the catalyst temperature sensors. The limit values may be changed. Highlight any fault (Hi) field and press the ENTER key to clear. An open thermocouple connection will also cause a Hi fault. Any other fault condition configured for shutdown will be indicated by Control:SD.

```
     Hi Hth      Hi Lo
EGO1:OK OK  VL1:OK OK
EGO2:OK OK  VL2:OK OK
EGO3:OK OK  AL: OK OK
```

4.) This screen shows faults associated with the exhaust gas oxygen sensor signals or control which depends on EGO feedback. An EGO Hi fault indicates a signal voltage higher than a properly operating sensor can produce. Hth (Health) OK means that the EGO health has not dropped below 35%. The VL (Valve Limit) Hi and Lo faults are set when the closed loop valve commands reach their limits without bringing the EGO signal to its target. The EGO3 AL (Adaptive Limit) faults are similar, activating when the adaptive shifting of the EGO1 and EGO2 target values reaches a limit without bringing EGO3 to its own target value for best emissions. More information on fault causes can be found in the Trouble-shooting section.

```
       Hi Lo   Misc
Valv1i:OK OK   ECU: OK
Valv2i:OK OK   Trig:OK
DCPowr:OK OK
```

5.) The fuel metering valve electrical screen shows faults for high or low current. If the actual valve current does not match the valve command current, these faults will set. Further explanation of these faults can be found in the Troubleshooting section. This screen also displays a high or low voltage from the power supply. The miscellaneous faults on this screen are for internal ECU operation and problems with the engine speed signal.

```
        Open  LoExp
TCup:   OK    OK
TCdn:   OK    OK
CJC:    OK    OK
```

6.) In addition to the shutdown screen which indicates excessive catalyst temperatures, this screen shows faults for the actual signal from the thermocouple sensors. TCup refers to the catalyst upstream sensor, and TCdn refers to the downstream sensor. An open fault indicates an open circuit, or loss of sensor connection. The lower-than-expected fault indicates an unbelievably low temperature signal during operation. CJC refers to the Cold Junction Compensation sensor on the ECU. More information on these faults can be found in the Troubleshooting section.

```
EGO  Volt  Target  Hlth
1    0.XXX 0.XXXV  XX%
2    0.XXX 0.XXXV  XX%
3    0.XXX 0.XXXV  XX%
```

7.) The EGO monitoring screen displays signal and target voltages for all of the oxygen sensors. The EGO1 and EGO2 targets will adaptively change to keep the EGO3 signal near its “best emissions” target. In addition, the health of the sensors can be checked for anticipating future maintenance.

```
RPM    XXXX    Ctl1 ADPT
Mode   RUN     Ctl2 OPEN
Hrs    XXXX    Tcup XXXX
DCPwr  XX.X    TCdn XXXX
```

8.) Additional operator information is included in this screen. The engine speed, engine mode, and run time since the last control power-up are displayed. The power supply voltage is shown as DCPwr. CTL1 and CTL2 show whether the control is in closed-loop or adaptive operation, or whether a fault or warm-up period is causing open-loop control. Open-loop operation can also be activated by the manual switch on the circuit board or with the hand-held terminal or PC interface. The catalyst upstream and downstream temperatures are also displayed.

```
GAIN    %  BASE  Volts
ClsdLp 20 EGO1 0.XXX
Adapt  10 EGO2 0.XXX
          EGO3 0.XXX
```

9.) This screen shows the valve commands and actual valve current. Records of these values can be helpful in diagnosing valve-related problems or trending valve deterioration. The adaptive EGO target shift is also displayed; the percentage values are somewhat arbitrary but give a rough indication of actual air/fuel ratio changes.

Hand-Held Terminal Configuration Screens

IMPORTANT **Password required for these screens. Contact your distributor for more information.**

```
Valv1  +XX.X%  0.Xxamp
Valv2  +XX.X%  0.Xxamp
Adapt  -X.X%
Manual Valv Mode OFF
```

10.) The closed loop and adaptive gain values control system response and stability. Higher numbers produce faster control response, but stability is reduced. The EGO1&2 Base voltages center the adaptive authority range. These values should be set to typical EGO1&2 target values during nominal operation. The EGO3 Base value is the EGO3 target, which is set during emissions calibration. Follow the tuning procedures in Chapter 4 or the recommendation of your distributor when adjusting these values.

```
Misc Alarm   Config
EGO          TC
MaxV:ON      Open :SD
Hlth:OF      LoExp:ON
```

11.) This screen allows faults to be configured to activate the alarm or shutdown relays, or to be inactive. ON status would activate the alarm relay, SD activates both alarm and shutdown relays, and OF is inactive.

```
Valve Configuration
ALARM V1 V2   DEFAULT
CrntH:SD ON   Run 45 %
CrntL:OF OF   Cnk 35 %
```

12.) This screen allows faults to be configured to activate the alarm or shutdown relays, or to be inactive. ON status would activate the alarm relay, SD activates both alarm and shutdown relays, and OF is inactive. During open-loop running or cranking, valve commands are default values.

```
I/O Configuration
VALV    TC      EGO1:ON
1:ON    up:ON   EGO2:OF
2:OF    dn:ON   EGO3:ON
```

13.) The I/O is configured for single- or dual-bank engines. Valve 2 and EGO2 are for dual-bank engines only. EGO3 is needed for catalyst-downstream oxygen sensing, which is required for adaptive catalyst control. The catalyst temperature thermocouple inputs are also activated on this screen.

```
Engine Xface Config
RPM_SIGNL
Source:G
P/Rev:6
```

14.) The engine interface configuration gives several choices for the engine-running signal to the control. Usually, the RPM source is set to G for G-lead input, or MPU for magnetic pick-up input. The pulses per rev value need to be correct for this signals to correlate to true engine speed. If speed signals are not available, the control can be activated by a switch signal through the digital input D1.

Hand-Held Programmer Configuration

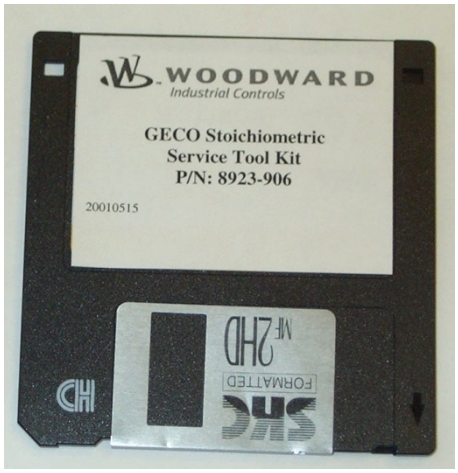
A hand-held set-up mode is activated by holding down any key when power is applied. Although it should never be necessary to change this configuration, it can be initiated accidentally during power-up or when the unit is disconnected from the GECO circuit board. The first screen displays “Contrast.” The 1 key will increase, and the 2 key will decrease the LCD display contrast. The 3 key accepts the current value. The next screen displays “Baud: 9600.” This value must be at 9600 Baud for proper operation—the GECO control communicates only at this speed. The last set-up screen displays “DF: 8n.” The data format must be 8n1 for proper operation.

IMPORTANT

If the Modbus Baud is set to 19200, then the Hand-Held will not communicate to the GECO. If you require the Hand-Held terminal and the Modbus communications simultaneously, then the Modbus Baud must be set to less than 19200.

Chapter 6.
PC Interface Software Operation

Introduction



The PC service tool software is executed on a Windows compatible PC. When the COM port of the PC is connected to the RS-232C port of the GECO™ Stoichiometric control (DB9 connector), the service tool software will provide monitoring and display of the set-up and tuning parameters of the GECO control application software.

The RS-232C connection is made with a straight-through (no null modem adapter) cable, 9-pin “DB9” male to 9-pin “DB9” female.

The GECO PC software includes the interface screens with separate “frames” for related data or functions. The following sections explain operator navigation and describe the individual screens, frame by frame. Like the Hand-Held Terminal, many of the frames indicate fault status, and these faults can be cleared using the ENTER key. In addition, the PC interface allows configuration changes.

To install the GECO PC interface software:
1. Insert the CD or diskette in the appropriate disk drive.
2. Run the file named “GECOPC_Setup.exe” and follow the on-screen instructions, selecting an install folder and default COM port.

To start the GECO PC software:
1. With a DB9 male to DB9 female RS-232 cable, connect the on-line control DB9 female RS-232 port to the PC DB9 serial port.
2. Using the Start menu, go to Programs and find the newly created GECO PC Service Tool shortcut.
3. Run this shortcut to execute the Service Tool file.

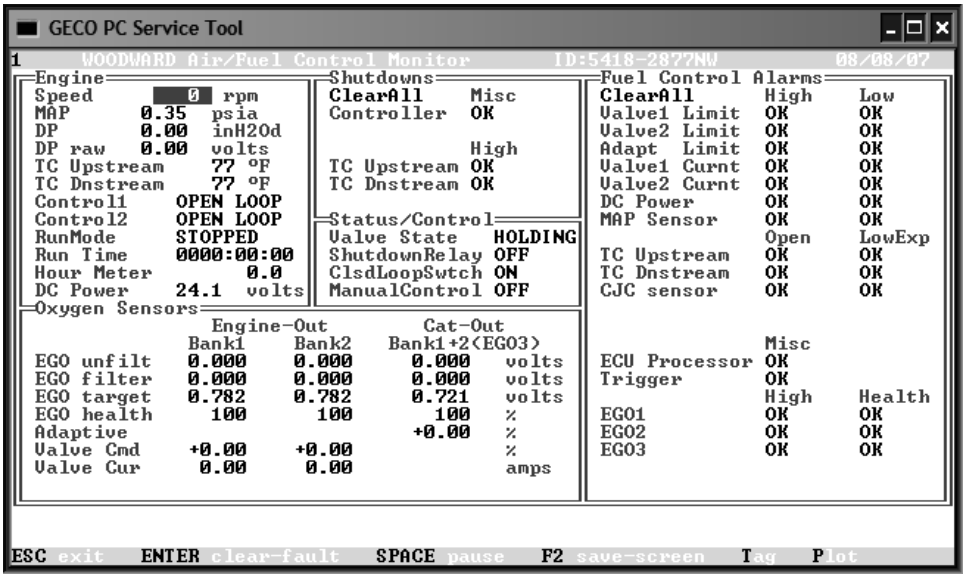
The control will attempt communication on the requested COM port before closing on a failed communication attempt. If a different COM port is needed, it must be entered in the command line as a “-“ flag (i.e. GECO_PC.exe – com3). If metric units are needed, add “-siunits.” If the “-siunits” flag is not used, the default units are US.

Screen Navigation

All interface screens show the following reminders along the bottom of the screen:
ESC exit **ENTER** modify **SPACE** pause **PGUP-PGDN** screen **F2** save **T**ag **P**lot

The PgUp and PgDn (page up and page down) keys are used to toggle through each individual screen. Screens 2, 3, and 4 require password access (contact your GECO distributor for more information). The interface screens also show a reverse-color cursor highlighting the current configurable variable. This cursor is moved to other variable locations with the arrow keys on the PC keyboard. A mouse interface device is NOT supported. To change a variable, press Enter when the variable is selected with the cursor. A command line will appear near the bottom of the screen where new values may be entered. In the case of a variable which has modes (rather than a numerical value), such as fault disable/enable/enable+shutdown, the modes can be toggled with the arrow keys, then selected with the ENTER key. The current text information from any screen can be saved to a file with the F2 function key. The ESC (escape) key will exit from the GECO interface program.

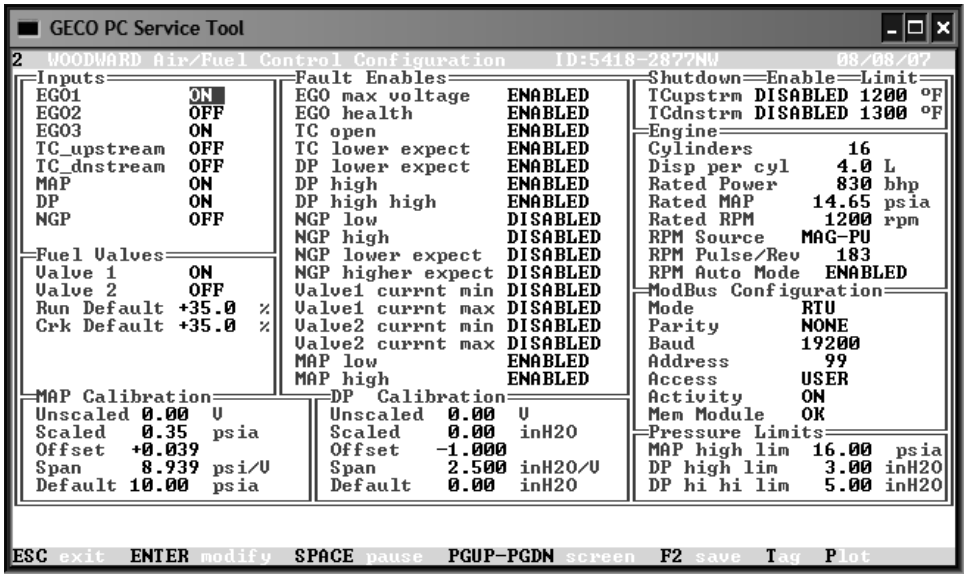
The GECO PC software includes four main interface screens with separate “frames” for related data or functions. The following sections explain operator navigation and describe the individual screens, frame by frame. Like the hand-held terminal, many of the frames indicate fault status, and these faults can be cleared using the computer (the Troubleshooting section covers the complete explanation of fault causes). In addition, the PC interface allows configuration changes, including some that are not available through the hand-held terminal.



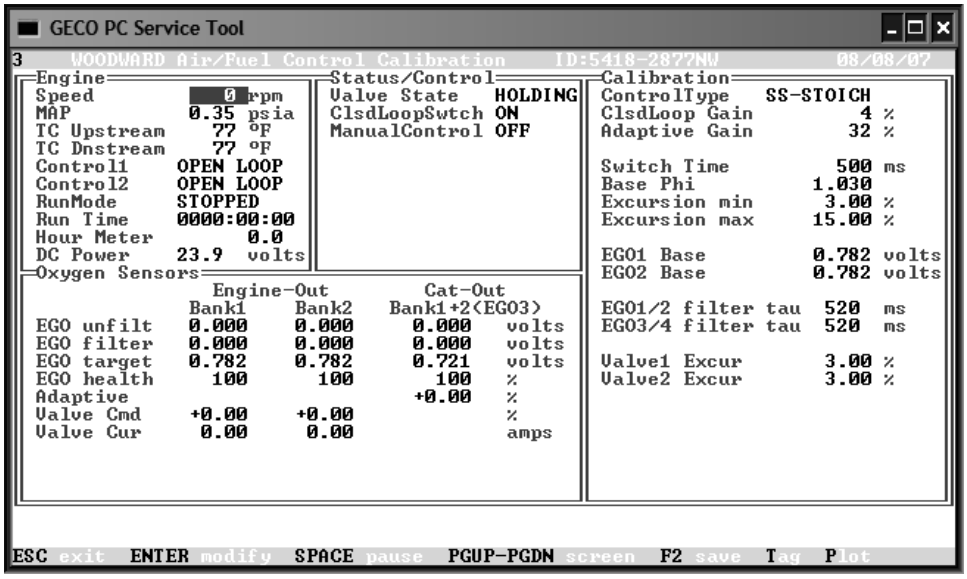
Screen 1: GECO·Stoichiometric Air/Fuel Control Monitor

IMPORTANT

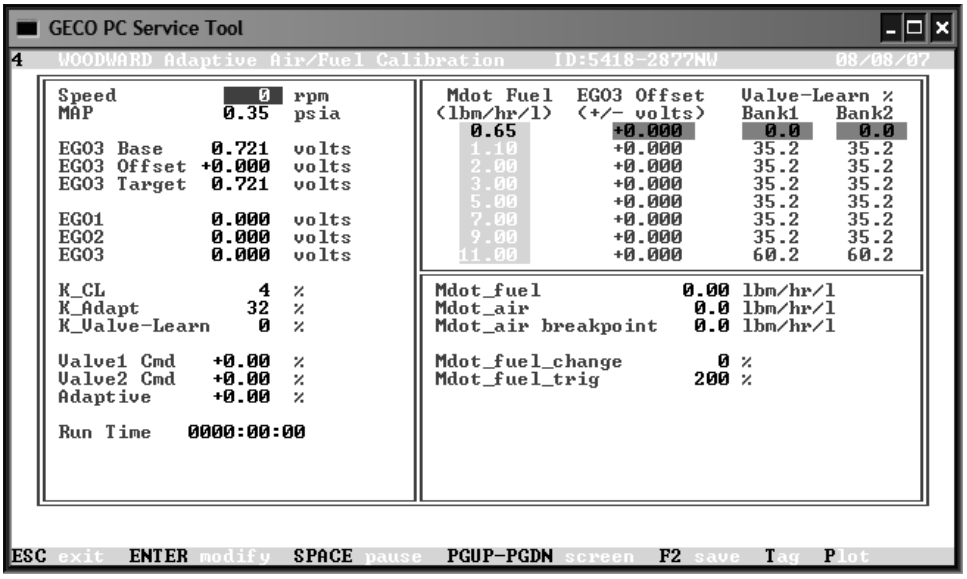
Access to screens 2, 3, and 4 requires entering a password for configuration protection. Contact your GECO distributor for more information.



