WARNING: DEVIATION FROM THESE INSTALLATION INSTRUCTIONS MAY LEAD TO IMPROPER OPERATION OF THE ENGINE WHICH COULD CAUSE PERSONAL INJURY TO OPERATORS OR OTHER NEARBY PERSONNEL .

1.0 SYSTEM DESCRIPTION

1.1 The Altronic EPC-150 is an air/fuel ratio controller for use on carbureted gas engines. The controller utilizes microprocessor technology, allowing a high level of sophistication in control strategy, ease of programming and diagnostic capability. The EPC-150 is designed for use on lean-burn engines operating at air/fuel ratios of lambda 1.2 to 1.8.

1.2 One model is universal and can be applied to in-line or V-type engines.

1.3 The EPC-150 provides single or dual channel operation for application with most carbureted lean burn engines. See application listing below or contact factory for more information. For each control channel a wide range oxygen sensor is used in the exhaust stream to sense O_2 content; a thermocouple input signals when the engine is running in order to switch power on to the heated O_2 sensor. For each controlled channel a fuel/control valve installed in the fuel line to the carburetor is precisely adjusted by a microprocessor controller to maintain the correct O_2 content in the exhaust. Pressure sensors upstream and downstream of the throttle plate are used to determine the target O_2 value versus the load and throttle reserve. Settings for the target O_2, offset table versus manifold absolute pressure, as well as several other settings, can be easily adjusted through the sealed membrane keypad or through the use of a PC.

EPC-150 APPLICATION LISTING:

MANUFACTURER	MODELS
Caterpillar	All models running lean of lambda 1.0, except 3600 series.
Cummins	All carbureted models running lean of lambda 1.0
Superior	All carbureted models running lean of lambda 1.0
Waukesha	All carbureted models running lean of lambda 1.0

1.4 The EPC-150 has an alphanumeric LCD display which can display operating status, Boost and MAP pressures, O_2 voltage, exhaust temperature, stepper motor position and diagnostic information.

1.5 System power requirement is 24 VDC, 5 amp. In remote areas, power can be provided by the Altronic 24 VDC Alternator Power Package. Refer to Altronic Form ALT.

2.0 SYSTEM COMPONENTS

2.1 Parts from each group below are required in the quantity shown for each installation:

PART NO.	DESCRIPTION	QUANTITY REQUIRED
EPC-150	Air/fuel Controller	1 per engine
690154-1	Control Valve, standard 1.5" NPT	1 per carburetor
690154-2	Control Valve, low HP 1.5" NPT	
690220-1	Control Valve, butterfly 2.0" NPT	
690225-1	Control Valve, butterfly 2.5" NPT	
690230-1	Control Valve, butterfly 3.0" NPT	
610813	Oxygen Sensor	1 per carburetor
691204-50	Pressure Sensor 50 psia	2 per carburetor
691207-1	Sensor Converter	1 per carburetor
693005-1	Cable, control valve, 25 ft.	1 per valve
693005-2	Cable, control valve, 50 ft.	
693008-25	Cable, pressure sensor, 25 ft.	2 per carburetor
693009-1	Cable, oxygen sensor, 25 ft.	1 per carburetor
693009-2	Cable, oxygen sensor, 50 ft.	
**	"K" Thermocouple probe (ungrounded w/thermowell)	1 per carburetor
**	"K" Thermocouple extension wire	50 ft. per carburetor
**	12-16 AWG hook-up wire	150 ft. per engine

** Not supplied by Altronic.

2.2 See fig. 1 for illustration of system components. Fig. 10 lists the accessory kit contents.

2.3 Refer to fig. 2 for the general layout of components used in the EPC-150 control system.

3.0 MOUNTING THE EPC-150

3.1 The EPC-150 is preferably panel-mounted off the engine in such a manner as to minimize exposure to vibration. Refer to fig. 3 for physical mounting details.

3.2 The EPC-150 controller should be mounted within 50 ft. of the exhaust stack of the engine.

3.3 Operating temperature range is -40° to 158° F. / -40° to 70° C. Humidity specification is 0-95%, non-condensing. Housed in a NEMA 4 enclosure, the EPC-150 is splash resistant; however, the mounting site should provide as much protection from inclement weather as is practical. Avoid mounting the LCD display and keypad in direct sunlight.

4.0 MOUNTING THE OXYGEN SENSOR AND SENSOR CONVERTER MODULE

4.1 The wide range exhaust oxygen sensor system requires a Sensor Converter module for proper operation. The sensor should be installed in the exhaust system just after the turbocharger. The best mounting orientation is horizontal. Care should be taken to avoid placing the sensing element where it may be exposed to moisture from condensation or rain. The external portion of the sensor must be kept cool. It must be understood that temperatures above 350°F will cause sensor degradation and premature failure. On most lean burn engines which use only one fuel pressure regulator and one control channel, exhaust flow from all cylinders must be sensed. On Vee engines with two carburetors which require two fuel pressure regulators and two control channels, two sensors and two Sensor Converter modules are required. Do not locate the sensor in a coupling or in a location where the exhaust gas flow is uneven due to obstructions or sharp bends. Effort should be taken to install the sensor in a location of minimum vibration. The sensor location chosen should allow easy access since sensor replacement will be required; the life of this sensor technology varies with the application, but is generally measured in thousands of hours.

4.2 For each sensor, drill, tap and spot face a hole in the exhaust pipe at the selected location. A flat smooth sealing surface is required to assure accurate readings since air or exhaust leaks will impact sensor operation. See fig. 4 for details. NOTE: A weldment boss may be required for sensor installation in soft or thin wall exhaust systems.

4.3 New sensors are packaged with an anti-seize compound already applied to the threads. There is no need to apply additional anti-seize unless reinstalling a used sensor. If required, use high temperature anti-seize very sparingly and apply only to the sensor threads. Sensors should be torqued to 28-34 lb. ft.

4.4 The Sensor Converter uses the pre-assembled cable P/N 693009-x for connection to the oxygen sensor. Locate the module in a cool location within reach (50 ft. max.) of the exhaust oxygen sensor. If a protective conduit is used, the 693009-x cable should be pulled through the conduit from the sensor end to avoid splicing the cable.

5.0 MOUNTING THE K-TYPE THERMOCOUPLE

5.1 A thermocouple is used to monitor the temperature of exhaust gases near the exhaust oxygen sensor and should be mounted as close as possible to the O_2 sensor. As with the O_2 sensor, the location should be easily accessible, and the tip of the probe, which should be enclosed by a thermowell, should be surrounded by unobstructed exhaust flow.

5.2 ONLY UNGROUNDED thermocouple probes can be used with the EPC-150. Grounded type thermocouples will not function correctly. Resistance from either lead of the thermocouple to the probe shell should be 2 megohms or greater.

6.0 MOUNTING THE FUEL CONTROL VALVE

NOTE: For detailed instructions covering the gas control valve, see form GCV1 OM (690154 series) or GCV2 OM (6902XX series).

6.1 In order to control the air/fuel ratio, an electronically controlled valve is connected in series between the regulator and carburetor. The valve should be installed as close to the fuel inlet of each carburetor as possible. The distance from the valve to the carburetor inlet should not exceed 12 pipe diameters in length. The valve should be installed with the control cable connector facing upward to avoid the collection of condensation in the stepper motor.

6.2 If possible, gas connection piping should be of the same diameter as that currently in use. The threaded connection to the valve body may require the use of thread adapters. If adapters are used, proper plumbing procedures must be followed.

6.3 Each control valve is connected to the EPC-150 using the 693005-x cable. If it is desired to enclose the cable in conduit, this can be accomplished by cutting the 693005 cable in half. The cables are color coded and must be reconnected with each wire color matching. This cable must not be run in the same conduit as the ignition primary or other wires. A distance of 4 to 6 inches should be maintained between EPC-150 wiring and other engine wiring. Note that the upper connector on the EPC-150 controls the stepper valve for single control channel applications and the left bank valve on V-engines.

7.0 ELECTRICAL HOOK-UP

7.1 The power connections to the EPC-150 must be in accordance with the National Electrical Code. The EPC-150 is suitable for installation in Class I, Division 2, Group C & D locations.

7.2 Although the input power has internal protective fuses (3 amp), an external fuse (5 amp min.) near the power source is recommended.

7.3 The EPC-150 can be powered in one of the following ways:

a. 24 volt battery with a battery charger (5 amp min. output).
b. DC power supply capable of furnishing 18-30 VDC, 5 amps.
c. Altronic 24 VDC Alternator Power Package - see form ALT.

NOTE: Voltage and current supplied must be sufficient to operate all transducers used in the installation.

7.4 Power wiring and signal (transducers) wiring must be in separate conduits and conduit entries into the EPC-150 to avoid undesired electrical interaction. Separate as follows (see fig. 6):

Left Conduit Entry:	Power Wiring and Earth Grounding
Center Conduit Entry:	Signal Wiring - all Sensor wiring (O_2, pressure, thermocouple)
Right Conduit Entry:	Alarm Output

7.5 Input power supply wires (16 AWG minimum) should enter the left most conduit entry and connect to the 24 volt supply terminals of terminal block TS2A. An earth ground wire (12 AWG minimum) should enter this same location and connect to the Earth Ground terminal. This connection is in addition to the power negative which may also be grounded.

NOTE: Engines using positive ground DC accessories or starter motors will require a separate dedicated ungrounded power supply for the EPC-150.

7.6 The Sensor Converter module has 2 conduit openings. The first conduit opening is for the connection of the 24 volt power and control wiring from the EPC-150 and conditioned oxygen sensor signals from the Sensor Converter back to the EPC-150. These wires should enter the EPC-150 enclosure through the center conduit opening and connect to the 20 pin terminal block. Terminate the wires as shown in fig. 6.

The second conduit opening on the Sensor Converter is for connection of the Oxygen sensor to the converter module. The 693009-x cable assembly is used for this connection. The 693009-x cable carries the low voltage sensor signals from the sensor back to the converter as well as the heater current from the converter to the sensor. Take care to route this cable away from ignition wiring and other possible sources of interference. Do not splice this cable. Note: Engines with two fuel pressure regulators require two O_2 Sensors and two Sensor Converters.

7.7 The thermocouple (24 AWG min. Type K extension) wires should be run in a separate conduit. These thermocouple wires should enter the EPC-150 enclosure through the center conduit opening and connect to terminal block TS4. The yellow wire should be connected to the T/C (yellow) terminal and the red wire to the T/C (red) terminal.

7.8 The "Single Channel" mode of the EPC-150 is programmed via a jumper wire connection on terminal block TS1. The "Dual Channel" mode is enabled by removing this jumper wire. NOTE: See fig. 7 for Wire Terminal Lay-Out.

7.9 Although the EPC-150 does not require a computer to be operated or installed, a serial port (located on the control board assembly) has been included which can be used to communicate with a personal computer. Connections to the RS-485 port are made via TS3, a 3-position plug located near the center of the circuit board. A software terminal package which permits communication with the EPC-150 is provided on a CD-ROM shipped with each unit. This Modbus based PC program provides operational monitoring and the capability to adjust default parameters and setpoints remotely. On screen directions and help are provided by the Altronic terminal software. User programmed Modbus communication routines may be used to interface to PLC or SCADA systems. See section 18.0 for details.
There is also a 9-pin D-type connector for RS-232. This is the default communication method on the EPC-150 controller.