Screen 2: GECO·Stoichiometric Air/Fuel Control Configuration (password protected)



Screen 3: GECO·Stoichiometric Air/Fuel Control Calibration (password protected)



Screen 4: GECO·Stoichiometric Adaptive Air/Fuel Calibration (password protected)

The following is an explanation of the individual screen frames:

Screen 1: Engine

Engine	
Speed	0 rpm
MAP	10.00 psia
DP	0.35 inH2Od
DP raw	0.00 volts
TC Upstream	1020 °F
TC Downstream	1080 °F
Control1	OPEN LOOP
Control2	OPEN LOOP
RunMode	STOPPED
Run Time	0000:00:00
Hour Meter	0.000
DC Power	23.9 volts

Speed: Engine rpm from magnetic pickup (MPU) or "G-lead". (This value defaults to 1350 if the Digital In RUN signal is used.)
MAP: Intake manifold absolute pressure in pounds per square inch.
DP: Differential Pressure across the catalyst in inches of Water differential.
DP raw: Differential Pressure input voltage.
TC Upstream: Pre-catalyst thermocouple input in degrees F.
TC Downstream: Post-catalyst thermocouple input in degrees F.
Control1: OPEN LOOP, CLOSED LOOP, CL+ADAPTIVE. These are the air/fuel ratio control modes.
Control2: Same as Control1 except for Bank 2.
RunMode: STOPPED, CRANKING, RUNNING. These are the start sequence modes. Once the engine reaches idle speed, it should be in the RUNNING mode.
Run Time: The time, in hours, since the last engine start.
Hour Meter: The total engine run time since the control was installed.
DC Power: Power supply voltage to the circuit board.

This frame shows the status of the input fault detection function:

Screen 1: Shutdowns

```
          Shutdowns

ClearAll          High
TC Upstream       OK
TC Downstream     OK

Misc.
Controller        OK
```

ClearAll: Clears all shutdown faults.
TC Upstream: OK/SHUTDN/clear shutdown.
TC Dnstream: OK/SHUTDN/clear shutdown. If exhaust temperature thermocouples are used, they can be configured to shut the engine down when the alarm is tripped. This indicates if that is the cause of a shutdown.
Controller: OK/SHUTDN/clear shutdown. This will indicate if the control has triggered a shutdown command.

IMPORTANT **Tech Tip: Controller shutdown indicates any ENABLED+SD faults (from Fault Enables on screen 2).**

Screen 1: Status/Control

```
        Status/Control

Valve State       HOLDING
ShutdownRelay         OFF
ClsdLoopSwtch         ON
ManualControl         OFF
```

ShutdownRelay: OFF, ON. The state of the shutdown output.
Valve State: HOLDING, ACTIVE. The state of the Control Valve.**ClsdLoopSwtch**: OFF, ON. The position of the closed loop switches on the circuit board.
Manual Mode: OFF, ON. This mode can be activated only while in the OPEN LOOP control mode. It allows for manual positioning of the control valves.

Screen 1: Oxygen Sensors

```
                    Oxygen Sensors

                 Engine-Out          Cat-Out
                Bank1     Bank2   Bank1+2(EGO3)
 EGO unfilt     0.642     0.656      0.675    volts
 EGO filter     0.618     0.661      0.698    volts
 EGO target     0.600     0.600      0.712    volts
 EGO health        34        97         90    %
 Adaptive                             +2.10    %
 Valve Cmd     +33.00    +65.00              %
 Valve Cur       0.41      0.59              amps
```

EGO unfilt : Oxygen sensor signals before filtering.
EGO filter: Oxygen sensor signals after filtering.
EGO target: Target values for CL and adaptive.
EGO health: Remaining “life” of sensor.
Adaptive: Adaptive control shift for EGO3 (Cat-Out)
Valve Command: Valve opening command.
Valve Cur: Actual valve control current.

Screen 1: Fuel Control Alarms
[See Troubleshooting section for description of fault causes]

```
        Fuel Control Alarms

 ClearAll        High     Low
 Valve1 Limit    OK       OK
 Valve2 Limit    OK       OK
 Adapt  Limit    OK       OK
 Valve1 Curnt    OK       OK
 Valve2 Curnt    OK       OK
 DC Power        OK       OK
 MAP Sensor      OK       OK
                 Open     LowExp
 TC Upstream     OK       OK
 TC Downstream   OK       OK
 CJC sensor      OK       OK

                 Misc.
 ECU Processor   OK
 Trigger         FAULT
                 High     Health
 EGO1            OK       FAULT
 EGO2            OK       OK
```

ClearAll: Clears all alarm faults
Valve1 Limit: Fault sets when the CL valve commands reach their limit without bringing the EGO signal to its target.
Valve2 Limit: See above
Adapt Limit: Similar to valve limits, sets when the adaptive shift of the EGO1 or EGO2 targets reaches their limit without bringing EGO3 to its best emissions target value
Valve1 Current: Current doesn't match command.
Valve2 Current: Current doesn't match command.
DC Power: Power supply voltage out of range.
MAP Sensor: MAP Sensor problem.
TC Upstream: TC signal problem.
TC Downstream: TC signal problem.
CJC sensor: TC cold junction sensor problem.
ECU Processor: Internal microprocessor problem.
Trigger: Speed signal problem.
EGO1: Signal too high or poor health value.
EGO2: See above.
EGO3: See above.

Screen 2: Inputs

```
          Inputs

 EGO1             ON
 EGO2             ON
 EGO3             ON
 TC_upstream      ON
 TC_dnstream      ON
 MAP              OFF
 DP              OFF
 NGP              OFF
```

EGO1: ON/OFF.
EGO2: ON/OFF.
EGO3: ON/OFF.
TC_upstream: Catalyst inlet temperature ON/OFF.
TC_downstream: Catalyst outlet temperature ON/OFF.
MAP: Inlet manifold temperature ON/OFF.
DP: Diff Pressure input ON/OFF.
NGP: Auxiliary input ON/OFF.

Screen 2: Fuel Valves

```
        Fuel Valves

 Valve 1           ON
 Valve 2           ON
 Run Default       +35.0%
 Crk Default       +0.0%
```

Valve 1: ON/OFF- This turns the Valve1 output off and on
Valve 2: ON/OFF.
Run Default: XX %: This is the failsafe position the valve is commanded to take if all other control functions are lost.
Crank Default: XX %- This is the position the valve is commanded to take when the control recognizes the engine is cranking.

Screen 2: MAP Calibration

```
      MAP Calibration
Unscaled       0.00  V
Scaled         0.35  psia
Offset        +0.039
Span           8.939 psi/V
Default       10.00  psia
```

Unscaled: Raw MAP input voltage
Scaled: Manifold Absolute Pressure in psia.
Offset: The offset applied to the MAP voltage input and is the low-end calibration variable.
Span: The multiplier applied to the MAP voltage input and is the high-end calibration variable.
Default: The value that the MAP scaled reads when the higher than expected limit is reached.

Screen 2: DP Calibration

```
      DP Calibration
Unscaled     0.00  V
Scaled       0.00  inH2O
Offset      -1.000
Span         2.500 inH2O/V
Default      0.00  inH2O
```

Unscaled: Raw DP input voltage
Scaled: Differential Pressure in inH2O.
Offset: The offset applied to the inH2O voltage input and is the low-end calibration variable.
Span: The multiplier applied to the DP voltage input and is the high-end calibration variable.
Default: The value that the DP scaled reads when the higher than expected limit is reached.

Screen 2: Pressure Limits

```
      Pressure Limits
MAP High lim   16.00  psia
DP High lim     3.00 inH2O
DP hi hi lim    5.00 inH2O
```

MAP high lim: MAP high limit that causes a MAP high fault.
DP high lim: DP high limit that causes a DP high fault.
DP hi hi lim: DP high limit that causes a DP high high fault.

Screen 2: Fault Enables

Fault Enables	
EGO max voltage	ENABLED
EGO health	ENABLED
TC open	ENABLED
TC lower expect	ENABLED
EBP low	ENABLED
EBP high	ENABLED
EBP higher expect	ENABLED
NGP low	ENABLED
NGP high	ENABLED
NGP lower expect	ENABLED
NGP higher expect	ENABLED
Valve1 currnt min	ENABLED
Valve1 currnt max	ENABLED
Valve2 currnt min	ENABLED
Valve2 currnt max	ENABLED
MAP low	ENABLED
MAP high	ENABLED

All faults configurable:
alarm ENABLED/DISABLED
alarm and shutdown
ENABLED+SD/DISABLED

IMPORTANT **Tech Tip: It is best to leave faults enabled and turn off unused sensors on the Inputs frame.**

Screen 2: Shutdowns

Shutdown	Enable	Limit
TCupstrm	ENABLED	1300 °F
TCdnstrm	ENABLED	1400 °F

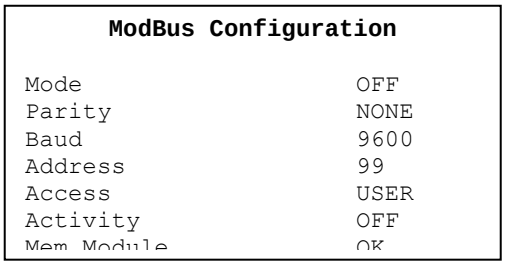
TCupstream:
ENABLED/DISABLED–temp limit.
TCdownstream:
ENABLED/DISABLED–temp limit.

Screen 2: Engine

Engine	
Cylinders	6
Displacement	10.0 L
Rated Power	250 bhp
Rated MAP	30.00 psia
Rated RPM	1800 rpm
RPM Source	OFF
RPM Pulse/Rev	3
RPM Auto Mode	ENABLED

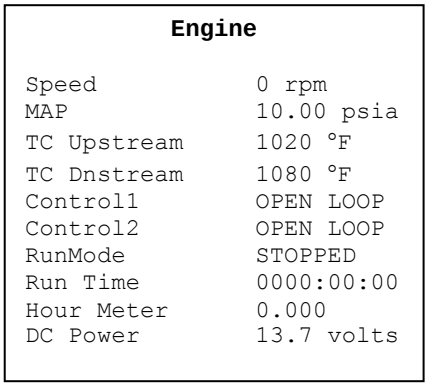
Cylinders: Number of engine power cylinders.
Displacement: Nominal displacement of each cylinder in liters.
Rated Power: Engine rated brake horsepower.
Rated MAP: Intake manifold absolute pressure at rated power.
Rated RPM: Engine rated speed.
RPM Source: Magnetic pickup or G-lead. This identifies the source of the speed signal.
RPM Pulse/Rev: The number of gear teeth per revolution seen by the magnetic pickup.
RPM Auto Mode: ENABLED or DISABLED. When DISABLED, the start sequence switches from CRANKING to RUNNING at 450 rpm. When ENABLED, this switch takes place at a speed calculated from the Rated RPM. This allows the control to be used on engines that run at less than 450 rpm. A 300 rpm engine will switch at 250 rpm.

Screen 2: Modbus Configuration



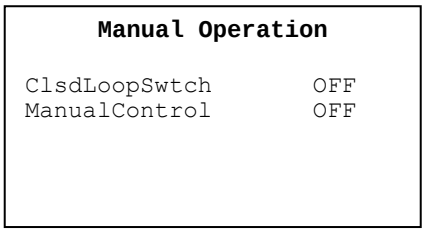
Mode: ASCII, RTU, or OFF.
Parity: EVEN, ODD, or NONE.
Baud: 1200, 2400, 4800, 9600, or 19200. Choice of possible communication baud rates.
Address: 0-247. Modbus slave address.
Access: USER, or OPERATOR.
Activity: YES or NO, this indicates that the control is currently recognizing communication activity on the RS485 port.
Mem Module: OK, this indicates that the Modbus memory circuitry is functional.

Screen 3: Engine



Speed: Engine rpm from magnetic pickup (MPU) or "G-lead." (This value defaults to 1350 if the Digital In RUN signal is used).
MAP: Intake manifold absolute pressure in pounds per square inch absolute.
TC Upstream: Pre-catalyst thermocouple input in degrees F.
TC Downstream: Post-catalyst thermocouple input in degrees F.
Control1: OPEN LOOP, CLOSED LOOP, CL+ADAPTIVE. These are the air/fuel ratio control modes.
Control2: (same).
RunMode: STOPPED, CRANKING, RUNNING. These are the start sequence modes. Once the engine reaches idle speed, it should be in the RUNNING mode.
Run Time: The time, in hours, since the last engine start.
Hour Meter: The total engine run time since the control was installed.
DC Power: Power supply voltage to the circuit board.

Screen 3: Manual Operation



ClsdLoopSwtch: OFF, ON. The position of the closed loop switch on the circuit board.
Manual Mode: OFF, ON. This mode can be activated only while in the OPEN LOOP control mode. It allows for manual positioning of the control valves.

Screen 3 Oxygen Sensors

```
                    Engine-Out          Cat-Out
                    Bank1 Bank2         Bank1+2 (EGO3)
 EGO unfilt         0.642  0.656        0.675  volts
 EGO filter         0.618  0.661        0.698  volts
 EGO target         0.600  0.600        0.712  volts
 EGO health         34     97           90%
 Adaptive           +2.10%
 Valve Cmd          +33.00 +65.00%
 Valve Cur          0.41   0.59 amps
```

EGO unfiltered: Oxygen sensor signals before filtering.
EGO filter: Oxygen sensor signals after filtering.
EGO target: Target values for CL and adaptive.
EGO health: Remaining "life" of sensor.
Adaptive: Adaptive control shift for EGO3 (Cat-Out).
Valve Command: Valve opening command.
Valve Cur: Actual valve control current

Screen 3: Calibration

```
          Calibration

ControlType          SW-STOICH
ClsdLoop Gain        20 %
Adaptive Gain        10 %

Switch Time          700 ms
Base Phi             1.010
Excursion min        0.03 %
Excursion max        0.15 %

EGO1 Base            0.600 volts
EGO2 Base            0.600 volts

EGO1/2 filter tau    61  ms
EGO3/4 filter tau    76  ms

Valve1 Excur         0.04 %
```

ControlType: SS-STOICH/steady-state SW-STOICH/switching-mode.
ClsdLoop Gain: Control response to EGO1/2 errors.
Adaptive Gain: Control response to EGO3 errors.
Switch Time: Cycle time for switching-mode.
Base Phi: Base point (0% adaptive) for switch-mode.
Excursion min: Switching-mode excursion limit.
Excursion max: Switching-mode excursion limit.
EGO1 Base: Voltage corresponding to Base Phi.
EGO2 Base: Voltage corresponding to Base Phi.
EGO 1/2 Filter Tau: EGO sensors 1 & 2 filter time constant.
EGO 3/4 Filter Tau: EGO sensors 3 & 4 filter time constant.
Valve1 Excursion: Valve excursion in switching-mode.
Valve2 Excursion: Valve excursion in switching-mode.