8.0 THEORY OF OPERATION

8.1 The primary task of the EPC-150 is to accurately control the air fuel ratio (AFR) of an engine in a closed loop control strategy utilizing a heated wide range O_2 exhaust sensor. Control is maintainable through typical load and fuel BTU variations. Upset conditions may require a somewhat longer time for the controller to stabilize the engine at the optimum AFR. The explanation given here is for single channel operation; dual channel operation simply repeats the same control approach on each control channel, based upon that channel's individual response.

8.2 To address the emissions side of the problem, the O_2 sensor is used to maintain a target O_2 percentage in the exhaust which produces the best emissions for the current operating conditions. The controller determines the control target as well as when to assume control based on the manifold pressure of the engine which provides a good indication of load. Typically, the best emissions performance requires slightly leaner control settings for higher manifold pressures and a slightly richer setting for lower loads. For this reason, the control has a Lean Set Point, which is essentially the leanest targeted O_2 signal. From this value, a rich offset voltage can be subtracted from the lean setpoint to provide an enrichment offset for lighter load conditions based on the MAP signal.

8.3 Exhaust emissions of the Lean Burn engine are effected by the air/fuel ratio of the engine. On the Lean Burn engine, the adjustment of the air/fuel ratio can also have an impact on the engine's ability to carry load. A common problem with control on Lean Burn engines results in a condition referred to as "lug". In lug, the engine cannot reach the target speed of the governor even though the governor is commanding wide open throttle. This condition occurs when the lean operation of the engine at lighter loads does not produce enough exhaust heat for the turbo to make significant surplus boost (more than is required to carry the current load). In normal operation there is always surplus boost. This is reflected by the pressure drop across the throttle plate. Surplus boost is required to increase the flow of air/fuel mixture as the throttle opens, causing an increase in engine output torque, which will in turn increase the engine RPM. As the RPM reaches the governor setpoint, the governor will regain control and start to close the throttle. The engine can then accept additional load. In the lug condition, since there is no surplus boost, the opening of the throttle by the governor does not increase engine RPM and the engine will actually slow down or stall. Once in this lug condition, the only way out is to reduce the load and try again or momentarily run rich of the O_2 setpoint.

8.4 To address the "lug" condition, a value called "Throttle Reserve percent" is calculated from the MAP and BOOST pressures. This value indicates the amount of authority left to the governor to increase the torque of the engine. When this value is very low, it provides an indication that the throttle is virtually wide open, and that the engine may be in lug. When this condition occurs, a rich offset step can be made to the target O_2 voltage which enables the engine to recover from the lug condition. Therefore, below a selected throttle reserve (10% default), the O_2 control target will be offset by a user adjustable voltage (1.0 volts default) in the rich direction. Running richer will enable the engine to produce more heat and more torque to restore control to the governor at which point normal control for emissions can resume.

8.5 In order to avoid always running rich in the event of an overloaded condition, a timer will increment while the low throttle reserve condition is present. When the engine is not in low throttle reserve, the same timer will decrement at ½ the speed. If the timer reaches a count of 255, the control will turn on the Alarm Output permitting the user load control system to respond to the potential overloaded condition and avoid any possible engine damage due to overload.

8.6 <u>On unattended engines, it is important that the Alarm Output be connected to shut down the engine.</u> On engines in critical service with operators constantly present, the Alarm Output should be used to notify the operator of the overload problem so that appropriate action can be taken by the operator.

8.7 A type K thermocouple is used to identify a running engine and to identify an exhaust over-temperature. Above a user selected value (300°F default), the controller will turn on power to the O_2 sensor/module. Control for the heater is provided by an FET (transistor) switch to ground inside the EPC-150. Above a user selected temperature (1200°F default), the controller will turn on the Alarm Output. Since certain failures of the oxygen sensor can cause excessive exhaust temperatures and possible engine damage, the Alarm Output should be connected on all applications to alert an operator or to shutdown the engine to avoid unnecessary damage.

8.8 An electronic control valve is used to create a variable restriction between the fuel pressure regulator and the carburetor inlet. This restriction is used to adjust the effective inlet pressure seen by the carburetor and results in a mechanical adjustment of the air/fuel mixture delivered by the carburetor. A stepper motor adjusts the restriction by moving a plunger or throttle plate inside the valve. A stepper motor is a brushless motor consisting of a permanent magnet armature and a four-coil multi-pole stator. The armature is moved by sequentially pulsing the four stator coils. Coupled to a worm screw, the rotating armature of the motor provides very accurate linear positioning capability. The motor used provides 1700 steps of travel at .0005 inch/step for a total valve stroke of 0.85 inch.

8.9 The EPC-150 adjusts the stepper motor to maintain the target voltage from the O_2 sensor. When the sensor voltage is above the O_2 target voltage, the system is leaner than desired, and the stepper position is decreased to reduce the restriction of fuel flow. Conversely, when the sensor voltage is below the O_2 target voltage, the system is richer than desired, and the stepper position is increased to further restrict fuel flow to the carburetor.

8.10 Because the response of the engine to the number of steps is not constant, it would not be practical to adjust the system faster when the error from the set-point is greater. So in order to maximize the control response, the motors are instead adjusted faster as the error persists longer. This method provides rapid response characteristics as well as control stability. Control target voltages must be determined with the use of an exhaust analyzer to locate the operating point of lowest stack emissions. These target values are adjustable in the EPC-150 through the keypad. The resulting system provides accurate and stable control of air/fuel ratio which results in reduced engine exhaust emissions.

9.0 PRE-START INSTALLATION CHECKLIST

9.1 Before applying power to the EPC-150:

a. Measure the power supply voltage to assure voltage is within limits (18-30 volts). Leave unit un-powered.

b. Inside the EPC-150, disengage the thermocouple terminal block and measure voltage between yellow and red wires. The voltage should be 0.80-1.50 mV for temperatures 60-100 °F. This verifies that thermocouple wires are terminated. If the engine had been running, measurements will be higher reflecting higher actual temperature.

c. With the thermocouple terminal block still disengaged, measure resistance between the red wire and the still connected earth ground terminal. Resistance should be very high or open circuit. Repeat measurement between yellow wire and earth ground. This verifies that thermocouples are ungrounded and that wires are not shorted in conduit.

9.2 With the EPC-150 powered up and the engine not running:

a. Display should follow the power-up sequence described in section 11.

b. Display of Boost and Map pressures should be similar and between 13 and 15 psia. With a meter, measure the supply voltage to the pressure sensors which should be 5V +/- 0.25V.

c. Data display screen for exhaust temperatures should indicate ambient temperatures. Note: If engine was running recently, temperature will be higher.

d. Control valve operation should be verified during a start position command. This can easily be done if the valves are not yet fully installed in the fuel line. Press "ALARM ACK." if the alarm LED is on. Then press "F1" followed by "START POS". During the start position activity, the valve plunger should be fully retracted then positioned near the middle of its travel. On the butterfly valves, the valve will go fully open and then position itself with the butterfly partially closed. No movement, erratic movement, or movement in the wrong direction will result from incorrect wiring of the stepper cable.

e. The set-up values should be returned to the factory default values. This can be done by slowly pressing the following keys in order "F1, F3, F2, F4". Once the screen indicates the set-up mode, press "F2" followed by "F2" again to restore default setup values. Then press "F4" to exit the setup mode. The default values are set as follows:

<u>Single Channel Applications</u>

Gain Value	= 0.50	LoTempSet	= 300 °F
O_2 Target	= 2.50v	HiTempSet	= 1200 °F
Default Pos.	= 1000	LoTRthresh	= 10.0%
LoMAPset	= 13.0psi	Min O_2 set	= 1.000 V
		MapTable Offsets all set to 0.000 V	

<u>Dual Channel Applications</u>

Gain Value	= 0.50	LoTempSet	= 300 °F
Left O_2 Target	= 2.50v	HiTempSet	= 1200 °F
Left Default Pos.	= 1000	LoTRthresh	= 10.0%
Right O_2 Target	= 2.50v	Min O_2 set	= 1.000 V
Right Default Pos.	= 1000	MapTable Offsets all set to 0.000 V	
LoMAPset	= 13.0psi		

9.3 When all of these checks have been made successfully, move on to the Start-Up Procedure. NOTE: In section 9.2 above and in following sections, “Left” refers to the channel used of the EPC-150 for single pressure regulator applications as well as the “Left Bank” of dual pressure regulator Vee engine applications.

10.0 START-UP PROCEDURE

10.1 Before starting engine:

a. Check for fuel leaks where the fuel line was modified.

b. Be sure that the power screw adjustments on the carburetor is full open or full rich. If these adjustments are not fully open, then the control range of the stepper control valve will be limited.

c. If the Alarm Output of the EPC-150 is being used, temporarily disconnect or override this signal so that an alarm indication will not shut down the engine during startup.

d. Press "F1", then press "START POS" on the EPC-150 keypad to reset the stepper position and enable the warm-up delay.

e. Place the EPC-150 controller in manual mode by pressing "LEFT MANUAL" key, and then the “RIGHT MANUAL” key for dual channel applications.

f. Start and warm-up engine.

10.2 With the engine running:

a. Note that Display should have changed from Cold to Warmup.

b. Note that Boost Pressure should be greater than MAP pressure.

c. Verify that the exhaust temperature data screen is displaying reasonable values. Refer to section 14.0 for an explanation of the display key operation.

d. Wait for the 2-minute warmup period to expire, then verify that the display is reading a reasonable O_2 sensor voltage between 1 and 4 volts.

e. Enable automatic control by pressing the "AUTO OPER" key. If the MAP pressure exceeds the LoMAP setpoint, then the unit should begin adjusting the stepper valves trying to control the engine’s air/fuel ratio. Use any diagnostic warnings which may occur to troubleshoot the system. Rich or lean limit errors are a good indication that the pressure regulators need some adjustment.

f. Once the unit has gained control of the engine (O_2 sensor voltage very near the target voltage), adjust the fuel pressure regulator until the EPC-150 is controlling with the stepper valve positions near 1000 steps. This is approximately the middle of the valve's control range. Typically, little or no adjustment of the pressure regulator will be required. If a large adjustment of the pressure regulator appears to be required, check that the power screw adjustment is fully open.

10.3 Fine tune the control setpoints:

a. Using an exhaust analyzer, determine the set-point voltage which results in the best measured emission performance for the target reference O_2 values. This can be done by incrementally adjusting the O_2 target voltage in the set-up mode. Reference section 12.0 for an explanation of the setup mode. Alternatively, manual mode can be used to adjust the control valve to the position which gives the best emissions performance. Reference section 15.0 for an explanation of manual mode operation. Then the O_2 target voltage should be adjusted to match the actual sensor voltage using the Set-Up Mode. Follow this procedure for both engine banks on dual channel applications.

b. The control gain rate and default stepper positions can also be adjusted now; however, the default values represent the best typical values for these parameters.

10.4 Once the system is controlling at the best emissions point, the Alarm Output can be re-enabled.

10.5 At this point, the EPC-150 set-up is complete; the unit should be controlling the engine. Further adjustment of rich offsets versus manifold pressure, or adjustments of the LoTRthresh or LoTRoffset values can be made to assure proper recovery from “lug”.

11.0 GENERAL - KEYPAD AND DISPLAY OPERATION

11.1 The EPC-150 includes a front mounted keypad and an LCD display which permits the monitoring and adjustment of various parameters and actions. Two LED indicators are also included. The power LED (green) is illuminated any time there is power to the unit. The alarm LED (yellow) will light momentarily during power up, then go out as soon as the unit is running. The alarm LED is used to indicate when a diagnostic test is violated. Reference section 16.0 for more detail regarding diagnostics and the alarm indicator.

11.2 The keypad and display function together as the user interface. Only one key on the pad should be pressed at one time. Some commands require a key sequence (a series of key presses, one followed by the next). Whenever possible, special messages indicate what is happening or why a command is not accepted.

11.3 With the engine not running (cool exhaust), when power is first applied to the EPC-150, the display will show an Altronic product description message.

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Lean A/F Control

11.4 After a few seconds the display will indicate that the controller is in Cold mode as well as Manual or Auto mode. This display indicates that the thermocouples are still reading temperatures too cool for a running engine. The number on the top line at the end of the message indicates the current stepper valve position in steps. The EPC-150 when used in dual channel applications will display both the left and right bank status on the home screen. On single channel applications the added values 14.1B and 14.0M are the boost and manifold absolute pressures. The uppercase “M” would be lowercase “m” if the MAP was below the LoMAPset value. The *0.0% represents the Throttle Reserve Percent and the * indicates that the value is below the LoTRthresh setting. This display will persist until the engine is started.

Single Channel Applications	Dual Channel Applications
Auto Cold 1000 **14.1B 14.0M *0.0%**	**L Auto Cold 1000** **R Auto Cold 1000**
MAN! Cold 1000 **14.1B 14.0M *0.0%**	**L MAN! Cold 1000** **R MAN! Cold 1000**

NOTE: The format above with the single channel screens on the left and dual channel screens on the right will be used throughout this document to show the equivalent screens for each. If the screen is exactly the same for both applications, it will be shown on the left.

11.5 For single channel applications, if a diagnostic fault condition was detected, the WARN status would appear on the top line. The bottom line will display the nature of the current diagnostic conditions in rotation changing about once a second. The screens below depict the exhaust over-temp warning condition.

Single Channel	Dual Channel
Auto !WARN! 1000 **! EXH. TOO HOT !**	**L Auto 1.96v 1000** **R! EXH. TOO HOT !**
MAN! !WARN! 1000 **! EXH. TOO HOT !**	**L! OVERLOADED !** **R MAN!1.97v 1000**

For dual channel applications, if the diagnostic fault condition of exhaust over-temp was detected on the right bank while the left bank operated normally, then the nature of the condition would appear about once per second on the second line. If the diagnostic fault condition of overload would occur on the left bank while the right bank continued to operate normally, then the diagnostic display would appear on the top line once per second.

11.6 Press "ALARM ACK." and the alarm LED which was turned on by the above warning will begin to flash. The high temperature alarm has now been acknowledged, and the EPC-150 will accept other keypad commands. Any time the alarm LED is on steady, no keypad commands will be accepted until the "ALARM ACK." key is pressed. The display will indicate that the unit is responding to this command with message "**WORKING**".

12.0 SETUP MODE - KEYPAD AND DISPLAY OPERATION

12.1 Once the alarm LED is no longer on steadily, press "F1" followed by "F3" followed by "F2" followed by "F4" (FI-F3-F2-F4). This is the setup mode entry key sequence. The display will indicate that the setup mode is now active. Note that all screens in setup mode include the "**$**" character. The setup screens for the single and dual channel applications are the same except for one added screen described in section 12.6, 12.7, and 12.8.

F1=Next F4=EXIT
$$$ SETUP $$$

12.2 Press "F2", then press "F2" again (F2-F2) to restore factory default parameters. This special command can be used only from this screen when the user wants to restore factory default values. A message will indicate that the default values have been restored, and then return to the main setup message. Note default values which are listed in section 9.2(e).

RESTORING
DEFAULT SETUP

F1=Next F4=EXIT
$$$ SETUP $$$

12.3 Press "F1" to increment to the control gain setup screen. The factory default value for this parameter is 0.50 as shown on the display. This parameter determines the stepper valve adjustment rate when in automatic mode. The higher the value, the faster the controller will move the stepper in response to the O_2 sensor voltage.

GAIN VALUE=0.50
$ F2=Up F3=Dn $

12.4 Press "F2" to increase the value for the gain parameter. At this point the value is updated and will be used until the value is changed again. NOTE: Holding the key down, or multiple presses of the key will continue to increment the value.

GAIN VALUE=0.60
$ F2=Up F3=Dn $

12.5 Press "F3" to decrease the value. Now the value is decreased to the default value again. Note that the range for the gain value is limited to (0.1 to 2.0). The value cannot be moved beyond its limits.

GAIN VALUE=0.50
$ F2=Up F3=Dn $

12.6 Press "F1" to increment to the left O_2 target setup screen. The factory default value for this parameter is 2.5 volts as shown on the display. Like the gain value, the target can be increased and decreased with the "F2" and "F3" keys. The typical range is near 2.5 volts. The allowable range is 0.5 to 4.5 volts. On dual channel applications press “F1" again to set the target voltage for the right bank.

LO2Target=2.500v
$ F2=Up F3=Dn $

RO2Target=2.500v
$ F2=Up F3=Dn $

12.7 Press "F1" to rotate to the left default stepper position screen. The default position is used when any of the O_2 sensor or thermocouple diagnostics are active. The number on the right is the current default position. Because the temperature diagnostic is still active, the actual stepper position on the left is also 1000. On dual channel applications press “F1" again to go to the right default position.

1000 ---> 1000
$F2=chng L.dflt$

12.8 When viewing the default of the desired channel (Left or Right Stepper motor) press "F2" to update the default position (on right side of display) with the value of the current position (on left side of display). Since both values are the same no change was actually made in this example. By using the manual mode which is described in section 15.0, the actual position can be adjusted to the desired position before entering the setup mode.

1000 ---> 1000
$F2=chng L.dflt$

12.9 Press “F1" to rotate to the LoExhTemp screen which displays the temperature above which the engine will be considered to be running. Above this temperature, the power control signal from the EPC-150 to the Sensor Converter will be turned on. This threshold can be increased and decreased with the "F2" and "F3" keys respectively.

LoExhTemp= 300˚F
$ F2=Up F3=Dn $

12.10 Press “F1" to rotate to the HiExhTemp screen which displays the temperature above which the engine exhaust temperature will be considered to be too hot. Above this temperature the EPC-150 will activate the alarm LED and Alarm Output switch. This threshold can be increased and decreased with the "F2" and "F3" keys respectively.

HiExhTemp= 1200˚F
$ F2=Up F3=Dn $

12.11 Press “F1" to rotate to the LoTRthresh screen which displays the throttle reserve percent below which the controller will enable the enrichment offset and count time until an overload condition will be flagged. On the home screen display, the “*” character will be displayed just ahead of the throttle reserve percent number to indicate the low throttle reserve condition. This threshold can be increased and decreased with the "F2" and "F3" keys respectively.

LoTRthresh =10.0%
$ F2=Up F3=Dn $

12.12 Press “F1" to rotate to the LoTRoffset screen which displays the low throttle reserve enrichment offset voltage setting. This offset can be increased and decreased with the "F2" and "F3" keys respectively.

LoTRoffset =1.000v
$ F2=Up F3=Dn $

12.13 Press “F1" to rotate to the LoMAPset screen which displays the manifold absolute pressure threshold below which the engine will be considered to be unloaded. During the unloaded condition, the controller will send the stepper motor to the default position and will not attempt to control the air/fuel ratio. On the home screen display, the “M” designator for the MAP pressure value will be changed to lower case “m”. This threshold can be increased and decreased with the "F2" and "F3" keys respectively.

LoMAPset =13.0psi
$ F2=Up F3=Dn $

12.14 Press “F1" to rotate to the Min O_2 set screen which displays the minimum O_2 target limit value. The enrichment offsets applied to the O_2 setpoint cannot result in an O_2 target richer than this voltage limit. This limit can be increased and decreased with the "F2" and "F3" keys respectively.

MinO2set= 1.000v
$ F2=Up F3=Dn $

12.15 Press “F1" to rotate through the setup screens which address the enrichment offset versus manifold pressure table. For each of the following manifold pressure break points, an enrichment offset value can be used to change the control target versus manifold pressure. The breakpoints of the table are as follows in PSIA (0.0, 4.1, 8.2, 12.3, 16.4, 20.5, 24.6, 28.7, 32.8, 36.9, 41.0, 45.1, 49.2, >50). These limits can be increased and decreased with the "F2" and "F3" keys respectively.

0.0psiA-0.000v
$ F2=Up F3=Dn $

4.1psiA-0.000v
$ F2=Up F3=Dn $

8.2psiA-0.000v
$ F2=Up F3=Dn $

Fill in all Table values

49.1psiA-0.000v
$ F2=Up F3=Dn $

OverpsiA-0.000v
$ F2=Up F3=Dn $

12.16 Press “F1" to access the Modbus setup screen, use the “F2" and “F3" keys to select the desired communications setting.

ModBus ID=101
$ F2=UP F3=DN

12.17 Press "F1" to rotate back to the main screen.

$$$ SETUP $$$
F1=Next F4=EXIT

12.18 Press "F4" to exit the setup mode. "F4" can be used from any setup screen. Remember all setup screens will display the "**$**" character. NOTE: “F4" can also be used to return to the HOME screen from any other display screen.

13.0 ENGINE STARTUP - KEYPAD AND DISPLAY OPERATION

13.1 Press "ALARM ACK." to acknowledge alarms if alarm LED is ON.

13.2 Press "F1", then press "START POS" to send the steppers to start position (stepper default position) and disable the alarm warnings for 10 minutes. The controller will return the stepper to its start position and then display the warmup screen. This procedure should ALWAYS be used when starting the engine.

13.3 Now the engine should be started, warmed up and loaded. Once the thermocouple is above 300 °F, the O_2 sensor warmup will begin. After two minutes the O_2 Voltage will be displayed.