IMPORTANT

Tech Tip: Base Phi centers the adaptive slightly rich for effective catalysis. If adaptive limit alarms are consistently being set always high or low, EGO Base should be shifted to center the adaptive zero point.

Screen 4: Calibration

```
Speed           1200 rpm
MAP             22.32 psia

EGO3 Base       0.712 volts
EGO3 Offset     +0.061 volts
EGO3 Target     0.773 volts

EGO1            0.781 volts
EGO2            0.784 volts
EGO3            0.778 volts

K_CL            20 %
K_Adapt         10 %
K_Valve-Learn   10 %

Valve1 Cmd      +33.00 %
Valve2 Cmd      +65.00 %
Adaptive        +2.10 %

Run Time        0002:15:59
```

Speed: Engine rpm from magnetic pickup (MPU) or "G-lead". (This value defaults to 1350 if the Digital In RUN signal is used).
MAP: Intake manifold absolute pressure in pounds per square inch.
EGO3 Base: The primary EGO3 reference voltage value at nominal or full power conditions. This value plus the EGO3 Offset becomes the EGO3 Target voltage.
EGO3 Offset: The amount that the EGO3 Base voltage is adjusted to accommodate better catalyst performance at off load or off speed conditions.
EGO3 Target: The reference voltage that the adaptive control loop is trying to maintain.
EGO1: Oxygen sensor signal voltage from the pre-catalyst EGO sensor on bank 1.
EGO2: Oxygen sensor signal voltage from the pre-catalyst EGO sensor on bank 2.
EGO3: Oxygen sensor signal voltage from the post-catalyst EGO sensor.
K_CL: The proportion gain value of the closed loop control.
K_Adapt: The proportion gain value of the adaptive control loop.
K_Valve-Learn: The gain value of the valve position learning function that determines how quickly the recorded valve position value moves toward the current value.
Valve1 Command: The bank 1 valve position command value from the closed loop control.
Valve2 Command: The bank 2 valve position command value from the closed loop control.
Adaptive: The value of the adaptive control loop output that modifies the EGO Base value to get the EGO1/2 Target value.
Run Time: The time, in hours, since the last engine start.

Screen 4: Valve Learn Table

Mdot Fuel (lbm/hr/l)	EGO3 Offset (+/- volts)	Valve-Learn % Bank1	Bank2
0.65	+0.050	35.2	35.2
1.10	+0.050	35.2	35.2
2.00	+0.061	35.2	35.2
3.00	+0.061	35.2	35.2
5.00	+0.030	35.2	35.2
7.00	+0.000	35.2	35.2
9.00	-0.030	35.2	35.2
11.00	-0.030	35.2	35.2

Mdot Fuel: These values represent the operating range of the engine in terms of fuel mass flow per liter of engine displacement. These eight values should be evenly distributed from idle to full power. The highlighted values are the two values between which the control is interpolating an open loop valve position command.
EGO3 Offset: The EGO3 Offset values that are used at each load point to adjust the EGO3 Base voltage to accommodate better catalyst performance at off load or off speed conditions. These values are added to the EGO Base to get the EGO Target.

Valve-Learn %: The learned fuel valve position commands that the control will use in the event that OPEN LOOP mode is activated for any reason. A position is learned for each load point represented by the Mdot Fuel values above. New values are learned only when the engine is operating in a steady state and the K_Valve_Learn is greater than zero. When utilized, actual fuel valve position command values are interpolated from the two closest values from the table.

Screen 4: Valve Learn Parameters

```
Mdot_fuel             2.20 lbm/hr/l
Mdot_air              20.0 lbm/hr/l
Mdot_air breakpoint   10.0 lbm/hr/l

Mdot_fuel_change      0 %
Mdot_fuel_trig        30 %
```

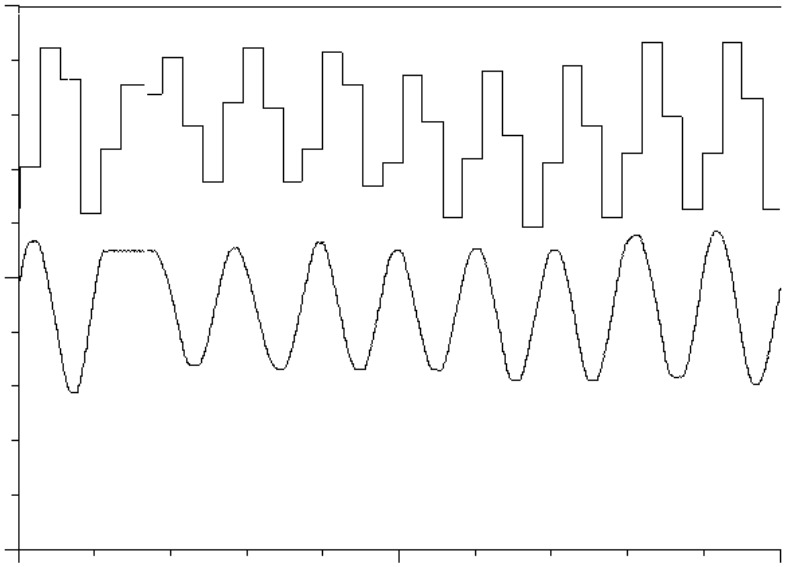
Mdot_fuel: The current calculated fuel mass flow value in units of pounds per hour per liter of engine displacement.
Mdot_air: The current calculated air mass flow value in pounds per hour per liter of engine displacement.
Mdot_air breakpoint: The value of air mass flow above which the closed loop function is enabled. Also, it divides “high loads” from “low loads” for purposes of blocking the Valve-Learn function.
Mdot_fuel_change: The current fuel flow derivative or rate of change in units of percent per second. This is a measure of the magnitude of engine transient response to a load change.
Mdot_fuel_trig: The trigger point at which the control temporarily switches to OPEN LOOP mode and utilizes the Valve-Learn table for better transient response by the control.

Plotting and Data Logging

```
Enter the full scale time in seconds (10.000000): 10.0
Do you want to datalog the variables to disk? (y/n)? (N): y
Enter the datalogging sampling interval in seconds (0.05000): 0.05
Enter the datalogging output file name (datalog.dat): datalog.dat

Datalogging initialized to record FIRST 10.0000 seconds of data to the file
DATALOG.DAT

Press any key to start datalogging.
```



A very useful feature for troubleshooting is the plotting and data logging capability of the GECO·Stoichiometric interface software. Up to six variables may be selected with the cursor and the T (Tag) key. The selected data is then displayed in a scanning, scope-type format with the P (Plot) key.

Display time scale and data logging information will be requested by the software, but the defaults (10 second scan, no logging) can be accepted by simply pressing the ENTER key at these input lines to quickly display the data. The space bar key will freeze (pause) the display for review. To return to the interface screens, press the ESC (escape) key.

If data logging is desired, the program will request information about the data time intervals and file names as shown on the plot information screen. The first full-scale time scan will be saved to the file with data for every sampling interval step. The normal plotting function will continue thereafter. These data files can then be reviewed and used to generate reports or graphs in other software applications.

Chapter 7.
GECO™ Vista HMI Display

Overview

The GECO™ Vista includes a Human Machine Interface (HMI) display that allows monitoring and logging of key GECO information. The screen communicates to the GECO via RS-485 RTU Modbus at 19200 baud, parity none, and slave address 99. The screen also provides for limited historical and real-time trending coupled with diagnostic monitoring to allow full utilization of the GECO Vista AFR control. The screen firmware can be modified to meet your specific needs such as activating the V-bank Main screen (Figure 7-4) and is capable of Ethernet connection to a PC server for system data gathering as well as flash drive upload of stored data, please contact your GECO distributor for options.

Navigation

When powered up, the HMI starts on the Splash screen (Figure 7-2), and when touched will switch to the Main display screen (Figure 7-3). To cycle through the pages, press the NEXT and BACK button.

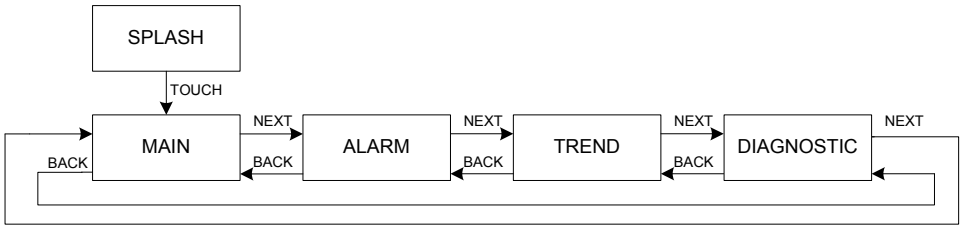


Figure 7-1. GECO Vista HMI Screen Navigation

Figure 7-2. GECO Vista HMI Splash Screen

Main Screen

The Main screen allows access to the key operating information such as engine speed, manifold pressure, catalyst health, and control status.

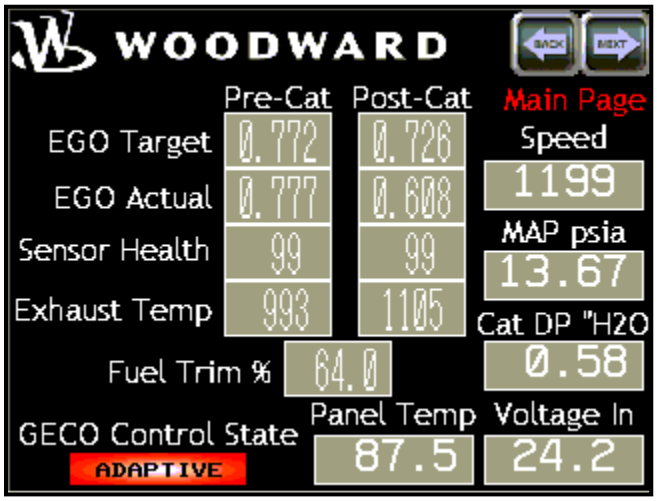


Figure 7-3. GECO Vista Main Screen

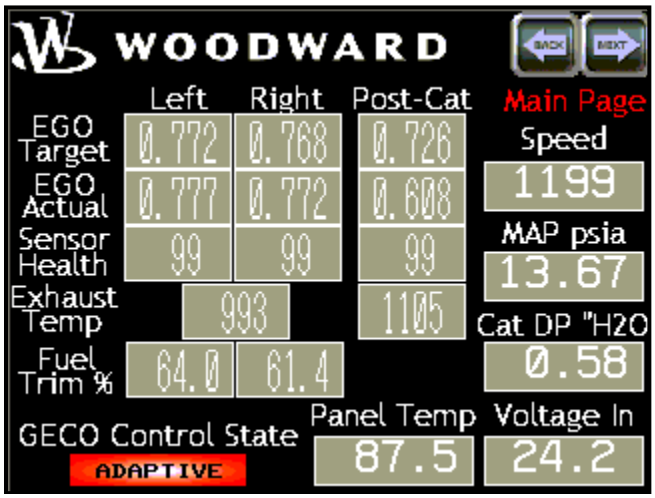


Figure 7-4. GECO Vista V-Bank Main Screen

Alarm Screen

The Alarm screen displays system diagnostic information in table form. New Alarms will appear at the top of the screen and older alarms will drop towards the bottom. The Date and time of the occurrence is displayed along with a detailed description of the fault. The Alarms and Shutdowns may be cleared by pressing the respective reset button. The faults are not permanently logged and will drop out when the reset button is pressed.

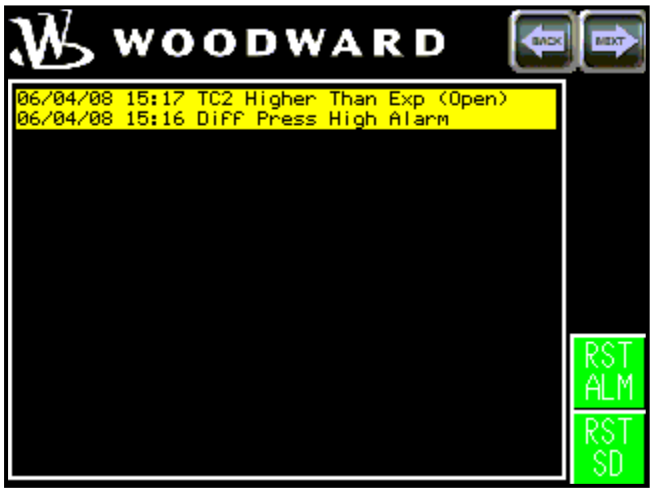


Figure 7-5. GECO Vista Alarm Screen

Trend Screen

The Trend screen displays a real-time rolling chart of the key closed-loop values. The values are displayed in text at the bottom of the screen and the colors key the trendlines above. The screen displays a total of one minute of data.

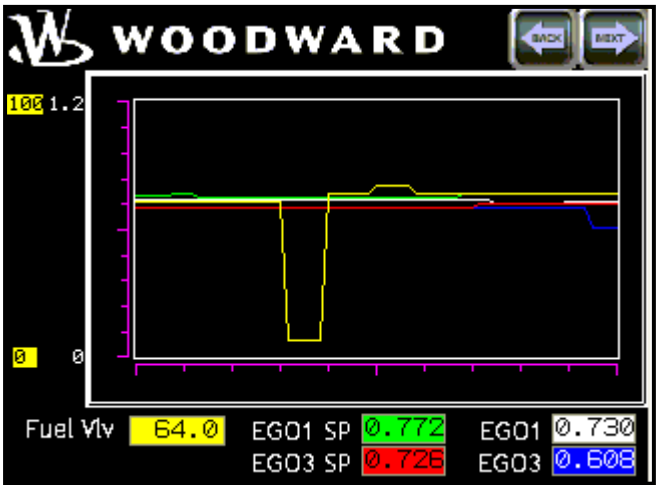


Figure 7-6. GECO Vista Trend Screen

Diagnostic Screen

The Diagnostic screen displays information critical to troubleshooting wiring and control problems. This screen provides a window into the control inputs and outputs and may allow a technician to expose simple problems without connecting the PC Service Tool.

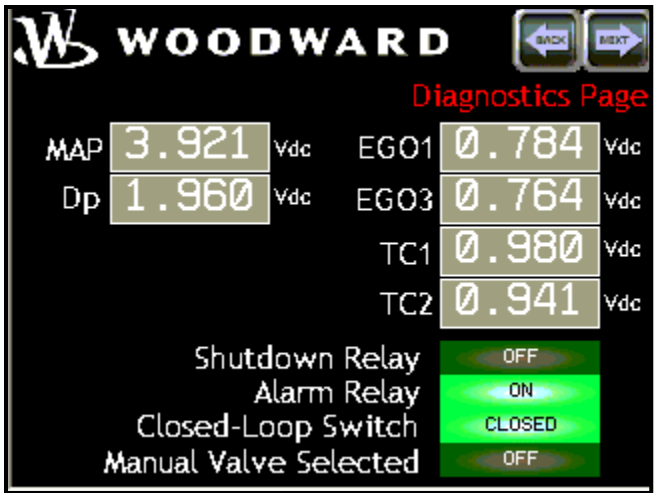


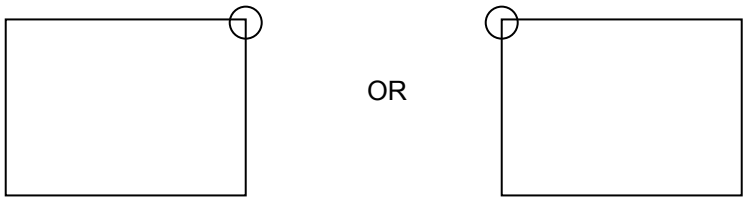
Figure 7-7. GECO Vista Diagnostic Screen

HMI Display Offline Mode

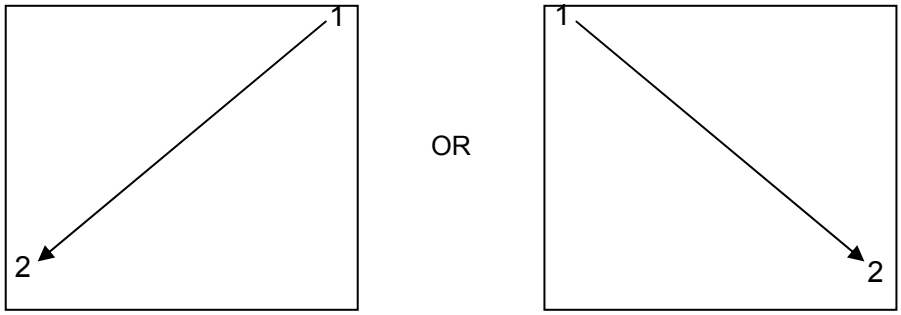
The HMI display can be placed in OFFLINE mode to set the current time and date.