Auto Warmup 1000 **14.2B 10.6m 25.3%**	**L AutoWarmup1000** **R AutoWarmup1000**	Waiting for 2 min. O_2 sensor warmup timer
Auto 1.85v 1000 **14.2B 10.6m 25.3%**	**L Auto1.96v 1000** **R Auto1.94v 1000**	Ready for auto, but inhibited due to light load
AUTO 2.15v 1064 **19.2B 16.1M 16.1%**	**L AUTO 2.12v 1064** **R AUTO 2.14v 1075**	Now loaded in Automatic, trying to get to O_2 target voltage
AUTO 2.51v 1103 **19.5B 17.3M 11.2%**	**L AUTO2.50v 1103** **R AUTO2.51v 1117**	Now loaded in Automatic, running at setpoint

14.0 DATA VIEWING - KEYPAD AND DISPLAY OPERATION

14.1 From the home screen press "DISP SEL" to display the first data view screen

Single Channel	Dual Channel	
AUTO 2.51v 1103 **19.5B 17.3M 11.2%**	**L AUTO 2.51v1103** **R AUTO 2.50v1096**	Home Screen now loaded in control
19.5B 17.5M psia **Throt Rsrv 11%**	**L 19.5B17.5M 11%** **R 20.1B17.7M 13%**	1st screen, manifold and boost in psia, throttle reserve in %

14.2 Press "DISP SEL" to display the second data view screen.

O2 Voltage 2.51V **O2 Target 2.51V**	**L o2v2.50trg2.50** **R o2v2.50trg2.50**	2nd screen shows O_2 voltage and O_2 control target with offset

14.3 Press "DISP SEL" to display the third data view screen.

O2Setpnt 2.51V **O2Target 2.51V**	**L spv2.53trg2.53** **R spv2.54trg2.54**	3rd screen shows O_2 lean set and O_2 control target with offset

14.4 Press "DISP SEL" to display the fourth data view screen.

EXH Temp = 1145˚F **GAIN VALUE=0.500**	**L EXHTemp=1060°F** **R EXHTemp=1062°F**	4th screen exhaust temperatures view gain setting on single only

14.5 Press "DISP SEL" again to display the fifth data view screen.

Stepper Pos =1103 **Default Pos = 1000**	**L DfltPos = 1000** **R DfltPos = 1000**	Default stepper position

15.0 MANUAL MODE - KEYPAD AND DISPLAY OPERATION

15.1 Press "LEFT MANUAL" to enter the manual mode. The display will indicate "**WORKING**" and then return with the controller in manual mode. This mode can be used to help set up the controller and to diagnose problems. Because no diagnostic alarms are present, it was not necessary to acknowledge alarms. Also, once in manual mode, diagnostic alarms are disabled. The alarm LED will flash while in manual mode to serve as a reminder that the EPC-150 is not in automatic control.

AUTO 2.51v 1100	**L AUTO2.50v 1100**	Now loaded in Automatic,
19.5B 17.3M 12.7%	**R AUTO2.51v 1117**	running at setpoint

15.2 Press "LEFT LEAN" to increase the stepper position by 25 steps. A descriptive message will be displayed and then the modified position will be attained. Increasing the position causes the valve to close and the mixture to change in the lean direction.

MOVING	**MOVING**
STEPPER	**STEPPER**
MAN! 2.62v 1125	**L MAN! 2.50v 1125**
20.2B 18.1M 11.6%	**R AUTO2.51v 1117**

15.3 Press "LEFT FAST", then press "LEFT RICH" to decrease the stepper position by 100 steps. Decreasing the position causes the valve to open and the mixture to change in the rich direction.

MOVING	**MOVING**
STEPPER	**STEPPER**
MAN! 2.38v 1028	**L MAN! 2.50v 1025**
18.5B 15.6M 18.6%	**R AUTO2.51v 1117**

15.4 Press "LEFT LEAN" to increase the stepper position again by 25 steps.

MOVING	**MOVING**
STEPPER	**STEPPER**
MAN! 2.45v 1050	**L MAN! 2.50v 1050**
18.9B 16.4M 13.2%	**R AUTO2.51v 1117**

15.5 Press "AUTO OPER" to return to automatic mode. Any time this key is pressed, automatic mode will be enabled.

AUTO 2.48v 1116	**L AUTO2.50v 1100**	Now back in Automatic control
19.4B 17.2M 11.3%	**R AUTO2.51v 1117**	

16.0 DIAGNOSTIC DISPLAYS AND OPERATION

16.1 The Alarm LED and Alarm Output operate in conjunction with the diagnostic features of the EPC-150. The four operation modes of these alarm features are described below.

a. Alarm LED OFF - Indicates that the unit is operating correctly in automatic mode, or in warm-up mode waiting for the exhaust temperatures to increase.

b. Alarm LED ON Steady - Indicates that the unit is attempting automatic control; however, one of the diagnostic criteria has not been satisfied. The alarm indicator will stay on solid until the alarm acknowledge key is pressed at which time the LED will flash. A solid-on yellow LED also indicates that the Alarm Output terminal is in its alarm state.

c. Alarm LED Flashing - Indicates one of two things; either an acknowledged alarm condition still exists, or the unit is in manual operation mode. The flashing LED should simply signify to the operator that the unit is not in normal automatic control. The Alarm Output is in its normal state if the LED is flashing.

d. The EXH TOO HOT warning will turn on the LED solid as well force the Alarm Output terminal to its alarm state. This protection feature will operate in Auto or Manual.

e. Stepper motor diagnostic messages do not turn on the Alarm Output.

NOTE: Both the alarm LED and the Alarm Output return to the normal condition when the system fault is corrected.

16.2 The Alarm Output is configured as a Normally Closed output signal. Any system fault will open the alarm circuit including loss of power, diagnostic warnings, etc. As described above, the Alarm Output would be in its fault condition (open) any time that the alarm indicator on the front panel is on solid.

CAUTION: To avoid possible engine damage, connect the Alarm Output to a device which can shut the engine down when the engine is normally left operating unattended.

16.3 The system diagnostics included in the EPC-150 are designed to identify conditions which are not considered normal operation. These diagnostic tests are performed continuously while the controller is in automatic mode. Each of the diagnostics will display a descriptive message, turn on the Alarm LED (yellow) and place the Alarm Output in the fault condition (open).

16.4 Active diagnostic warning messages are displayed in rotation, each message being displayed for about one (1) second. A generic warning message is also displayed and includes the current stepper position. The actual diagnostic displays shown are for a single channel application, the displays for the dual channel application are essentially the same with the addition of a L/R indicator.

Auto !WARN! 1000
19.4B 17.2M 11.3%

16.5 The Exhaust Temperature diagnostic monitors the exhaust for an over-temperature condition based on the thermocouple input. If the temperature is above a user selected value (1200°F default), then the EPC-150 displays the message as shown below. Note that thermocouple probe or thermocouple connection failures may also activate this diagnostic.

Auto !WARN! 1000
! EXH TOO HOT !

16.6 The pressure sensor diagnostics are designed to identify an open, shorted or broken pressure sensor input. Valid pressure signals are 0.5 to 4.5 volts and sensor values below 0.2V or above 4.8V will generate one of the messages below depending on which of the two sensors is faulted.

Auto !WARN! 1000
! BOOST HI/LO !

Auto !WARN! 1000
! MAP HI/LO !

16.7 The O_2 sensor signal diagnostic is designed to identify a problem with the O_2 sensor input signal. Causes of this fault may be a lack of power to the O_2 sensor, an open or shorted connection of the O_2 input signal wires or a failed sensor or Sensor Converter. When the controller has tried to power the sensor through the warmup period and the sensor signal is below 0.2 volts, the message below will be displayed.

Auto !WARN! 1000
! O2 SIGNAL LO !

16.8 The Lean and Rich Limit diagnostic monitors the stepper positions. If the position of a stepper valve is at the minimum (0) or maximum (1700) travel limit, the EPC-150 displays the appropriate message and activates the Alarm LED and Alarm Output. The rich limit warning indicates that the engine is too lean and the controller cannot open the valve any further to enrich the mixture. The lean limit warning indicates that the engine is too rich and the controller cannot close the valve any further.

Auto !WARN! 0
! LEAN LIMIT !

Auto !WARN! 1700
! RICH LIMIT !

16.9 A diagnostic exists that can identify an open stepper motor valve coil or wiring harness. The stepper motor must be moved for the diagnostic to set or to clear. It may take a great number of moves to clear the diagnostic once it has been flagged. When troubleshooting the stepper motor connections, power down the unit momentarily to clear a logged stepper problem. If the actions taken to address the condition previously detected have solved the problem, then the message will not appear when the unit is re-powered and further stepper moves are executed. These alarms do not activate the Alarm Output.

Auto !WARN! 1000
! STEP CoilPinA !

Auto !WARN! 1000
! STEP CoilPinB !

Auto !WARN! 1000
! STEP CoilPinC !

Auto !WARN! 1000
! STEP CoilPinF !

17.0 TROUBLE SHOOTING THE EPC-150 SYSTEM

17.1 Green LED and LCD display are blank; power is interrupted.

a. Check power supply voltage at EPC terminal block TS2A (18-30 volts), while still connected.
b. Power down unit, then remove and check resistance of on-board fuses (F1) (< 2 ohms). See fig. 9 and 10 for fuse location.
c. Verify tight cable connections between control and display boards.

17.2 Display reads "BOTTOM BOARD NOT RUNNING"; control board is not running.

a. Power-down unit for 1 minute. Then re-power and check display.
b. Replace control board assembly. See figs. 9 and 10.

17.3 Display top row is dark, bottom row is light; display board is not running.

a. Power-down unit for 1 minute. Then re-power and check display.
b. On back of display board, examine the large blue socketed IC for tight engagement.
c. Check cable connection between control and display boards.
d. Replace display board assembly. See figs. 9 and 10.

17.4 Display is blank, but green LED is on. Contrast adjustment required.

a. On back of display board adjust contrast potentiometer.
   Clockwise = Lighter; Counterclockwise = Darker. See Figs. 9 and 10 for location.
b. Replace display board assembly. See figs. 9 and 10.

17.5 Key pad entries cause no display response.

a. At bottom of display board, verify connection of keypad ribbon connector.
b. Replace enclosure and keypad assembly. See figs. 9 and 10.

17.6 Alarm LED is on solid.

a. Read the warning message on the display and reference the diagnostic section for an explanation of the warning.
b. Press "Alarm Ack" to permit normal keypad operation and to disable the Alarm Output terminal.

17.7 EPC-150 will not move stepper valves during "F1" then "Start Pos." command.

a. Check stepper cable connections at EPC-150 and at stepper valve.
b. Inside the EPC-150, verify that red LED on control board is ON. If LED is off or flashing, check the fuses on the control board.
c. Examine blue socketed chip for tight engagement.
d. Test EPC-150 with a spare stepper valve assembly.
e. Test EPC-150 and stepper valve assembly, with a spare stepper cable.
f. Replace control board assembly. See figs. 9 and 10.

17.8 High exhaust temp warnings persist OR unit always indicates COLD.

a. If engine is not running, start and warmup engine.
b. Test the disconnected thermocouple reading at EPC-150 with an alternate thermocouple reading device.
c. Replace thermocouple or correct wiring if temperatures are incorrect. The life of thermocouple probes is highly dependent on the use of a thermowell and on corrosives in the exhaust.
d. If low temperature is a problem during first installation, an alternate sensor and probe location may be required. Please contact the factory before pursuing any other action to raise sensor temperatures.
e. Replace control board assembly. See figs. 9 and 10.

17.9 Rich or lean limit warnings persist.

a. A misfiring engine can cause the system to shift in the rich direction. Check the engine for misfiring cylinders using a timing light or exhaust pyrometer.
b. Use an exhaust analyzer and the EPC-150 manual mode to adjust the % O_2. If the % O_2 cannot be manipulated in the manual mode, then test to make sure the stepper valve is functioning as was done during installation.
c. If manual mode moves the % O_2 but cannot attain the setpoint, then the fuel system may need to be readjusted. First verify that the load screw adjustments on the carburetors are full rich or full open. If they are not full open, the control range of the stepper valves will be limited. Second, adjust the fuel pressure regulators so that when in automatic mode, the stepper valves are controlling near 1000 steps.
d. If the fuel system appears to be adjusting correctly, use an exhaust analyzer and the EPC-150 manual mode to sweep the % O_2 from around 2% up to 7.2% while watching the O_2 sensor voltage on the display. The voltage should move from about 0.1 volts toward 4.0 volts as the % O_2 is changed. If this is not the case, a new sensor should be tested.
e. If EPC-150 O_2 sensor voltage display does not match actual sensor voltage, test for ground loop problems.
f. Replace control board assembly. See figs. 9 and 10.

17.10 EPC-150 setup values are lost at power-down; battery for BBRAM is failed.

a. Replace control board assembly. See figs. 9 and 10.

18.0 EPC-150 MODBUS REGISTER LIST

The EPC-150 incorporates both a RS-232 port and a half-duplex RS-485 port which are Modbus RTU slave compliant. The RS-232 is connected via the DB-9 connector near the center of the circuit board. The RS-485 terminals are on terminal strip TS3, a 3-position plug also near the center of the circuit board. The protocol used follows the Modicon Modbus RTU standard. A complete listing of the Modbus registers is included on the EPC-150 Terminal program CD along with a PC-based Modbus compatible monitoring program. The default configuration for the ports is 9600 baud N81 with a node ID of 100. The Modbus communications will allow the EPC-150 to meet the needs of continuous emissions monitoring should it be required.

The 10xxx registers are read only binary and support Modbus standard function 2. These registers are read in multiples of 8 (1 byte) addressed at each 8 bit boundary (10001-10008, etc.). A single Boolean read from registers 10001 to 10064 can be made which will return all 64 values as a group of 8 bytes. These registers also support an Altronic custom function 102 which will return a descriptive label for each specific register. The custom label function can be used to reduce the need for the Modbus master to maintain a current listing of all of the register labels for each unit.

10007 = Dual Bank Configuration
10008 = Unacknowledged Alarm Present
10009 = Left Moving Home
10012 = Left Throttle Reserve Low
10013 = Left Low MAP Unloaded
10014 = Left Warmup Mode
10015 = Left Cold Engine Not Running
10016 = Left Manual Override
10017 = Right Moving Home
10020 = Right Throttle Reserve Low
10021 = Left Low MAP Unloaded
10022 = Right Warmup Mode
10023 = Right cold Engine Not Running
10024 = Right Manual Override
10026 = Left O2 input out of range
10027 = Left Boost input out of range
10028 = Left MAP input out of range
10029 = Left Hi Exhaust Temperature
10030 = Left Low Throttle Reserve 255sec
10031 = Left Bank Stepper Lean Limit
10032 = Left Bank Stepper Rich Limit
10034 = Right O2 input out of range
10035 = Right Boost input out of range
10036 = Right MAP input out of range
10037 = Right Hi Exhaust temperature
10038 = Right Low Throttle Timer>255 sec
10039 = Right Bank Stepper Lean Limit
10040 = Right Bank Stepper Rich Limit
10041 = Right Bank Step Coil Open Pin C
10042 = Right Bank Step Coil Open Pin B
10043 = Right Bank Step Coil Open Pin A
10044 = Right Bank Step Coil Open Pin F
10045 = Left Bank Step Coil Open Pin C
10046 = Left Bank Step Coil Open Pin B
10047 = Left Bank Step Coil Open Pin A
10048 = Left Bank Step Coil Open Pin F
10049 = Left Auto Control is Active
10050 = Left Getting Richer
10051 = Left Very Rich
10052 = Left Rich
10053 = Left On Target
10054 = Left Lean
10055 = Left Very Lean
10056 = Left Getting Leaner
10057 = Right Auto Control is Active
10058 = Right Getting Richer
10059 = Right Very Rich
10060 = Right Rich
10061 = Right On Target
10062 = Right Lean
10063 = Right Very Lean
10064 = Right Getting Leaner
10070 = Left Low Throttle Timer>254 sec
10071 = Left Throttle Reserve %<Threshold
10072 = Left Low Load (MAP)<Threshold
10073 = Right Bank Step Coil Drive 1
10074 = Right Bank Step Coil Drive 2
10075 = Right Bank Step Coil Drive 3
10076 = Right Bank Step Coil Drive 4
10077 = Left Bank Step Coil Drive 1
10078 = Left Bank Step Coil Drive 2
10079 = Left Bank Step Coil Drive 3
10080 = Left Bank Step Coil Drive 4

The 30xxx registers are read only 16 bit analog values. The Modbus standard function 4 is supported. These registers also support an Altronic custom function 104 which will return a descriptive label for each specific register.

30001 = Supply Input Voltage .1v/cnt
30002 = Logic Vdd Voltage 1mv/cnt
30003 = CJT Deg C signed 0.01degc/cnt
30005 = Left Exhaust TC Temp 1degf/cnt
30006 = Left Exhaust O2 Voltage 1mv/cnt
30007 = Left O2 Target 1mv/cnt
30008 = Left Stepper Position
30009 = Left Boost Psia x 1000
30010 = Left MAP Psia x 1000
30011 = Left Throttle Reserve
30012 = Left Reserve Timer in seconds
30013 = Left AUX TC 1degf/cnt
30014 = Left AUX O2 1mv/cnt
30015 = Right Exhaust TC Temp 1degf/cnt
30016 = Right Exhaust O2 voltage 1mv/cnt
30017 = Right O2 Target
30018 = Right Stepper Position
30019 = Right Boost
30020 = Right MAP
30021 = Right Throttle Reserve
30022 = Right Reserve Timer
30023 = Right Aux TC
30024 = Right Aux O2 1mv/cnt
30027 = Left Enrichment Offset in mV
30101 = CJT Compensation 1uv/cnt
30102 = a/d 0 Filter 2.5v reference
30103 = a/d 1 Filter Supply Voltage
30104 = a/d 2 Filter Vss
30105 = a/d 3 CJT
30106 = a/d 4 O2 Right Aux 4pin
30107 = a/d 5 O2 Left Aux 4pin
30108 = a/d 6 TC Right Aux 4pin
30109 = a/d 7 TC Left Aux 4pin
30110 = a/d 8 TC Right Aux 20pin
30111 = a/d 9 TC Left Aux 20pin
30112 = a/d A O2 Right Aux 20pin
30113 = a/d B O2 left Aux 20pin
30114 = a/d C Sensor 1 Aux 20pin
30115 = a/d D Sensor 2 Aux 20pin
30116 = a/d E Sensor 3 Aux 20pin
30117 = a/d F sensor 4 Aux 20pin
30127 = Warm-boot Counter
30128 = Cold-boot Counter

The 40xxx registers are read/write 16-bit analog values and they support the Modbus standard functions 3, 6 and 16. These registers may have new values written to them in order to make setpoint adjustments from a remote location. They also support a custom function 103 which will return a label describing each specific register.

40001 = Left O2 Lean Setpoint in mV
40002 = Right O2 Lean Setpoint in mV
40003 = Left Bank Start Position in steps
40004 = Right Bank Start Position in steps
40005 = Control Gain Rate Value/40
40006 = Exhaust Temp Cold Setting °F
40007 = Exhaust Temp Hi Alarm Setting °F
40008 = Low O2 Alarm Setting in mV
40009 = Hi O2 Alarm Setting in mV
40012 = Auto Disabled MAP < Psia x 1000
40013 = Low Throttle Reserve Limit 0-1000
40014 = Low Throttle Enrichment Offset mV
40015 = 02 Exhaust Min Setpoint in mV
40021 = 0.0 Psia Enrichment Offset in mV
40022 = 4.1 Psia Enrichment Offset in mV
40023 = 8.2 Psia Enrichment Offset in mV
40024 = 12.3 Psia Enrichment Offset in mV
40025 = 16.4 Psia Enrichment Offset in mV
40026 = 20.5 Psia Enrichment Offset in mV
40027 = 24.6 Psia Enrichment Offset in mV
40028 = 28.7 Psia Enrichment Offset in mV
40029 = 32.8 Psia Enrichment Offset in mV
40030 = 36.9 Psia Enrichment Offset in mV
40031 = 41.0 Psia Enrichment Offset in mV
40032 = 45.1 Psia Enrichment Offset in mV
40033 = 49.2 Psia Enrichment Offset in mV
40034 = Overrange Enrichment Offset in mV
40125 = Aux Out D=128 C=64 B=32 A=16
40126 = MODBUS Port Config Code
40127 = MODBUS Node ID / Slave ID
40128 = MODBUS Key Command Register

Detailed below are the command values which can be written to the Modbus key Command Register (40128).

1. Reg(40128) = 00510 Select Auto mode for both banks
2. Reg(40128) = 00765 Select Manual for Left bank
3. Reg(40128) = 01020 Select Manual for Right Bank
4. Reg(40128) = 01275 F1-Start stepper reset
5. Reg(40128) = 01530 Alarm acknowledge
6. Reg(40128) = 01785 Increment Left O2 target leaner
7. Reg(40128) = 02040 Decrement Left O2 target richer
8. Reg(40128) = 02295 Increment Right target leaner
9. Reg(40128) = 02550 Decrement Right target richer
10. Reg(40128) = 02805 Decrement control gain rate
11. Reg(40128) = 03060 Increment control gain rate
12. Reg(40128) = 03315 Reload default calibrations
13. Reg(40128) = 03570 Left Start Position Updated to Current Position
14. Reg(40128) = 03825 Right Start Position Updated to Current Position
20. Reg(40128) = 05355 Move Left stepper rich -25
21. Reg(40128) = 05610 Move Left stepper lean +25
22. Reg(40128) = 05865 Move Left stepper rich -100
23. Reg(40128) = 06120 Move Left stepper lean +100
24. Reg(40128) = 06375 Move Right stepper rich -25
25. Reg(40128) = 06630 Move Right stepper lean +25
26. Reg(40128) = 06885 Move Right stepper rich -100
27. Reg(40128) = 07140 Move Right stepper lean +100
28. Reg(40128) = 07395 Decrease cold exhaust threshold
29. Reg(40128) = 07650 Increase cold exhaust threshold
30. Reg(40128) = 07905 Decrease hi   exhaust threshold
31. Reg(40128) = 08160 Increase hi   exhaust threshold
32. Reg(40128) = 08415 Decrease low reserve threshold percent
33. Reg(40128) = 08670 Increase low reserve threshold percent
34. Reg(40128) = 08925 Decrease low reserve offset voltage
35. Reg(40128) = 09180 Increase low reserve offset voltage
36. Reg(40128) = 09435 Decrease low load threshold psi
37. Reg(40128) = 09690 Increase low load threshold psi