Entering Offline Mode
There are two ways of entering Offline Mode. First is immediately after powering up the unit, and the second uses the Forced Reset feature.

After powering up the unit:
Touch the upper right corner or upper left corner (within 40 pixels of the edges) of the panel screen for at least 3 seconds soon after the start-up screen is displayed.

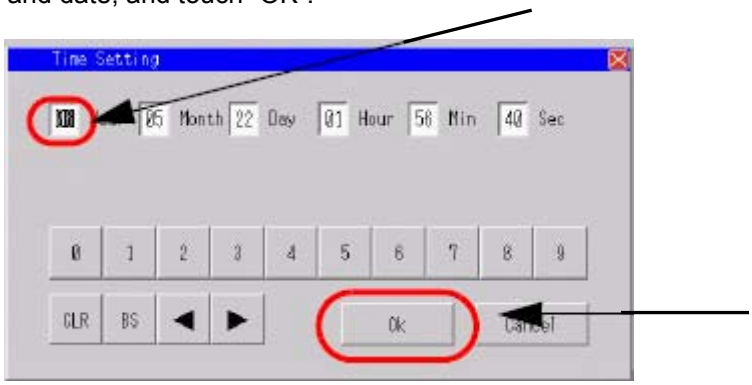


When operating the unit:
Touch either the upper right and lower left corners, or the upper left and lower right corners (within 40 pixels of the edges) of the panel screen in this order within 0.5 seconds



The System Menu will be displayed, touch the “Offline” button:

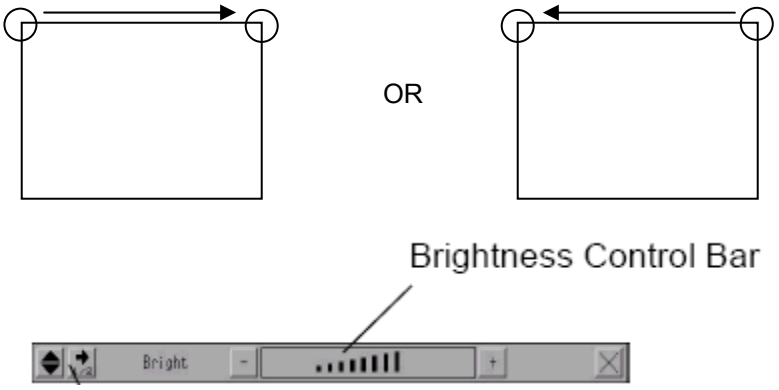
To set the current time and date, touch the date/time in the lower right corner, enter the time and date, and touch “OK”.



Touch “Exit” and select “Save changes and exit” to reset the HMI display.

HMI Screen Brightness Adjustment

This mode must be entered during Run mode only. Touch either the upper right and upper left corners, or the upper left and upper right corners(within 40 pixels of the screen edge) within 0.5 seconds.



Chapter 8. Installation/Setup

The GECO™·Stoichiometric system installer should be able to perform the following tasks with a high level of quality and workmanship, with consideration given to any applicable laws and regulations for the specific location.

Installation Tasks

- Provide a suitable control mounting location.
- Install weather-tight conduit and wiring, including grommet-end junction boxes and automotive-style electrical connectors.
- Provide the control with a magnetic pickup speed signal.
- Drill and tap (or weld) the oxygen sensor port into the engine exhaust system.
- Drill and tap (or weld) the MAP sensor ports into the intake system.
- Cut and weld tubing and flanges. Fabricate strong, stiff mounting brackets with consideration for vibration and fatigue.
- Provide a power source for the control.
- Provide a 5 A slow-blow fuse installed in line with the power supply input.
- Analyze exhaust emissions for calibration.
- Operate a laptop computer to calibrate the GECO·Stoichiometric control.

IMPORTANT

If the installer is unfamiliar or unable to complete any of the installation requirements listed above, contact your GECO·Stoichiometric distributor for information on qualified installers.

Included GECO·Stoichiometric Components

- GECO·Stoichiometric control
- Fuel trim valve(s)
- MAP sensor
- EGO sensor(s)
- HEGO sensor
- MAP, EGO, and HEGO sensor connectors
- GECO·Stoichiometric control manual

Optional GECO·Stoichiometric Components

- Hand Held Terminal
- Catalyst Thermocouples
- Catalyst Differential Pressure sensor
- Magnetic Pick-Up
- Speed Switch

Required Installer-Provided Components

- 9–30 Vdc power supply, 70 W for the control (for GECO Stoichiometric)
- 19.2–28.8 Vdc (class 2) power supply, 83 W for the control (for GECO Vista model)
- Electrical conduit
- Wiring as shown in the plant wiring diagrams
- “G-lead” type ignition speed signal (250 V max), OR magnetic pickup speed signal (100 V p-p max), OR switched “run” signal of 3–32 Vdc
- Oxygen sensor port (18 x 1.5 mm internally threaded, gasket spot face or weld bung)
- Fittings for fuel source, fuel trim valve and injection point
- Air-tight high-temperature fittings for catalyst temperature sensors
- Mounting bracket for the fuel metering valve
- Hose, clamps, and fittings for MAP pressure signal

⚠WARNING **Input power must be supplied from an NEC or CEC class 2 power source.**

Optional Installer-Supplied Components

- Appropriate fuel plumbing from 15–30 psig fuel source to the shut-off valve and trim valve and from the valve to the injection point
- Manual shut-off valve(s) for the trim valve plumbing (1/4-turn valve)
- Indicator lights/annunciator panel
- Alarm relay circuit
- Shutdown relay circuit

Unpacking

Before handling the control, read Electrostatic Discharge Awareness at the beginning of this manual. Be careful when unpacking the electronic control. Check the control for signs of damage such as bent panels, scratches, and loose or broken parts. If any damage is found, immediately notify the shipper.

Power Requirements

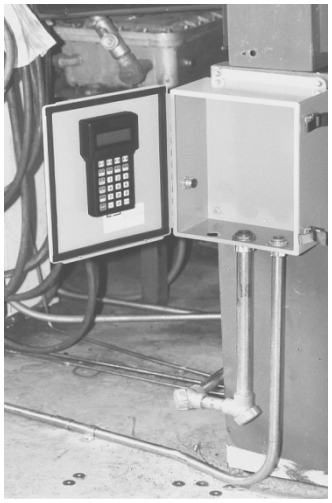
The GECO Vista control requires a voltage source of 19.2 to 28.8 Vdc, and draws a maximum of 83 W. The GECO Stoichiometric control requires a voltage source of 9.0 to 30.0 Vdc, and draws a maximum of 70 W. A 5 A slow-blow fuse should be installed in-line with the power supply input.

IMPORTANT **If a battery is used for operating power, an alternator or other battery-charging device is necessary to maintain a stable supply voltage.**

All tunable values which have been changed in the programming mode will stay in memory on power supply failure. For proper operation, the control requires an engine speed signal from a magnetic pickup speed sensor or ignition system “G-lead” (250 Vdc max.) from the ignition or a 3–30 V “run” signal.

NOTICE **To prevent damage to the control, do not exceed the input voltage range. Make sure that the alternator or other battery-charging device is turned off or disconnected before disconnecting the battery.**

Control Location Considerations



- Access to and clearance for front cover
- Access for conduit on bottom or sides of unit
- Ventilation
- Space for servicing and repair
- Protection from direct exposure to water or to a condensation-prone environment
- Protection from high-voltage or high-current devices, or devices which produce electromagnetic interference
- Avoidance of vibration; if the control is mounted to an engine skid, shock isolators are required; contact your GECO distributor for more information
- Selection of a location that will provide an operating temperature range of –40 to +70 °C (–40 to +158 °F) (for GECO Stoichiometric Model) or 0 to +40 °C (+32 to +104 °F) (for GECO Vista Model) internal box temperature
- Access to earth ground for grounding the enclosure

See the Enclosure Outline Diagram below for mounting hole locations.

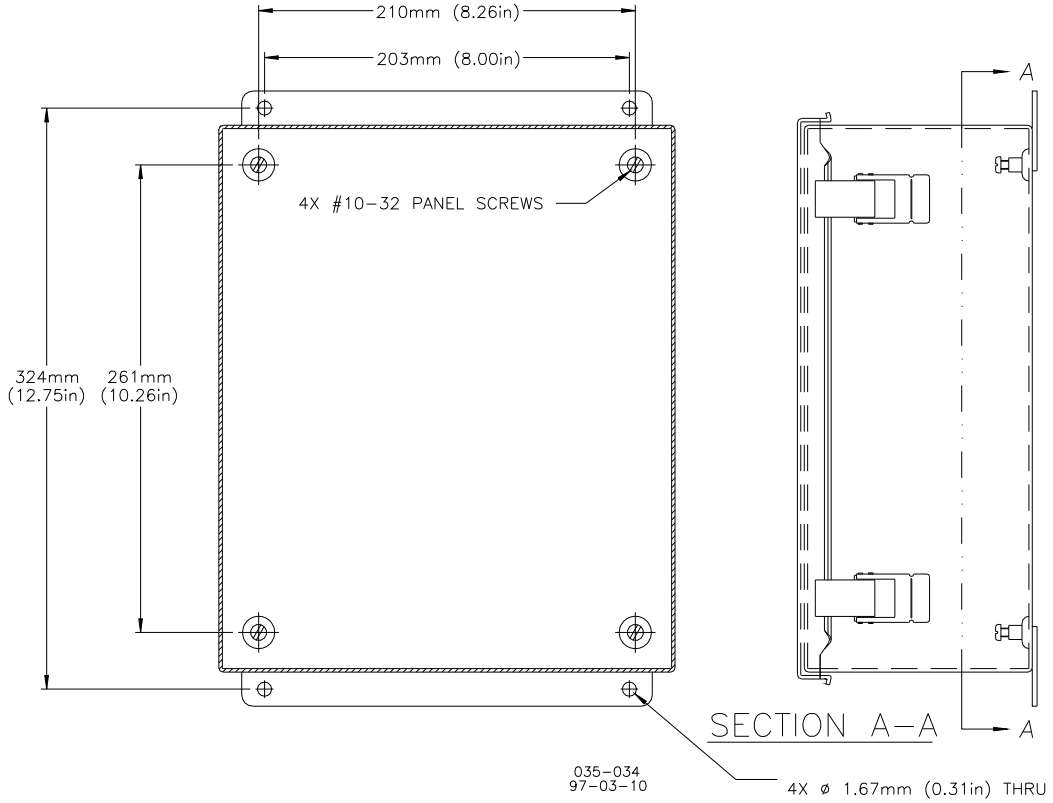


Figure 8-1. Enclosure Outline Drawing

IMPORTANT

To avoid damage to the circuit board it should be removed from the enclosure before mounting or punching conduit holes. The circuit board is attached to a mounting plate for easy removal and re-installation.

Class I, Division 2, Groups A, B, C, D Hazardous Locations

See Regulatory Compliance page for listing details for marked controls.

⚠WARNING

Installation wiring must be in accordance with Class I, Division 2 wiring methods in Article 501-4(b) of the NEC, and in accordance with the authority having jurisdiction. Due to the hazardous location listings associated with this product, proper wire type and wiring practices are critical to operation.

⚠WARNING

EXPLOSION HAZARD—Substitution of components may impair suitability for Class I, Division 2.

Do not connect or disconnect equipment while circuit is live unless the area is known to be non-hazardous.

Wiring Installation

This wiring should not run in the same conduit as wiring carrying alternating current or high voltage wiring signal wire. Any new alarm and shutdown wiring for the operator control panel such as switches, lights, horn, or gages should also be installed at this time. The GECO enclosure should be properly connected to earth ground.

Making Electrical Connections

External wiring connections and shielding requirements for control installation are shown in the Plant Wiring Diagram. Shielded cable with spiral wrapped foil and a separate twisted shield wire or braided shield cable is recommended for all sensor input, control output, and communications wiring.

Shielded Wiring

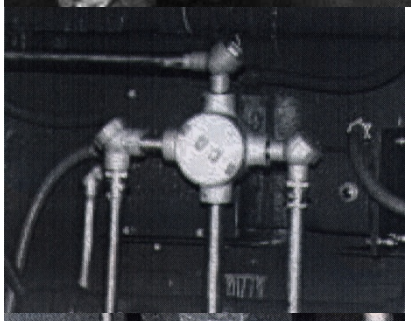
All shielded cable must be twisted-conductor pairs. Do not attempt to tin the twisted shield wire. All signal lines should be shielded to prevent picking up stray signals from adjacent equipment. Connect the shields to the indicated terminals on the Plant Wiring Diagram. Wire exposed beyond the shields should be as short as possible. The sensor end of the shields must be left open and insulated from any other conductor. DO NOT run shielded signal wires along side or in the same conduit with other wires carrying large currents.

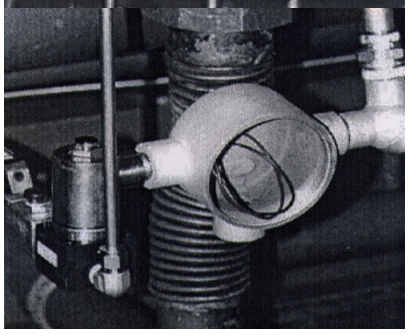
Where shielded cable is required, cut the cable to the desired length and prepare the cable as instructed below:

- Strip outer insulation from BOTH ENDS, exposing shield and wire. DO NOT CUT THE SHIELD WIRE.
- Carefully remove the excess foil shield, leaving enough shield wire to reach the proper GECO control terminal.
- Separate the inner conductor(s) from the shield. If the shield is the braided type, twist it to prevent fraying.
- Remove 6 mm (1/4 inch) of insulation from the inner conductors for GECO plug-in terminals.