38. Reg(40128) = 09945 Decrease low O2 target min limit
39. Reg(40128) = 10200 Increase low O2 target min limit
40. Reg(40128) = 10455 Decrease 0.0 psi offset table entry
41. Reg(40128) = 10710 Increase 0.0 psi offset table entry
42. Reg(40128) = 10965 Decrease 5.1 psi offset table entry
43. Reg(40128) = 11220 Increase 5.1 psi offset table entry
44. Reg(40128) = 11475 Decrease 10.2 psi offset table entry
45. Reg(40128) = 11730 Increase 10.2 psi offset table entry
46. Reg(40128) = 11985 Decrease 15.4 psi offset table entry
47. Reg(40128) = 12240 Increase 15.4 psi offset table entry
48. Reg(40128) = 12495 Decrease 20.5 psi offset table entry
49. Reg(40128) = 12750 Increase 20.5 psi offset table entry
50. Reg(40128) = 13005 Decrease 25.6 psi offset table entry
51. Reg(40128) = 13260 Increase 25.6 psi offset table entry
52. Reg(40128) = 13515 Decrease 30.7 psi offset table entry
53. Reg(40128) = 13770 Increase 30.7 psi offset table entry
54. Reg(40128) = 14025 Decrease 35.8 psi offset table entry
55. Reg(40128) = 14280 Increase 35.8 psi offset table entry
56. Reg(40128) = 14535 Decrease 40.9 psi offset table entry
57. Reg(40128) = 14790 Increase 40.9 psi offset table entry
58. Reg(40128) = 15045 Decrease 46.0 psi offset table entry
59. Reg(40128) = 15300 Increase 46.0 psi offset table entry
60. Reg(40128) = 15555 Decrease 51.2 psi offset table entry
61. Reg(40128) = 15810 Increase 51.2 psi offset table entry
62. Reg(40128) = 16065 Decrease over psi offset table entry
63. Reg(40128) = 16320 Increase over psi offset table entry

The EPC-150 unit also supports a Modbus function 17 which will return the unit information including the Version, Date and Name.

FIGURES SECTION:

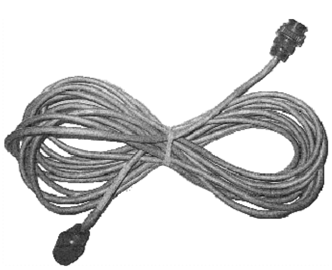
FIG. 1 EPC-150 COMPONENTS

Air/Fuel Controller
EPC-150

Sensor Converter
691207-1

Control Valve
690154-1

Oxygen Sensor
610813



Control Valve Cable
693005

Sensor Cable
693009

FIG. 2 GENERAL INSTALLATION LAYOUT

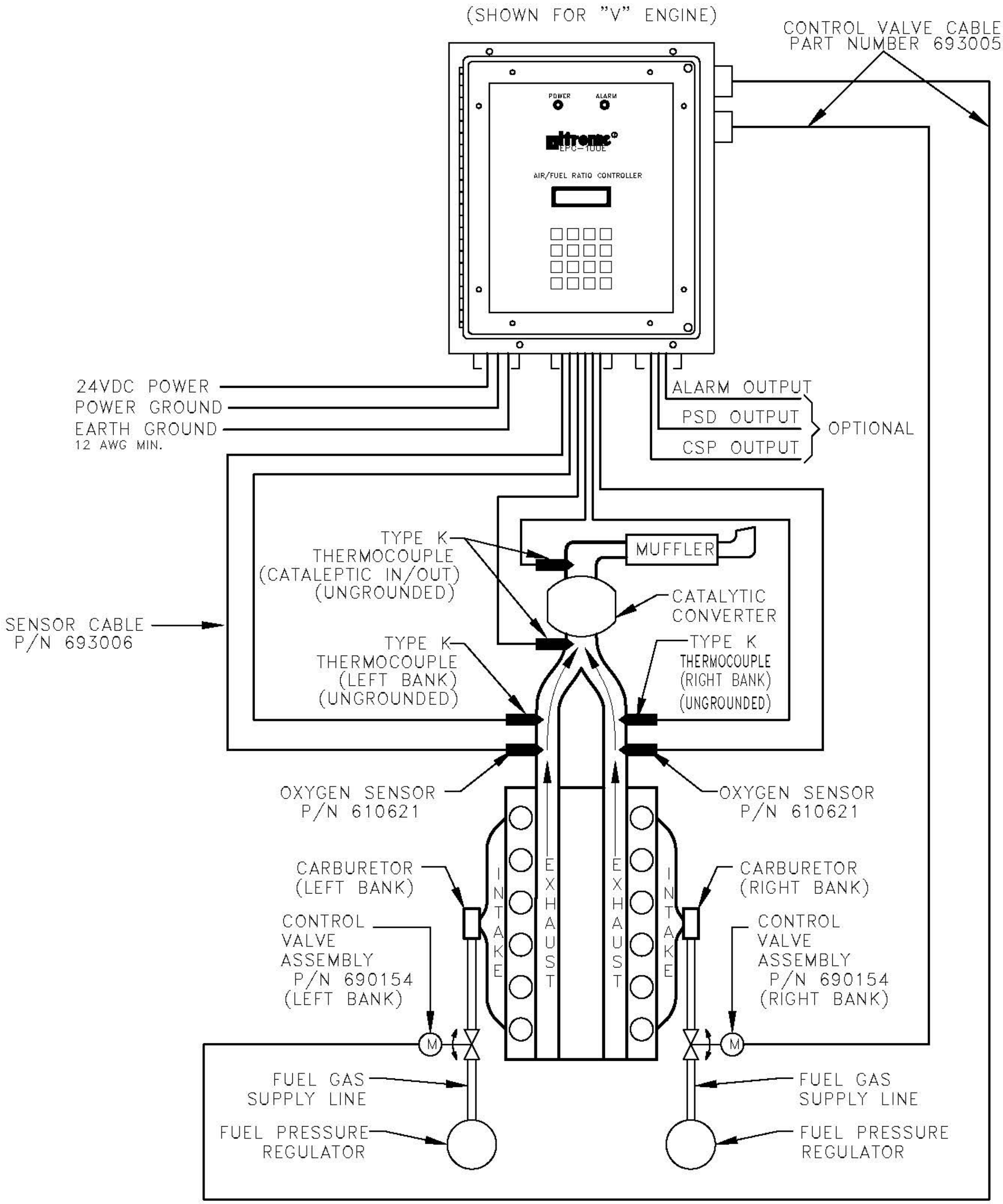
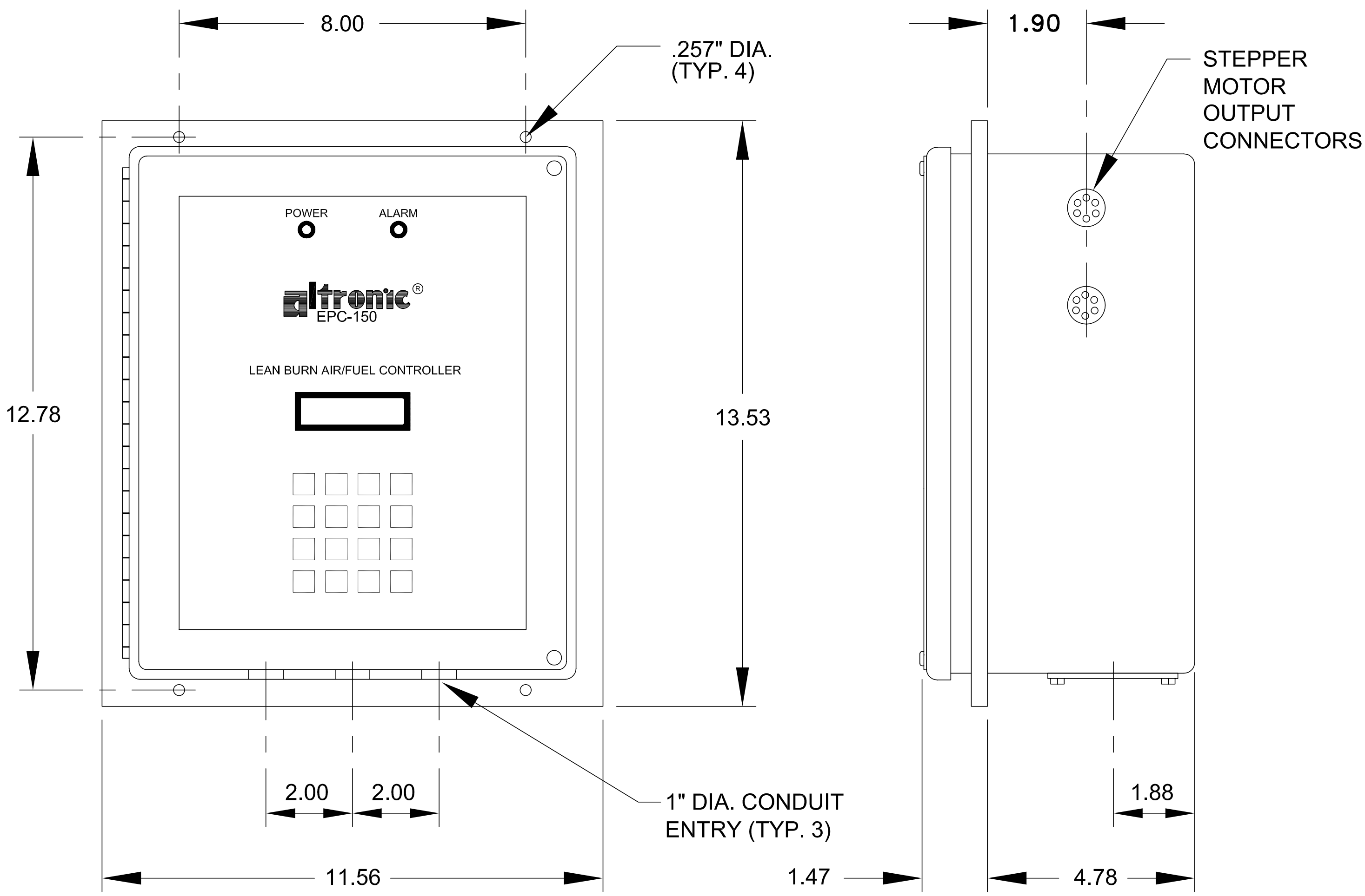
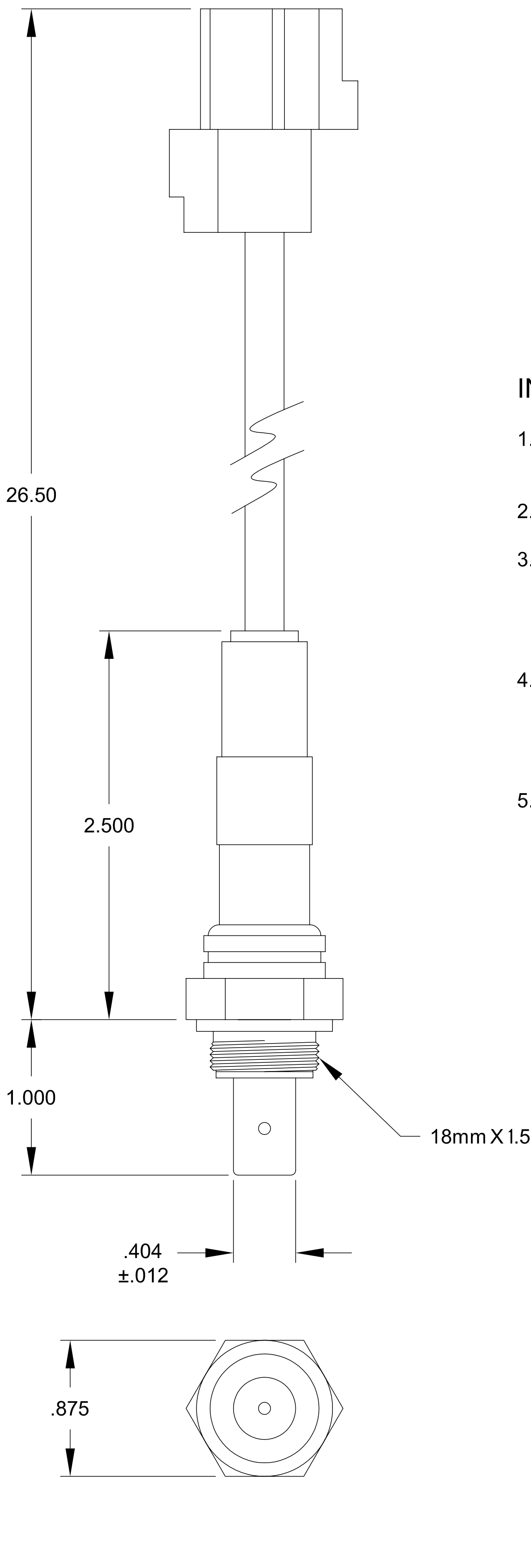