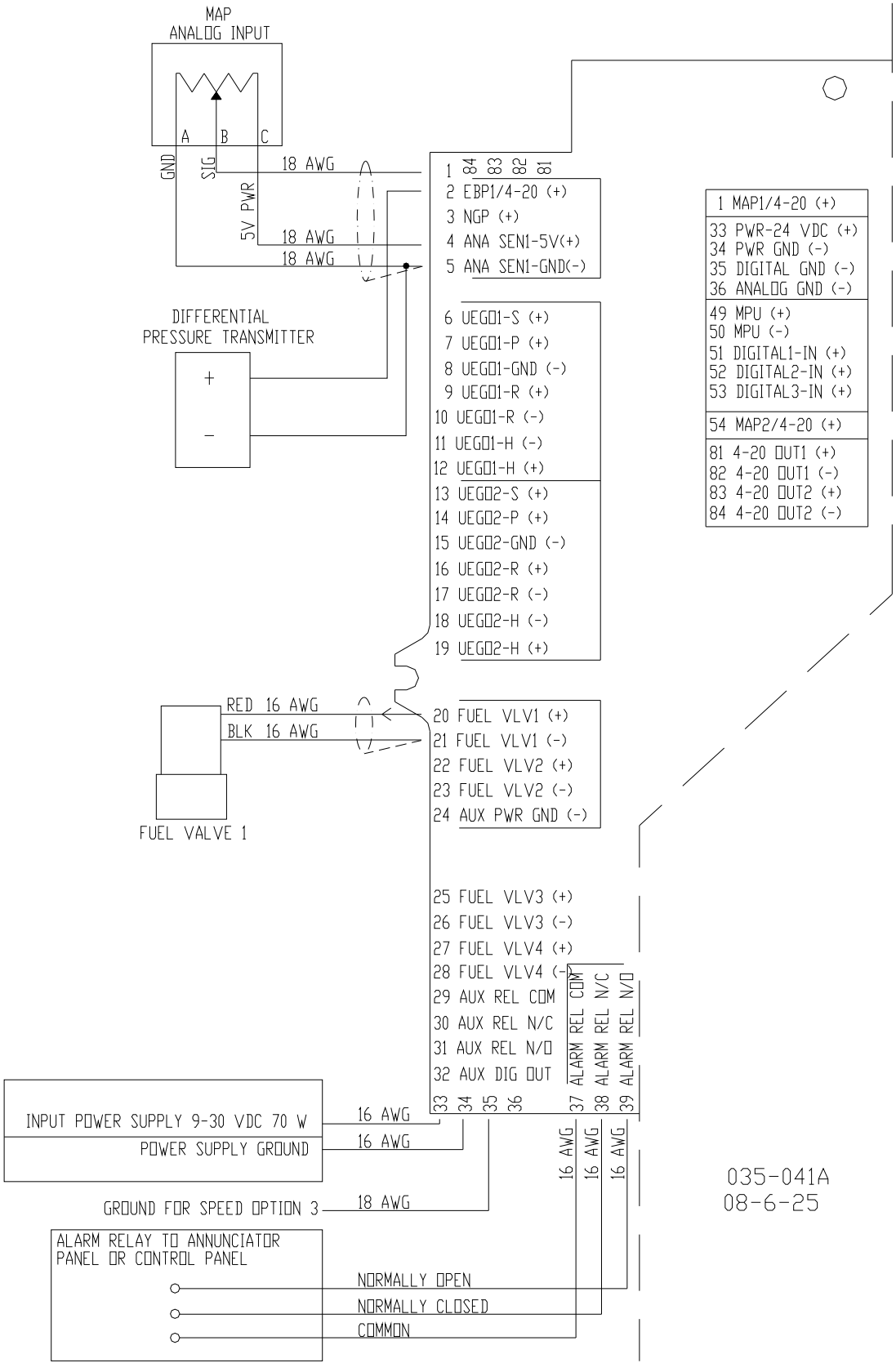
Installations with severe electromagnetic interference (EMI) may require additional shielding precautions.

Wiring Considerations





- Wiring must meet local codes.
- GECO enclosure should be tied to earth ground.
- High voltage or high current wires should run in separate conduit from GECO sensors and valves.
- Avoid conduit or wire proximity to hot surfaces—specially exhaust components.
- Grommets must be installed in holes, conduit ends, or boxes to protect wire insulation.
- Where wiring exits from grommet-end boxes, electrical RTV should be used for water-tight seal; the cable should be long enough to tie into a “drip loop” before entering conduit.
- Where conduit connects to junction boxes, the side or bottom is best; use an elbow when top connection is necessary.
- Flexible metal conduit must have sleeve inserts at junctions for insulation protection.
- If sensor wires have a protective covering, the cover should be tied with ends pointing down to drain liquids.
- Shields must be grounded to circuit board terminals only.
- Shields must be carried continuously through terminal blocks, splices, or connectors and must not be tied to any other shields unless sharing circuit board terminal location.
- All conduit wiring breaks or splices must be in junction, outlet, or equipment boxes only.


MAP
ANALOG INPUT
A
B
C
GND
SIG
5V PWR
18 AWG
18 AWG
18 AWG
DIFFERENTIAL
PRESSURE TRANSMITTER
+
–
RED 16 AWG
BLK 16 AWG
FUEL VALVE 1
1 84 83 82 81
2 EBP1/4-20 (+)
3 NGP (+)
4 ANA SEN1-5V(+)
5 ANA SEN1-GND(-)
6 UEGO1-S (+)
7 UEGO1-P (+)
8 UEGO1-GND (-)
9 UEGO1-R (+)
10 UEGO1-R (-)
11 UEGO1-H (-)
12 UEGO1-H (+)
13 UEGO2-S (+)
14 UEGO2-P (+)
15 UEGO2-GND (-)
16 UEGO2-R (+)
17 UEGO2-R (-)
18 UEGO2-H (-)
19 UEGO2-H (+)
20 FUEL VLV1 (+)
21 FUEL VLV1 (-)
22 FUEL VLV2 (+)
23 FUEL VLV2 (-)
24 AUX PWR GND (-)
25 FUEL VLV3 (+)
26 FUEL VLV3 (-)
27 FUEL VLV4 (+)
28 FUEL VLV4 (-)
29 AUX REL COM
30 AUX REL N/C
31 AUX REL N/O
32 AUX DIG OUT
33 34 35 36 37 38 39
ALARM REL COM
ALARM REL N/C
ALARM REL N/O
1 MAP1/4-20 (+)
33 PWR-24 VDC (+)
34 PWR GND (-)
35 DIGITAL GND (-)
36 ANALOG GND (-)
49 MPU (+)
50 MPU (-)
51 DIGITAL1-IN (+)
52 DIGITAL2-IN (+)
53 DIGITAL3-IN (+)
54 MAP2/4-20 (+)
81 4-20 OUT1 (+)
82 4-20 OUT1 (-)
83 4-20 OUT2 (+)
84 4-20 OUT2 (-)
INPUT POWER SUPPLY 9-30 VDC 70 W
POWER SUPPLY GROUND
16 AWG
16 AWG
GROUND FOR SPEED OPTION 3
18 AWG
16 AWG
16 AWG
16 AWG
ALARM RELAY TO ANNUNCIATOR
PANEL OR CONTROL PANEL
NORMALLY OPEN
NORMALLY CLOSED
COMMON
035-041A
08-6-25

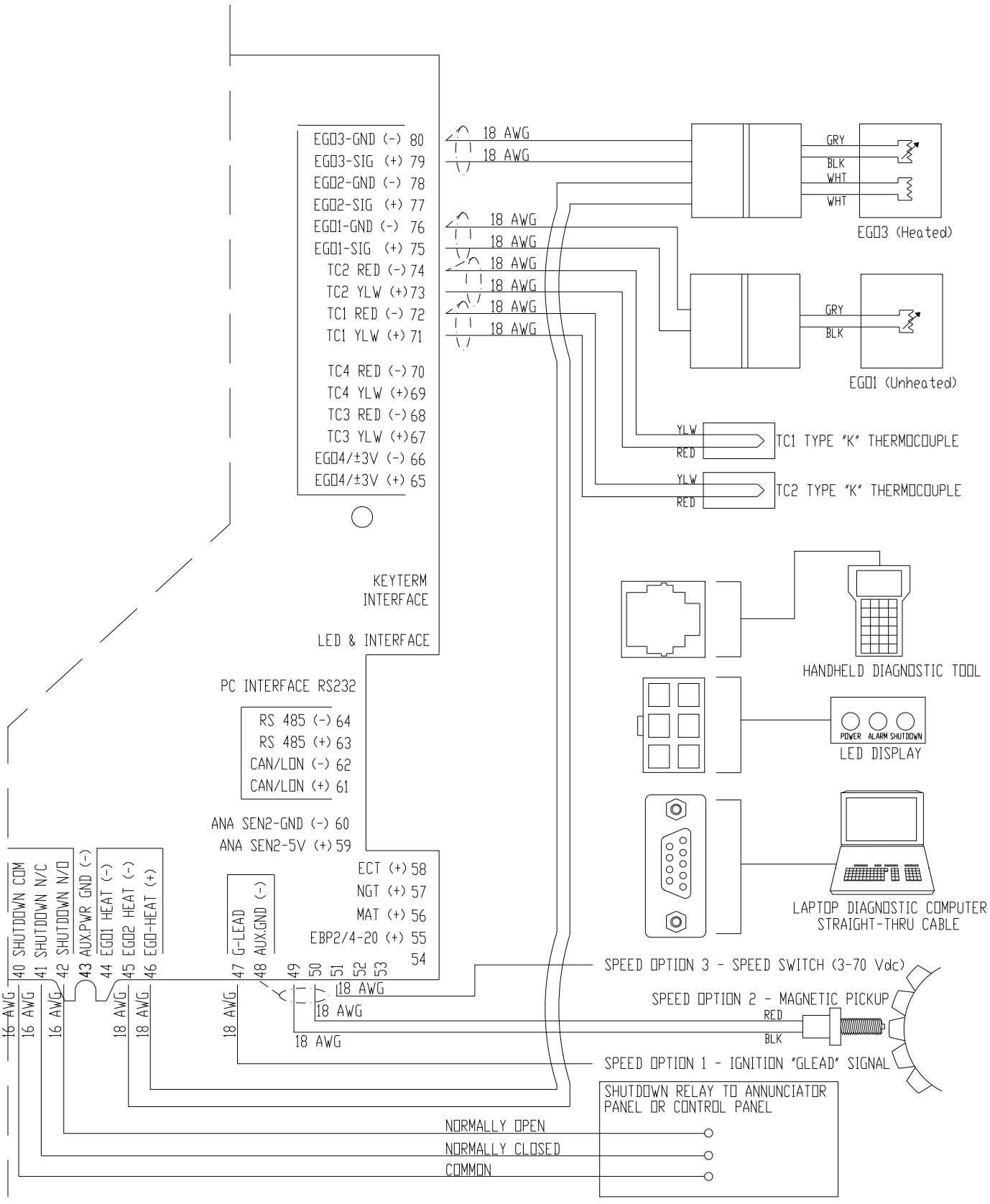
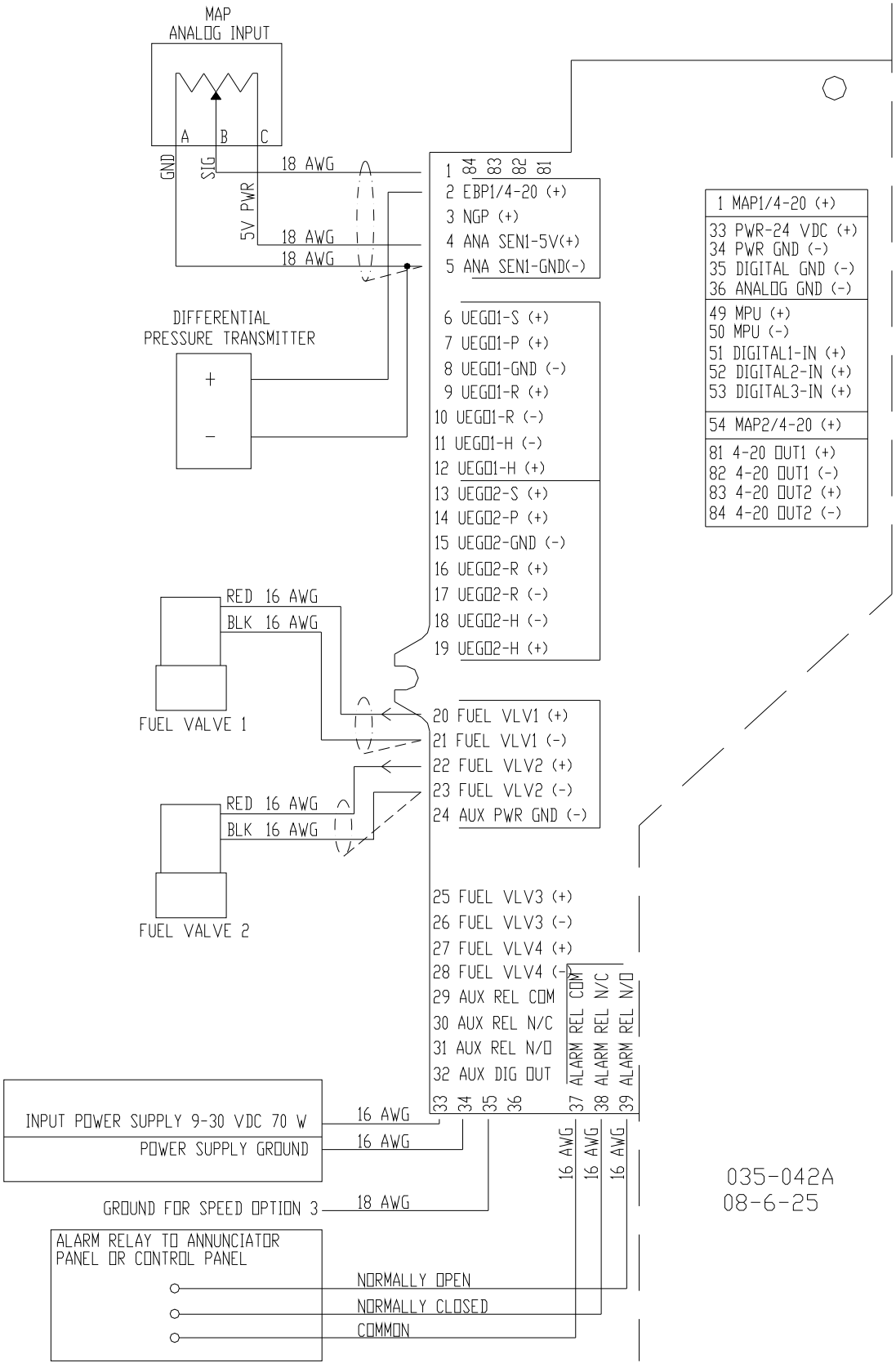


Figure 8-2. Wiring for Single Bank


MAP
ANALOG INPUT
A
B
C
GND
SIG
5V PWR
18 AWG
18 AWG
18 AWG
DIFFERENTIAL
PRESSURE TRANSMITTER
+
–
RED 16 AWG
BLK 16 AWG
FUEL VALVE 1
RED 16 AWG
BLK 16 AWG
FUEL VALVE 2
1 84 83 82 81
2 EBP1/4-20 (+)
3 NGP (+)
4 ANA SEN1-5V(+)
5 ANA SEN1-GND(-)
6 UEGO1-S (+)
7 UEGO1-P (+)
8 UEGO1-GND (-)
9 UEGO1-R (+)
10 UEGO1-R (-)
11 UEGO1-H (-)
12 UEGO1-H (+)
13 UEGO2-S (+)
14 UEGO2-P (+)
15 UEGO2-GND (-)
16 UEGO2-R (+)
17 UEGO2-R (-)
18 UEGO2-H (-)
19 UEGO2-H (+)
20 FUEL VLV1 (+)
21 FUEL VLV1 (-)
22 FUEL VLV2 (+)
23 FUEL VLV2 (-)
24 AUX PWR GND (-)
25 FUEL VLV3 (+)
26 FUEL VLV3 (-)
27 FUEL VLV4 (+)
28 FUEL VLV4 (-)
29 AUX REL COM
30 AUX REL N/C
31 AUX REL N/O
32 AUX DIG OUT
33 34 35 36 37 38 39
ALARM REL COM
ALARM REL N/C
ALARM REL N/O
1 MAP1/4-20 (+)
33 PWR-24 VDC (+)
34 PWR GND (-)
35 DIGITAL GND (-)
36 ANALOG GND (-)
49 MPU (+)
50 MPU (-)
51 DIGITAL1-IN (+)
52 DIGITAL2-IN (+)
53 DIGITAL3-IN (+)
54 MAP2/4-20 (+)
81 4-20 OUT1 (+)
82 4-20 OUT1 (-)
83 4-20 OUT2 (+)
84 4-20 OUT2 (-)
INPUT POWER SUPPLY 9-30 VDC 70 W
POWER SUPPLY GROUND
16 AWG
16 AWG
16 AWG
16 AWG
16 AWG
GROUND FOR SPEED OPTION 3
18 AWG
ALARM RELAY TO ANNUNCIATOR
PANEL OR CONTROL PANEL
NORMALLY OPEN
NORMALLY CLOSED
COMMON
035-042A
08-6-25

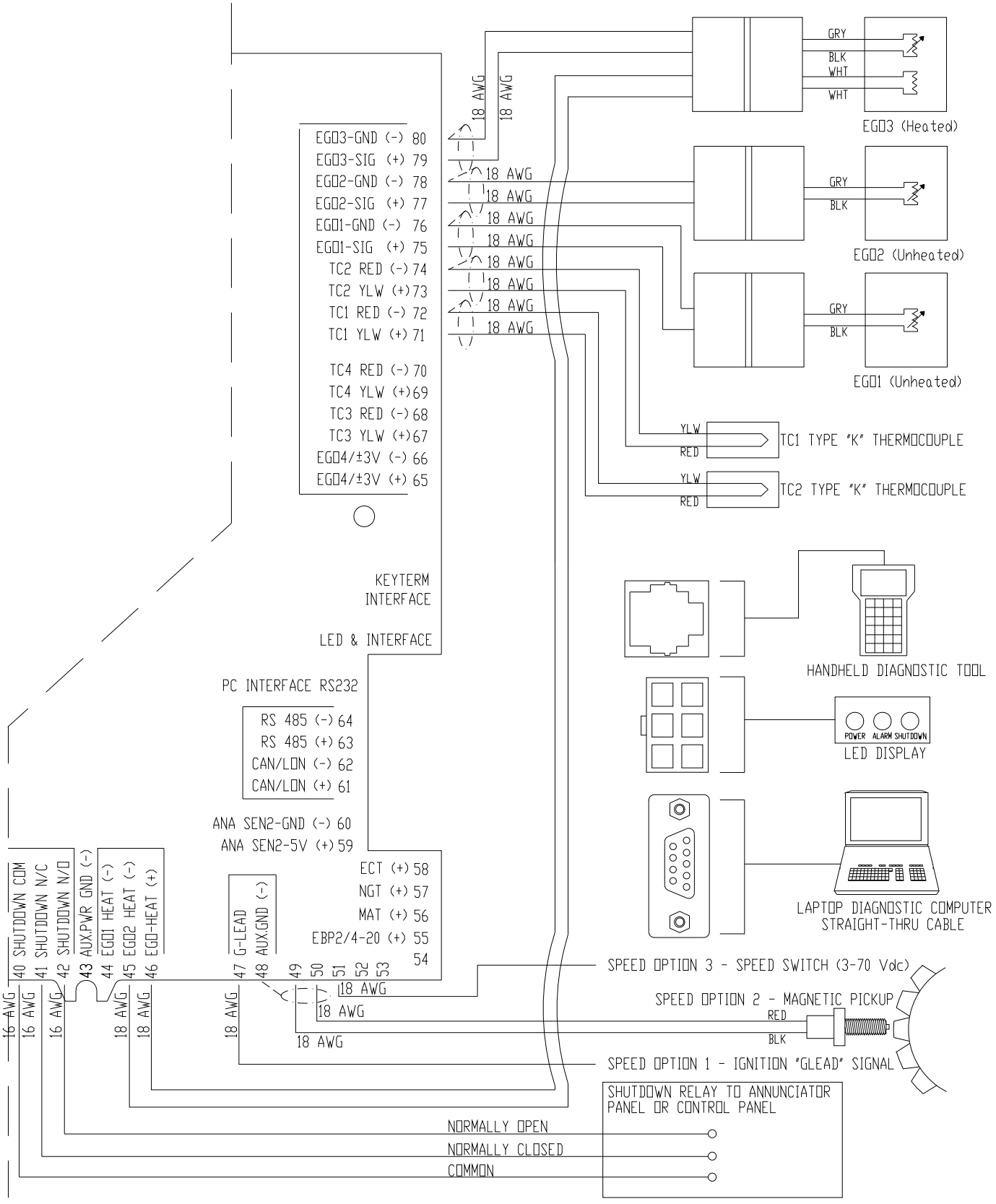


Figure 8-3. Wiring for Dual Bank

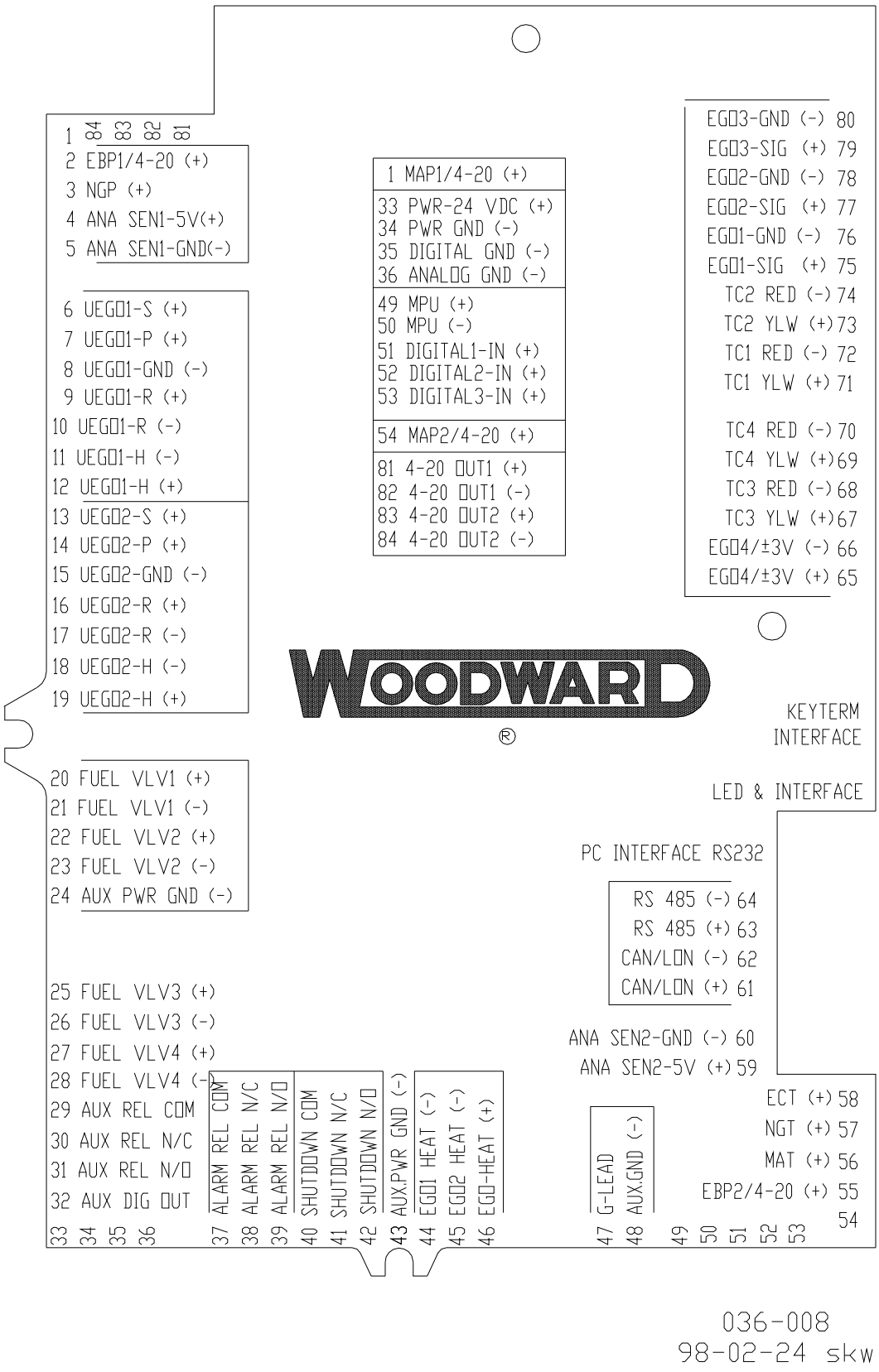
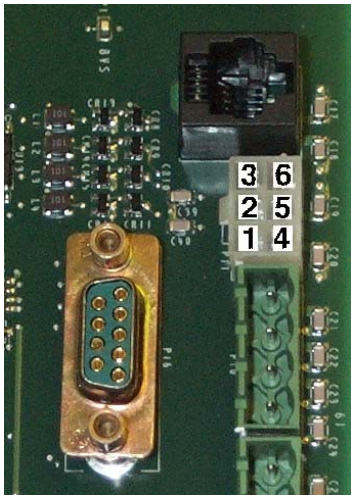
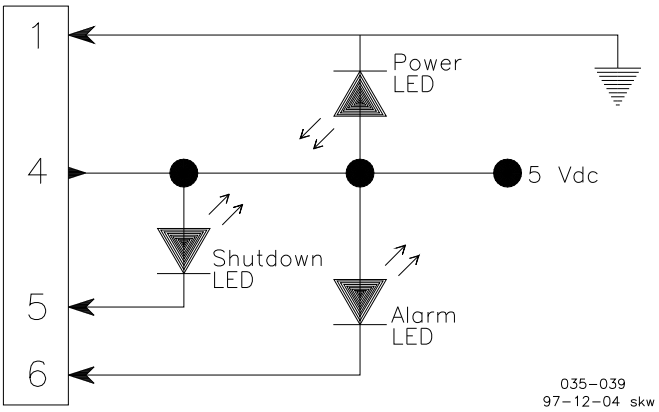


Figure 8-4. Legend Plate

Status Indicator LEDs

If the operator wishes to install lights for GECO control power, alarm, and shutdown (with or without the alarm and shutdown relay outputs), the circuit board also includes a 6-pin connector specifically for indicator LEDs.





Pin	Description
1	Ground
2	
3	
4	+5 Vdc
5	Shutdown LED
6	Alarm LED

Software Installation

The GECO·Stoichiometric control includes software for two separate functions. The user interface software is the program used to configure the system and perform all the data streaming and diagnostic work as described in the Operation section. This software will be updated periodically, but the program name can always be recognized by the extension .EXE. The other software is the programming for the microprocessor, which may also be updated to add features and new functions to the GECO system (this program has the extension .s19). These two programs work together when changes are made to the configuration or calibration of the system parameters. Changes made on the user interface screens will communicate with the circuit board microprocessor and update the on-board programming as well.

The interface software can be installed directly off the disk supplied, but it is recommended that a back-up copy of the disk be used, with the original disk safely stored. It may be more convenient to copy and run the software on the internal hard drive of the PC, again with the original disk safely stored. In addition to the .EXE and .S19 files described above, the user interface requires the GRAPH.FON support file on the same disk, in the same directory or folder as the other software.

⚠WARNING **An unsafe condition could occur with improper use of these software tools. Only trained personnel should have access to these tools.**

Updating Application Programming (.S19 file)

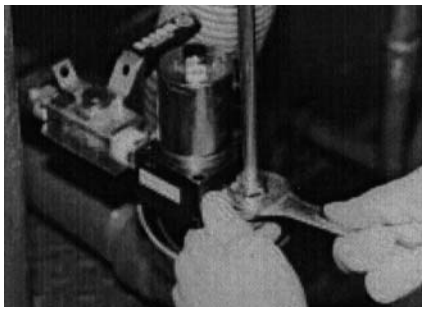
An .S19 file can be downloaded to the circuit board with the user interface software as follows:

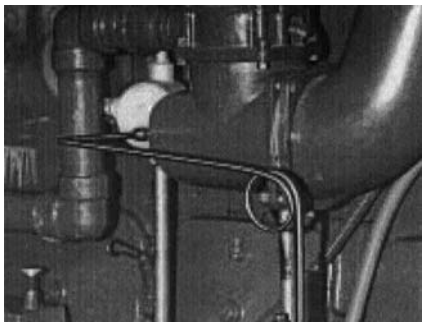
- Shut engine down.
- From any screen, type Alt-D (hold the Alt key and press D at the same time).
- An input message at the bottom of the screen will request the password included with the update software. Contact your GECO distributor for more information.
- Another message will request the pathname of the new .S19 file (example: c:\geco\9925050.s19).
- The new program will then be downloaded to the flash memory.

Fuel Metering/Valve Location Considerations

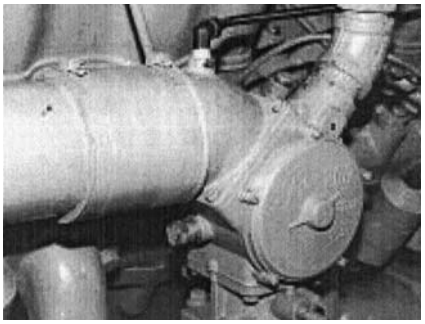
- Access for conduit connection
- Space for servicing and repair
- Protection from direct exposure to water
- Stable mounting surface or bracket; the valve should not be suspended on plumbing or conduit connections
- Avoidance of vibration
- Selection of a location that will provide an operating temperature within the specification range listed in the Components section; avoid the vicinity of exhaust system components.

Plumbing Considerations





- Check the Components section for valve port fitting sizes, pressure requirements, and plumbing size.
- Thin-wall stainless steel tubing is recommended.
- Flareless stainless steel fittings are recommended.
- A manual shut-off valve must be installed between the pressure source and the valve for servicing and troubleshooting (1/4-turn ball valve).
- The tubing should include vibration isolation loops (“pigtails”); these loops also facilitate installation and servicing of the valve.
- The valve should be mounted as close to the injection point as possible; lengthy plumbing runs are more acceptable on the higher pressure, inlet side of the valve.



- An automatic shut-off for engine shutdown is required upstream of the pressure source; when the control loses the engine speed signal, the trim valve(s) will close automatically as a backup.
- The injection point should be chosen to provide as much mixing as possible before the intake splits to individual cylinders; just upstream from the existing carburetor is ideal, but downstream may be acceptable if long intake plumbing and/or elbows are present before the throttle.
- Injection points where oil or fuel liquids pool up should be avoided, especially if liquids drain to the metering valve.
- All threads and tube fittings must be inspected for leaks with bubble-indicating liquids or electronic flammable-gas detection equipment.

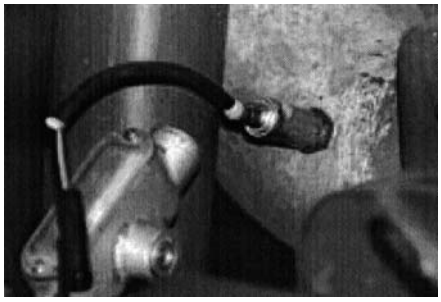
NOTICE

High-temperature anti-seize thread lubricant must be used to facilitate exhaust oxygen and temperature sensor replacement. Temperatures at the sensor threads can be as high as 1200°F (650 °C), so the anti-seize compound should be designed for this heat range. These products typically use copper or nickel compounds, although copper is recommended (nickel vapor is a suspected carcinogen).

EGO Installation

Location of upstream EGO sensor(s) should be:

- In the combined exhaust stream from all the controlled cylinders or after the turbocharger.



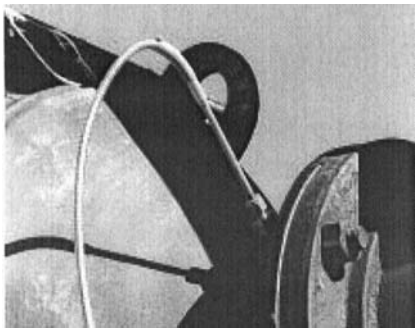
- Within 600 mm (24 inches) of the exhaust manifold outlet or turbo outlet.
- Shielded from the exhaust pulses of another bank or turbo (where 2 exhaust streams join) to avoid “cross-talk” feedback from the wrong bank.
- On the top 160° of the exhaust pipe (to avoid corrosion and thermal shock from condensation).
- Drill and spot face 15.5 mm hole in suitable location.
- Tap for 18 mm x 1.5 if pipe is at least 6 mm (1/4 inch) thick, or weld internally threaded port around the hole.
- Install sensor with anti-seize thread lubricant and torque to 40 N·m (30 lb-ft).

HEGO Installation

- Location of downstream HEGO sensor should be:
- In the exhaust stream after the catalyst.
- As close to the catalyst as possible.
- As far from exhaust outlet as possible; ambient air reversion from the exhaust pulses or air leaks in the exhaust pipe can cause false lean signals.
- On the top 160° of the exhaust pipe (to avoid corrosion and thermal shock from condensation).
- Drill and spot face 15.5 mm hole in suitable location.
- Tap for 18 x 1.5 mm if pipe is at least 6 mm (1/4 inch) thick, or weld internally threaded port around the hole.
- Install sensor with anti-seize thread lubricant and torque to 40 N·m (30 lb-ft).