FIG. 3 EPC-150 MOUNTING DETAIL



NOTE: PANEL CUT-OUT IS 10.12" X 12.12"
ALL DIMENSIONS ARE IN INCHES.

FIG. 4 OXYGEN SENSOR DETAIL



INSTALLATION INSTRUCTIONS:

1. INSTALL IN THE APPROPRIATE MOUNTING HOLE TO A TORQUE OF 28-34 Lb. Ft.

2. USE A 7/8" WRENCH SIZE.

3. SENSORS ARE SUPPLIED WITH THREADS COATED WITH MS-0572 ANTISEIZE COMPOUND.
   CAUTION: DO NOT APPLY ANTISEIZE COMPOUND TO AREAS OTHER THAN THE MOUNTING THREADS.

4. FOR OPTIMUM RESISTANCE TO WATER INTRUSION. MOUNT THE SENSOR SUCH THAT THE EXPOSED END (WIRE END) OF THE SENSOR IS ORIENTED AT OR ABOVE HORIZONTAL.

5. THIS SENSOR IS DESIGNED FOR WATER SPLASH RESISTANCE.

FIG. 6 EPC-150 WIRE ROUTING DETAIL

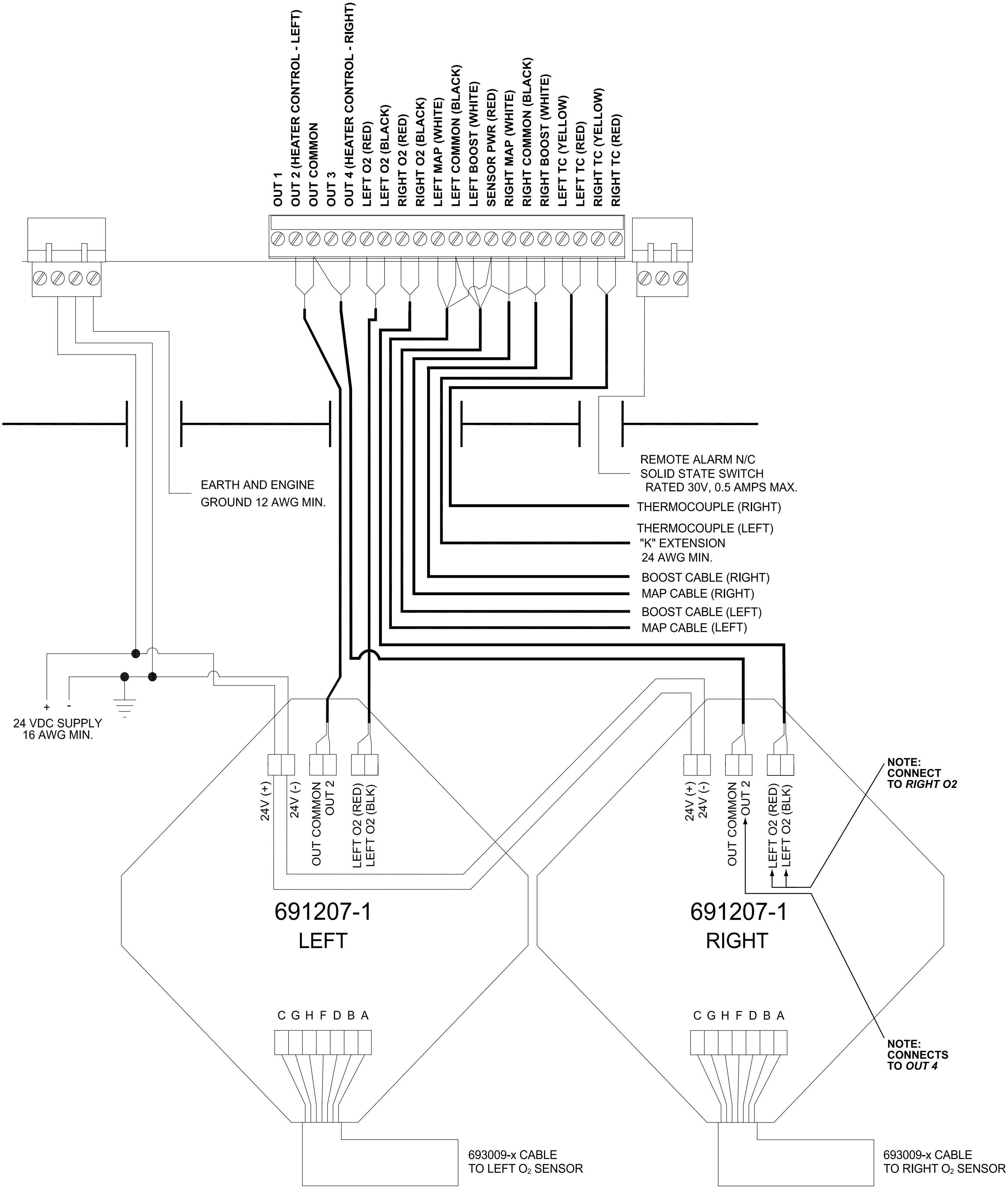
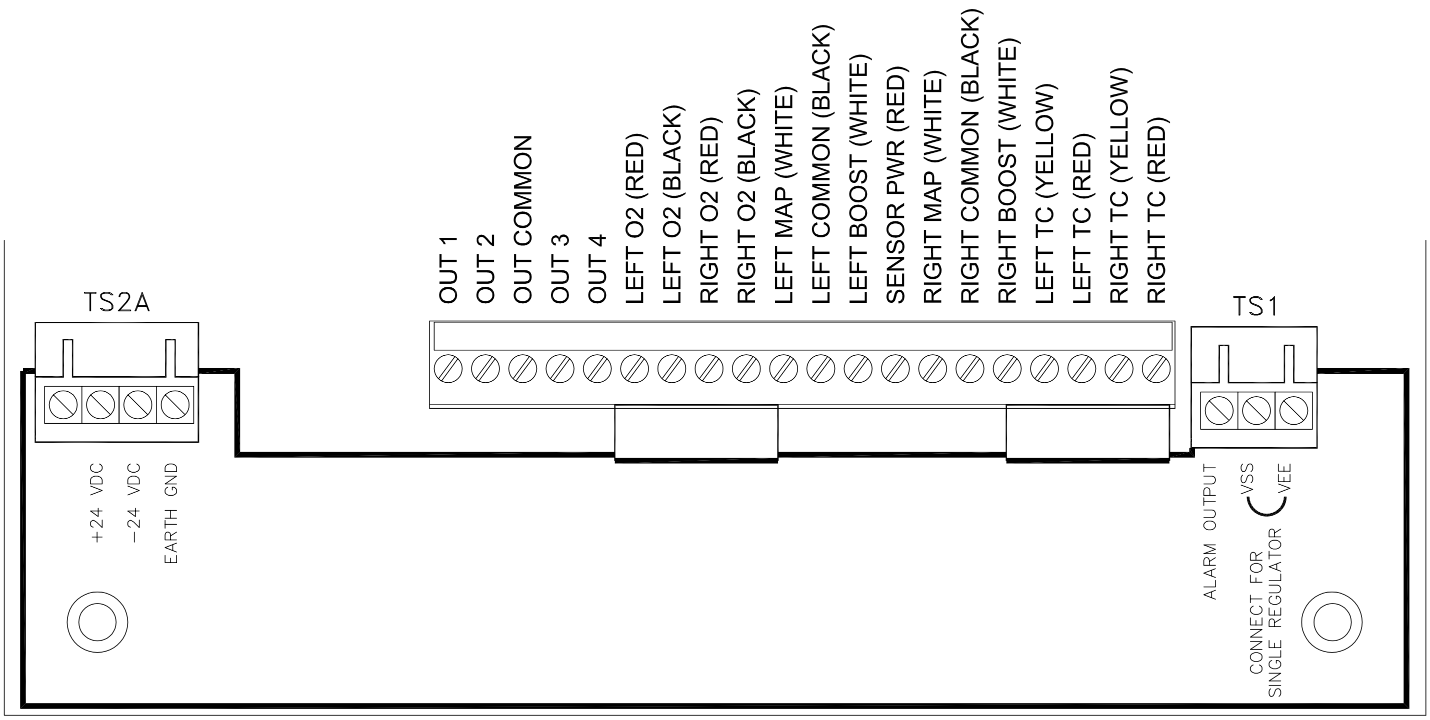


FIG. 7 EPC-150 TERMINAL LAYOUT



TS2A

+24 VDC	POSITIVE LEAD OF THE D.C. POWER SOURCE.
−24 VDC	NEGATIVE LEAD OF THE D.C. POWER SOURCE.
EARTH GROUND	EARTH GROUND ALSO CONNECTED TO ENGINE GROUND.