Catalyst Temperature Sensor Installation

Location of the catalyst temperature sensors should be:



- In the exhaust before and after the catalyst.
- As close to the catalyst as possible.
- Extended into the exhaust just enough to give a true exhaust temperature, not pipe temperature (very thin sensors and very strong exhaust pulses can fatigue and break the sensor tip).
- On the top 180° of the exhaust pipe (to avoid corrosion in the fitting due to condensation).
- Drill holes in suitable locations.
- Weld or tap for temperature sensor compression fittings.
- Install sensor with anti-seize thread lubricant and sensor tip at least 25 mm (1 inch) into the exhaust stream.

Oxygen Sensor Poisoning

Lubricants and sealants of any kind must be checked for oxygen sensor compatibility: Even for use on the intake or crankcase ventilation system. Contaminants drawn into the engine can propagate through the combustion process, and even small amounts can poison the activity of Zirconia-based sensors. Common sensor poisons include silicon, lead, and excessive oil contamination. Gasket sealers (RTV silicone), pipe thread sealers (pipe dope), and solder or brazing materials will typically contain these materials. Most products intended for modern automotive use are sensor-safe, but many products common in industrial environments are not. Double check products during repair or maintenance, and when in doubt, use automotive products and procedures.

Excessive oil consumption by the engine will also affect oxygen sensor life—regular maintenance of piston rings (and valve seals, where applicable) is very important. Although the sensors are inexpensive, they are damaged by the same contaminants that will eventually poison the exhaust catalyst. In other words, a sensor failure may give warning that maintenance is needed before the catalyst is also damaged.

Supplemental Valve Installation Diagrams

The fuel trim valve may be mounted in any position. The base of the valve housing has a bolt pattern that is used for mounting or support. There are four 6.9 mm (0.27 inch) diameter holes in a 41.1 mm (1.62 inch) square pattern.

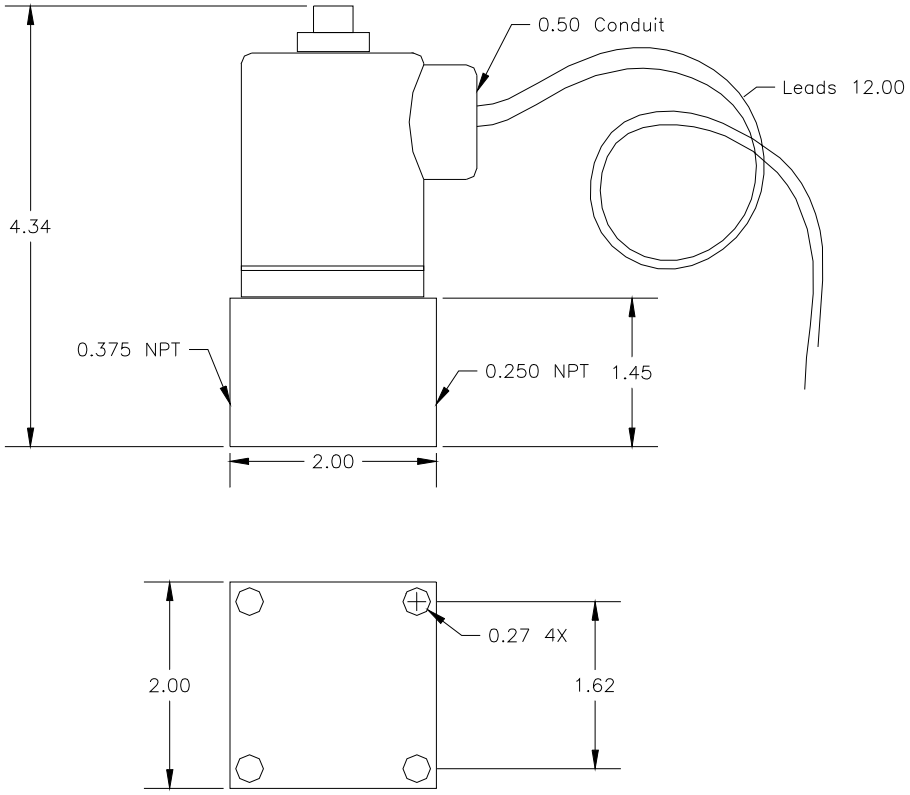


Figure 8-5. Valve Outline Drawing

Full-flow Valve Installation Diagrams

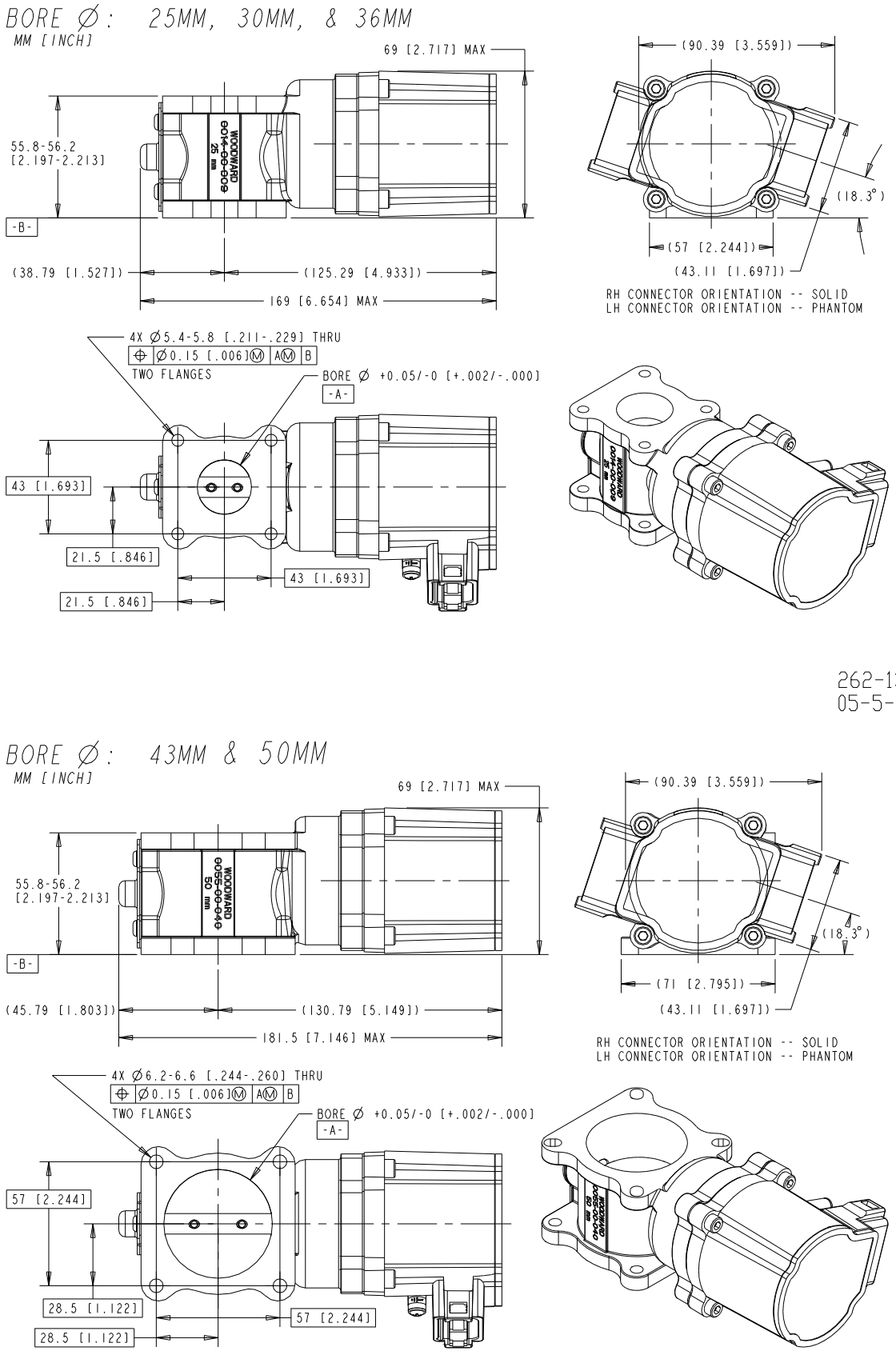


Figure 8-6. L-Series ITB Outline Drawings

Configuration and Calibration

These instructions assume that the engine is in good operating condition and the mechanical carburetor has been properly installed and calibrated.

Control Configuration Before Engine Start

1. Apply power to the control.

2. Connect a Windows compatible computer to the control via the RS-232 cable. Start the PC Tool software described in Chapter 6.

3. Enter the password to get full access to the configuration and calibration screens. Go to the Configuration screen on Screen 2.
   a. Enable the appropriate sensors for your situation.
   b. Enable the valve or valves for your situation. Check that the Run Default valve position is set at 35% and the Crank Default position is set at 35%.
   c. Enter the calibration values for the MAP sensor if needed and verify the MAP sensor is reading atmospheric pressure.
   d. Enable the desired alarm and shutdown functions.
   e. Enter the engine specific parameters:
      - cylinders
      - displacement
      - rated power
      - rated MAP
      - rated rpm
      - rpm source
      - rpm pulse/rev.

4. Move to the Monitor screen, Screen 1. Check that the cursor is highlighting the ClearAll label and press the Enter key. Check to see that all faults are cleared and remain clear.

5. Set the circuit board toggle switch to Open Loop. Go to the Valve-Learn table on Screen 4, upper right corner. Check that the default valve settings are set at 0%. The default valve settings will hold the valve closed so that at initial start up the engine will run on the mechanical carburetor only.

Calibrate Open Loop Valve Table below 50% Load

6. Start the engine.

7. Verify the speed measurement to confirm the correct Pulse/rev.

8. After the engine has warmed up, record the current Mdot_fuel value and enter this value in the first point of the Valve-Learn table.

9. Increase speed to the maximum rated speed of the engine. Record the current Mdot_fuel value and enter this value in the second point of the Valve-Learn table.

10. Ramp the engine load up to approximately 50%. Record the current Mdot_fuel and the Mdot_air values. Enter the Mdot_fuel value in the third point of the Valve-Learn table. Enter the Mdot_air value into the Mdot_air breakpoint parameter.

11. Ramp the engine load up to the 100% power. Record the current Mdot_fuel value. Enter this value into the last point of the Valve-Learn table.

12. Enter evenly distributed Mdot_fuel values into the remaining points of the Valve-Learn table between 50% and 100%.

13. Verify that the EGO sensor health values are greater than 50% and that the EGO1 sensor signal is reading below 0.8 Vdc. If the voltage is greater than 0.8 V, adjust the carburetor toward lean to bring this voltage below 0.8. Repeat this for EGO2 if it is present.

14. Set the control mode to Manual, on page 1. Enter a valve position command value of 35%. This will cause the EGO measurement to increase.

15. Close the carburetor “power valve” (or air/fuel ratio adjustment) toward lean to bring the EGO voltage to approximately 0.780 Vdc.

16. Using an exhaust emissions analyzer, verify that the current air/fuel ratio is correct for best emissions. If necessary, adjust the carburetor to tune the lowest emissions. Record the EGO1, EGO2, EGO3 sensor readings; Valve1 and Valve2 position commands; and the Mdot_fuel value.

17. Enter this EGO1 (and EGO2) value(s) into the EGO1 (and EGO2) Base value(s) on page 3. Enter the EGO3 value into the EGO3 Base value on page 4. Enter the Valve1 (and Valve2) positions in all Bank1 (and Bank2) points of the Valve-Learn table.

18. Enter 0.00 V for EGO3 Offset into the Valve_Learn at 100% load.

19. Set the circuit board toggle switch to Closed Loop. Verify that the control mode is CL+Adaptive. Allow the control to stabilize and verify that the control remains at the best emissions condition.

20. If the EGO voltage has regular, large swings under steady engine conditions, the closed loop gain (CL Gain) can be lowered. The CL Gain also affects response time, so operation during load or speed changes will suffer if the gain is too low.

21. After the control is stable, if the emissions is not as expected, adjust the EGO3 Base value a few millivolts at a time to get the proper emissions levels. Once stable, read the steady EGO1 and EGO2 Target values and enter these values into the EGO1 and EGO2 Base values.

22. Adjust the engine load to approximately 90%. Allow the engine to stabilize. Record the Mdot_fuel value and enter it into the Valve-Learn table at the next-to-last position. Adjust the EGO3 Offset value to achieve best possible emissions at this load. Enter the current valve positions into the Bank1 and Bank2 values on the Valve-Learn table. Repeat this process over the operating range of the engine. At each of these points, verify that engine emissions or exhaust oxygen are at the expected values. If not, adjust the EGO3 Offset values in the table to achieve the desired results. Remember that the control interpolates between points on the table.

Chapter 9.
Maintenance and Fault Indications

This chapter provides information for keeping the GECO™·Stoichiometric Air/Fuel Control in proper working order. Contact your GECO distributor for service options.

⚠WARNING

The GECO·Stoichiometric Air/Fuel Ratio Control is designed to supplement existing fuel controls in order to automatically provide the optimum fuel mixture for emissions compliance. As described in this manual, the system can be helpful for engine tuning and diagnosis; however, the GECO·Stoichiometric control is not a fix for an existing malfunction. The original engine, including the mechanical components, air throttle(s), carburetor(s), governor, ignition system, and safety shutdowns must be in proper working order before the GECO·Stoichiometric control is put into operation.

Maintenance

The GECO·Stoichiometric control and system components were designed to be very reliable in operation. None of the components require any maintenance, however the exhaust gas oxygen sensors intake manifold pressure sensors have a limited life and will require regular replacement.

A regular program for engine maintenance should continue after the GECO·Stoichiometric system is installed. To provide emissions compliance, the original engine systems need to be in proper working order. Please review the warning statement above, and any warnings associated with the exhaust system components (EGO sensors). The use of certain gasket and thread sealers or high temperature thread lubricants can cause poisoning of the oxygen sensor. Excessive engine oil consumption can also cause these effects over longer periods of time. The GECO·Stoichiometric system will relieve the operator of constant carburetor tuning for emissions compliance, but consistent engine maintenance is still required.

Safety Checks

The GECO·Stoichiometric control alarm and shutdown relays should be included in a regular safety check to verify their functionality.

Replacement Information

The highest maintenance requirement is for the automotive oxygen sensors (EGO). The typical life expectancy for these components is on the order of 2000 hours, or about three months of continuous service.

Troubleshooting

The diagnostic functions of the GECO·Stoichiometric system are reported to the user either through the hand-held interface or the PC interface software. Certain faults can also cause alarm or shutdown conditions, if these systems have been configured and integrated into the existing engine control panel. The table below describes all the faults and conditions which will cause an alarm or shutdown condition. In addition, the plotting and datalogging features of the PC interface software (see Chapter 3, Operation) can be very valuable for troubleshooting an intermittent fault or difficult diagnosis.

Diagnostic Faults–Indication only No Alarm or Shutdown	**Fault Conditions**
Closed loop valve limit low	Valve Command <= 5.0%
Closed loop valve limit high	Valve Command >= 99.0%
Adaptive limit low	Adaptive <= -5.0%
Adaptive limit high	Adaptive >= 7.0%
DC Power supply voltage low	Voltage < 9.5 V and RunMode = RUNNING
DC Power supply voltage high	Voltage > 31.0 V and RunMode = RUNNING
ECU Processor	Internal microprocessor errors
Trigger	Noisy G-lead speed signal
CJC Sensor open	> 4.95 V (> 300 °F)
CJC Sensor lower than expected	< 0.05 V (< 45 °F)
Alarm and Shutdown Configuration Disable/Enable/Enable+Shutdown	**Fault Conditions**
UEGO max voltage	> 1.1 V
EGO health	<35%
TC open	> 40 mV
TC lower than expected	<30 deg. F above CJC sensor after 240 sec run time
MAP low	< 0.25 Vdc
MAP high	> MAP high pressure
Valve1 current min	<0.1 A and Valve Cmd > 30%
Valve1 current max	> 0.6 A and Valve Cmd < 50%
Valve2 current min	< 0.1 A and Valve Cmd > 30%
Valve2 current max	> 0.6 A and Valve Cmd < 50%
Shutdown Only	**Fault Conditions**
TCupstream temperature limit	PC configurable
TCdnstream temperature limit	PC configurable

Suggested Troubleshooting Procedures

When a diagnostic fault is indicated, the following guidelines will help to quickly find and solve the cause. The steps should be taken in order; the possible causes are listed in order from most likely to less likely. The following section also lists trouble symptoms that may not set an indicated fault. Please contact the nearest Woodward distributor or service facility for further technical support.

Possible Fault	**Causes**
Valve Limit Low:	Carburetor too rich Upstream EGO – check EGO health High fuel supply pressure Fuel metering valve
Valve Limit High:	Carburetor too lean Upstream EGO - check EGO health Low fuel supply pressure Fuel metering valve

Valve Limit Low and High:	Fluctuating fuel supply pressure Fuel metering valve Carburetor not tracking well Low authority due to low pressure and rich carburetor settings
Adaptive Limit Low:	Downstream EGO3 health Fuel metering valve Set EGO Base lower to re-center adaptive authority “window”
Adaptive Limit High:	Downstream EGO3 health Fuel metering valve Set EGO Base higher to re-center adaptive authority “window”
DC Power Supply Low:	Power supply Poor connection
DC Power Supply High:	Power supply Short to other voltage source
Computer:	ECU
Trigger:	Other high-voltage or high-current wires near G-lead wiring Unshielded G-lead wiring Ignition system problem (magnetic pickup)
EGO Signal High:	EGO - check EGO health EGO signal ground open Other wiring problems (short) ECU
EGO Health Low:	EGO - check EGO health Signal wiring problem ECU
TC Open:	Open TC circuit TC ECU
TC Lower than Expected:	TC not in exhaust stream Shorted TC circuit TC ECU
Valve Current Low:	Open valve circuit Valve wired wrong (polarity, 2 valves in series) Fuel metering valve ECU
Valve Current High:	Shorted valve circuit Valve wired wrong (2 valves in parallel) Fuel metering valve ECU
TC Temperature Limit:	Ignition problems (misfire, retarded timing) Engine knock

Symptoms Without Indicated Faults	
No Hand-Held Display	Unplug and replug-in hand-held cable [SEE WARNING BELOW] Check circuit board LED for power supply, check power fuse Check hand-held cable Hand-held programmer Circuit board
Strange Hand-Held Display:	Power-on setup mode (see Operation section, hand-held programmer) Unplug and replug-in hand-held cable [SEE WARNING BELOW]
High Emissions:	Exhaust air leak–causes EGO signal errors Ignition timing Ignition system components EGO target calibration–recalibrate Installation section guidelines

⚠WARNING

EXPLOSION HAZARD—The GECO enclosure should not be opened when a hazardous atmosphere is present. Wiring connections which could cause sparks are available inside the cabinet.

Do not disconnect while circuit is live unless area is known to be non-hazardous.

The GECO control must not be operated with the hand held terminal connected to the control when a hazardous atmosphere is present.

RPM Signal Issues

The control will follow several different control strategies depending on the engine speed signal. If the control is not receiving proper speed signals, or if the "pulses/rev" setting is not correct, the GECO·Stoichiometric control may default to an incorrect operating condition.

There are three main operating conditions based on engine speed:

- Stopped–below 15 rpm–fuel metering valves closed
- Cranking–from 20 to 190 rpm–fuel metering valves cranking (usually 35%)
- Running–above 190 rpm–open loop default (usually 35%), closed loop or closed loop+adaptive when possible (after warm-up, good signals, no faults causing open loop)
- When using a switched run signal rather than MPU or G-lead input, the operating condition switches from stopped to running as described above. The cranking condition is skipped over. Any rpm values displayed by the PC software or hand-held terminal will show a 1350 rpm default value when the switched run signal is on

Recommended Spare Parts

WGC P/N	Description	Quantity
6910-315	EGO Sensor	2
6910-316	HEGO Sensor	1
1736-919	EGT Sensor (K-type TC)	2
1310-923	Fuel Metering Valve	1

Chapter 10.
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email (**EngineHelpDesk@Woodward.com**) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

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

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 option allows you to call your Full-Service Distributor 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 Full-Service Distributor.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic 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.

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. 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 for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:
- return number;
- 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.

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.

NOTICE

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*.

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.

Engineering Services

Woodward's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact.

Product Training is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from one of our Full-Service 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 information on these services, please contact one of the Full-Service Distributors listed at **www.woodward.com/directory**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory published at **www.woodward.com/directory**.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used In Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used In Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used In Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

For the most current product support and contact information, please visit our website directory at **www.woodward.com/directory**.

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number

Prime Mover Information

Manufacturer _____

Engine Model Number _____

Number of Cylinders _____

Type of Fuel (gas, gaseous, diesel, dual-fuel, etc.) _____

Power Output Rating _____

Application (power generation, marine, etc.)

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Symptoms

Description _____

_____

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.

Appendix.
Modbus Register Addresses

Integer Input/Output Parameters

Integer Address	Parameter Name	Parameter Description	Internal Bytes	Internal Units	Multiply By	Then Add	To Obtain
1	RPM	Engine speed	2	[16.0] rpm	1	0	rpm
2	MAP	Intake manifold pressure - bank 1	2	[8.8] psia	0.00390625	0	psia
5	DP	Catalyst Differential Pressure	[8.8]	inH2Od	0.00390625	0	inH2Od
12	CJC	Cold junction (control) temperature	2	[13.3] deg F	0.125	0	deg F
16	EGO1	Engine-out stoichiometric oxygen sensor - bank 1	1	[0.8] 1.2V	0.004684096	0	volts
17	EGO2	Engine-out stoichiometric oxygen sensor - bank 2	1	[0.8] 1.2V	0.004684096	0	volts
18	EGO3	Catalyst-out stoichiometric oxygen sensor - bank 1	1	[0.8] 1.2V	0.004684096	0	volts
20	EGO1_TARG	EGO1 desired voltage	1	[0.8] 1.2V	0.004684096	0	volts
21	EGO2_TARG	EGO2 desired voltage	1	[0.8] 1.2V	0.004684096	0	volts
22	EGO3_TARG	EGO3 desired voltage	1	[0.8] 1.2V	0.004684096	0	volts
24	EGO1_BASE	EGO1 base desired voltage	1	[0.8] 1.2V	0.004684096	0	volts
25	EGO2_BASE	EGO2 base desired voltage	1	[0.8] 1.2V	0.004684096	0	volts
26	EGO1_HEALTH	EGO1 health	1	[0.8] fraction	0.390625	0	%
27	EGO2_HEALTH	EGO2 health	1	[0.8] fraction	0.390625	0	%
28	EGO3_HEALTH	EGO3 health	1	[0.8] fraction	0.390625	0	%
30	CL1	Closed loop control value - bank 1	2	[S0.15]	0.003051758	0	%
31	CL2	Closed loop control value - bank 2	2	[S0.15]	0.003051758	0	%
32	ADAPT1	Adaptive control value - bank 1	2	[S0.15]	0.003051758	0	%
33	ADAPT2	Adaptive control value - bank 2	2	[S0.15]	0.003051758	0	%
34	VALVE1	Fuel valve command - bank 1	2	[S0.15]	0.003051758	0	%
35	VALVE2	Fuel valve command - bank 2	2	[S0.15]	0.003051758	0	%
39	VOLTAGE	Control supply voltage	1	[0.8] 32.45V	0.127274156	0	volts
42	GENERATOR_EST	Estimated generator output power	2	[16.0] bhp	0.7457	0	KW
43	POWER_EST	Estimated engine power	2	[16.0] bhp	1	0	bhp
44	TORQUE_EST	Estimated engine torque	2	[16.0] ft-lbs	1	0	ft-lbs
45	TC1	Thermocouple 1 temperature	2	[13.3] deg F	0.125	0	deg F
46	TC2	Thermocouple 2 temperature	2	[13.3] deg F	0.125	0	deg F
49	VALVE1_CUR	Valve driver 1 current	1	[0.8] 6.18A	0.024327349	0	amps
50	VALVE2_CUR	Valve driver 2 current	1	[0.8] 6.18A	0.024327349	0	amps
55	RUN_MODE	0=stopped, 1=cranking, 2=running	1	integer	1	0	0,1,2

Integer Input/Output Parameters

Integer Address	Parameter Name	Parameter Description	Internal Bytes	Internal Units	Multiply By	Then Add	To Obtain
56	CONTROL_MODE1	0=open loop, 1=closed loop, 3=adaptive+CL for bank1	1	integer	1	0	0,1,3
57	CONTROL_MODE2	0=open loop, 1=closed loop, 3=adaptive+CL for bank2	1	integer	1	0	0,1,3
58	EGO1_VOLTS	EGO1 raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
59	EGO2_VOLTS	EGO2 raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
60	EGO3_VOLTS	EGO3 raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
62	INJ1_VOLTS	INJ1 raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
63	INJ2_VOLTS	INJ2 raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
66	TC1_VOLTS	TC1 raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
67	TC2_VOLTS	TC2 raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
70	V_VOLTS	V raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
82	MAP1_VOLTS	MAP raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
85	CJC_VOLTS	CJC raw (unfiltered and scaled) voltage	1	[0.8] 5V	0.019607843	0	volts
86	DP1_VOLTS	DP raw (unfiltered and scaled) voltage		[0.8] 5V	0.019607843	0	volts
90	PROM_ID1	Application code - first 4 digits	2	integer	1	0	4 digits
91	PROM_ID2	Application code - last 4 digits	2	integer	1	0	4 digits
92	PROM_ID3	Calibration date month	2	integer	1	0	2 digits
93	PROM_ID4	Calibration date day	2	integer	1	0	2 digits
94	PROM_ID5	Calibration date year (2-digit)	2	integer	1	0	2 digits
95	PROM_ID6	Engine maker code	2	integer	1	0	integer
96	PROM_ID7	Engine model year (4-digit)	2	integer	1	0	4 digits
97	PROM_ID8	Engine displacement	2	0.1 liters/bit	0.1	0	liters
98	PROM_ID9	Cylinders	2	integer	1	0	cylinders
99	PROM_ID10	Engine displacement	2	cubic inches	1	0	cubic inches
100	PROM_ID11	UNUSED	2	integer	1	0	integer
101	PROM_ID12	HCN - Hardware compatibility number	2	integer	1	0	integer
102	PROM_ID13	SCN - Software compatibility number	2	integer	1	0	integer
103	PROM_ID14	WGC SCN - Woodward software compatibility number	2	integer	1	0	integer
104	PROM_ID15	GECO Model number	2	integer	1	0	integer
105	PROM_ID16	Revision code	2	integer	1	0	2-byte ASCII

Boolean Input/Output Parameters

Boolean Address	Table Index	Bit	Parameter Name	Parameter Description	Clear	Set	User Set	User Clear
1	0	0	MAP1_HIGH_AL	MAP voltage high alarm	OK	FAULT	0	1
7		6	BAT_HIGH_AL	Battery voltage high alarm	OK	FAULT	0	1
9	1	0	MAP1_LOW_AL	MAP voltage low alarm	OK	FAULT	0	1
15		6	BAT_LOW_AL	Battery voltage low alarm	OK	FAULT	0	1
35	4	2	TC2_LOW_EXP_AL	TC2 lower than expected alarm	OK	FAULT	0	1
36		3	TC1_LOW_EXP_AL	TC1 lower than expected alarm	OK	FAULT	0	1
39		6	TC2_HIGH_AL	TC2 open (high) alarm	OK	FAULT	0	1
40		7	TC1_HIGH_AL	TC1 open (high) alarm	OK	FAULT	0	1
42	5	1	MEM_AL	Bad memory byte alarm	OK	FAULT	0	1
43		2	COP_AL	COP fail detected alarm	OK	FAULT	0	1
44		3	EXEC_AL	Illegal instruction execution detected alarm	OK	FAULT	0	1
45		4	CLOCK_AL	Clocks stopped alarm	OK	FAULT	0	1
46		5	STACK_AL	Stack overflow alarm	OK	FAULT	0	1
47		6	TIMING_AL	A/D conversions not completed alarm	OK	FAULT	0	1
48		7	ISR_AL	Unscheduled or improper interrupt alarm	OK	FAULT	0	1
50	6	1	EGO3_OPEN_AL	Open EGO3 connection or lazy EGO3 sensor alarm	OK	FAULT	0	1
51		2	EGO2_OPEN_AL	Open EGO2 connection or lazy EGO2 sensor alarm	OK	FAULT	0	1
52		3	EGO1_OPEN_AL	Open EGO1 connection or lazy EGO1 sensor alarm	OK	FAULT	0	1
53		4	ADAPT_POS_AL	Adaptive hit positive limit alarm	OK	FAULT	0	1
54		5	ADAPT_NEG_AL	Adaptive hit negative limit alarm	OK	FAULT	0	1
61	7	4	EGO2_LEAN_AL	CL on bank 2 hit positive limit alarm	OK	FAULT	0	1
62		5	EGO2_RICH_AL	CL on bank 2 hit negative limit alarm	OK	FAULT	0	1
63		6	EGO1_LEAN_AL	CL on bank 1 hit positive limit alarm	OK	FAULT	0	1
64		7	EGO1_RICH_AL	CL on bank 1 hit negative limit alarm	OK	FAULT	0	1
65	8	0	OVERSPEED_AL	OverSpeed detected alarm	OK	FAULT	0	1
70		5	EGO3_HIGH_AL	EGO3 voltage high alarm	OK	FAULT	0	1
71		6	EGO2_HIGH_AL	EGO2 voltage high alarm	OK	FAULT	0	1
72		7	EGO1_HIGH_AL	EGO1 voltage high alarm	OK	FAULT	0	1
77			DP1_LOW_AL	DP low alarm	OK	FAULT	0	1
78			DP1_HIGH_AL	DP high alarm	OK	FAULT	0	1
79			DP1_LOW_EXP_AL	DP lower than expected alarm	OK	FAULT	0	1
80			DP1_HIGH_EXP_AL	DP higher than expected alarm	OK	FAULT	0	1

Boolean Input/Output Parameters

Boolean Address		Table Index Bit	Parameter Name	Parameter Description	Clear	Set	User Set	User Clear
83	10	2	INJ2_LOW_AL	Injector driver 2 current low alarm	OK	FAULT	0	1
84		3	INJ1_LOW_AL	Injector driver 1 current low alarm	OK	FAULT	0	1
87		6	INJ2_HIGH_AL	Injector driver 2 current high alarm	OK	FAULT	0	1
88		7	INJ1_HIGH_AL	Injector driver 1 current high alarm	OK	FAULT	0	1
92	11	3	CJC_LOW_AL	Cold junction compensation temperature low alarm	OK	FAULT	0	1
96		7	CJC_HIGH_AL	Cold junction compensation temperature high alarm	OK	FAULT	0	1
129	16	0	TC1_L_SD	TC1 low temperature shutdown	OK	SHUTDOWN	0	1
130		1	TC2_L_SD	TC2 low temperature shutdown	OK	SHUTDOWN	0	1
137	17	0	TC1_H_SD	TC1 high temperature shutdown	OK	SHUTDOWN	0	1
138		1	TC2_H_SD	TC2 high temperature shutdown	OK	SHUTDOWN	0	1
145	18	0	CTRL_FAULT_SD	Control internal diagnostic shutdown	OK	SHUTDOWN	0	1
146		1	OVERSPEED_SD	Overspeed shutdown	OK	SHUTDOWN	0	1
158	19	5	SD_RELAY	Shutdown relay state	OFF	SHUTDOWN	0	0
161	20	0	AL_RELAY	Alarm relay state	OFF	ALARM	0	0
187		2	CL_SWITCH	Closed-loop enable toggle switch state	OL	CL_ENABLE	0	0
189		4	MAN_CTRL	Manual valve control selection	AUTO	MANUAL	0	0
190		5	AL_CLEARALL	Alarm clear-all trigger	NORMAL	CLEARALL	1	0
191		6	SD_CLEARALL	Shutdown clear-all trigger	NORMAL	CLEARALL	1	0

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