TS4 *

OUT 2	POSITIVE LEAD OF THE SENSOR HEATER CONTROL.
OUT COMMON	NEGATIVE LEAD OF THE SENSOR HEATER CONTROL (LOGIC GROUND).
LEFT O2 (RED)	POSITIVE LEAD OF 610813 SENSOR.
LEFT O2 (BLACK)	NEGATIVE LEAD OF 610813 SENSOR.
LEFT MAP (WHITE)	POSITIVE LEAD OF THE MAP SENSOR (691204−50).
LEFT COM. (BLACK)	NEGATIVE LEAD FOR LEFT MAP AND BOOST SENSORS.
LEFT BOOST (WHITE)	POSITIVE LEAD OF THE BOOST SENSOR (691204−50).
SENSOR PWR (RED)	POWER LEAD FOR MAP AND BOOST SENSOR.
LEFT TC (YELLOW)	POSITIVE LEAD TO "K" EXTENSION WIRE AND THERMOCOUPLE.
LEFT TC (RED)	NEGATIVE LEAD TO "K" EXTENSION WIRE AND THERMOCOUPLE.

TS1

ALARM OUTPUT	POSITIVE LEAD, N/C TO GROUND. OPEN FOR ALARM. REQUIRED.
VSS	COMMON RETURN FOR VEE SELECT INPUT.
VEE	CONNECT TO "VSS" FOR SINGLE REGULATOR OPERATION.

* NOTE: ALL CONNECTIONS UNLISTED ARE NOT USED AND TO BE LEFT UNCONNECTED.

FIG. 8 SENSOR ADAPTER OUTPUT (V)

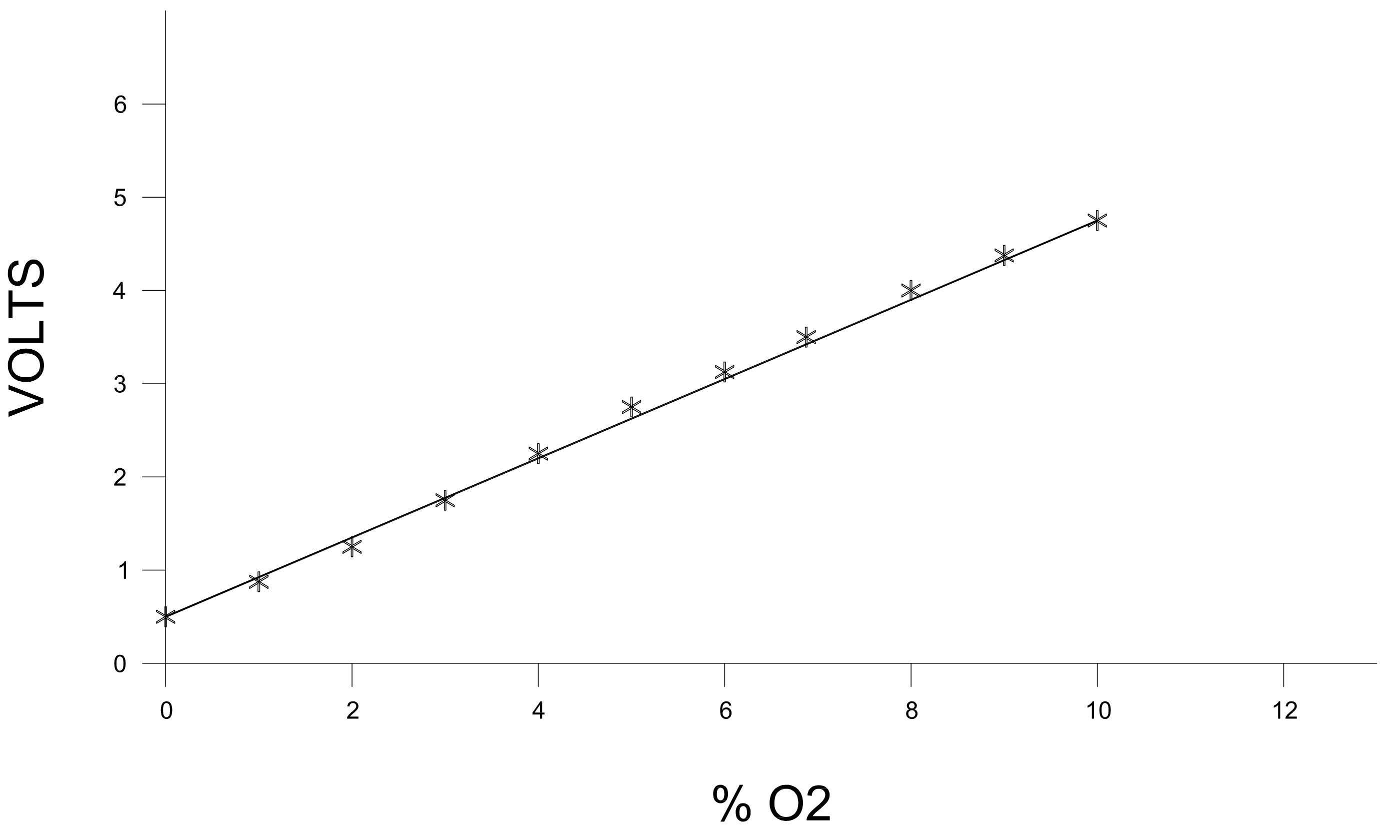


FIG. 9 PARTS BREAKDOWN - EPC-150

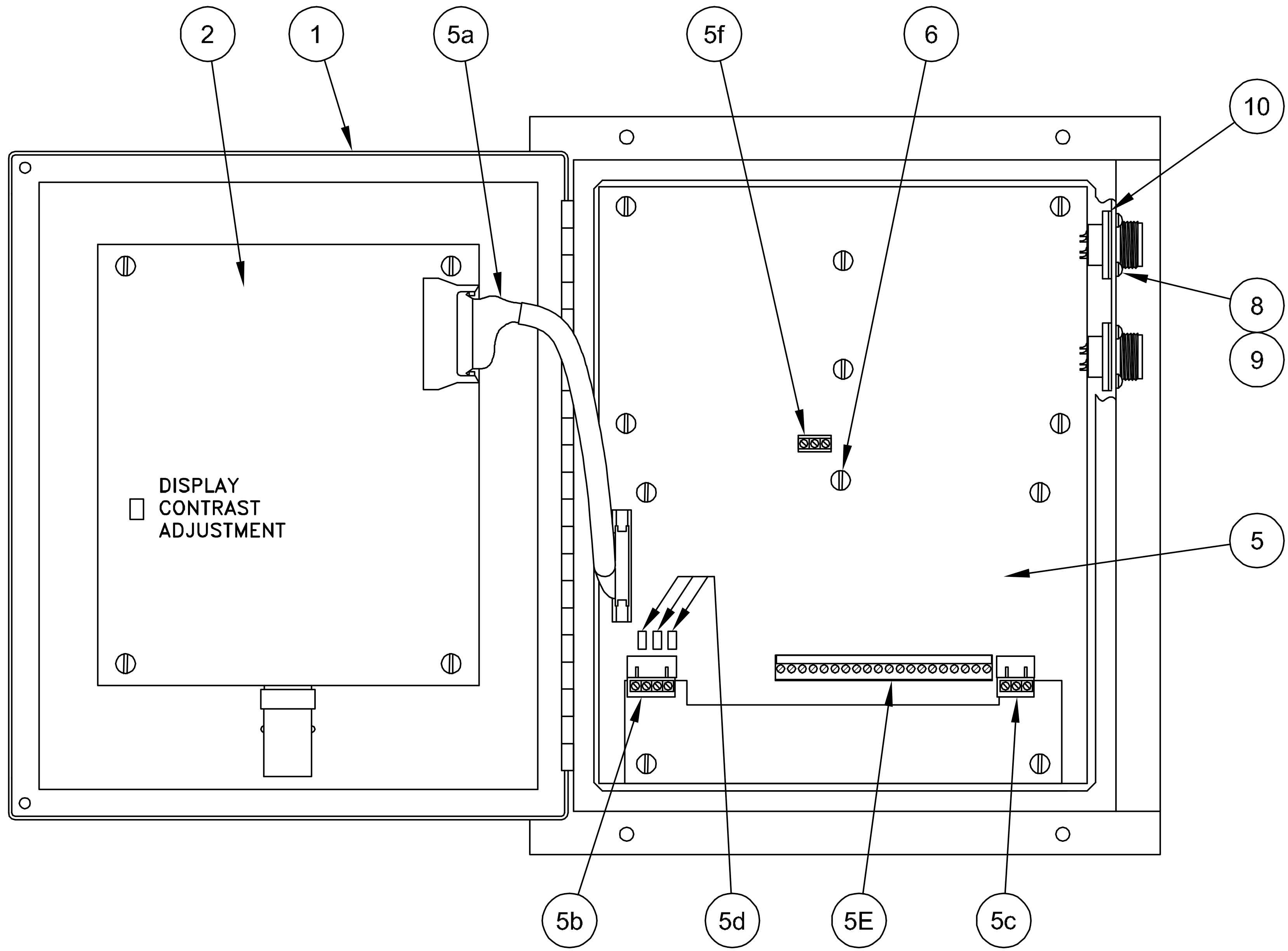


FIG. 9a - PARTS IDENTIFICATION - EPC-150

The following replacement parts are available from authorized Altronic distributors.

REF. NO.	QTY.	PART NO.	DESCRIPTION
1	1	670040-2	Enclosure/keypad assembly
2	1	672124-3	Display board assembly
5	1	681064-2	Control/stepper board assembly
5a	1	610583	Cable assembly, display board
5b	1	604137	Terminal block - 4 position
5c	1	604149	Terminal block - 3 position
5d	3	601653	Fuse, control board
5e	1	610243	Terminal block - 20 position
5f	1	610241	Terminal block - 3 position
6	15	902439	Screw 10-32 x 3/8"
8	8	902064	Screw 6-32
9	8	901000	Lockwasher #6
10	2	501335	Gasket, connector

NOTE: Reference numbers can be used to identify parts on fig. 9.

FIG. 10 - EPC-150 ACCESSORY KIT IDENTIFICATION

Contents of Accessory Kit 691315-1:

REF.NO.	QTY.	PART NO.	DESCRIPTION
1	1	610813	Oxygen Sensor
2	1	691207-1	Oxygen Sensor Converter
3	2	691204-50	Pressure Sensor
4	1	693005-1	Cable Assembly, Control Valve, 25 ft.
5	2	693008-25	Cable Assembly, Pressure Sensor, 25 ft.
6	1	693009-1	Cable Assembly, Oxygen Sensor, 25 ft.

Contents of Accessory Kit 691315-2:

REF.NO.	QTY.	PART NO.	DESCRIPTION
1	1	610813	Oxygen Sensor
2	1	691207-1	Oxygen Sensor Converter
3	2	691204-50	Pressure Sensor
4	1	693005-2	Cable Assembly, Control Valve, 50 ft.
5	2	693008-50	Cable Assembly, Pressure Sensor, 50 ft.
6	1	693009-2	Cable Assembly, Oxygen Sensor, 50 ft.