MODEL 4101-02

COMBUSTIBLE GAS MODULE

4-20 mA

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COMBUSTIBLE GAS MODULE

4-20 mA

FM APPROVED

APPLICABILITY & EFFECTIVITY

This manual provides instructions for the following Sierra Monitor products:

Model	Description
4101-02	Combustible Gas Module

The instructions are effective for the above models as of June 1, 1997

Instruction Manual Part Number: T13002
Rev B2

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1. PRODUCT DESCRIPTION

1.1 GENERAL

The Model 4101-02 Combustible Gas Sensor Module is designed for use in conjunction with industry standard 4-20mA loop controllers. The module requires three wire connection to a controller which provides nominal 24 VDC. The module sources current in proportion to the gas concentration. The 4101-02 standard features include:

- Automatic power-on delay to avoid nuisance alarms.
- Automatic delayed return to on-line after calibration.
- Percent LEL (as 0-1 VDC) readout on any digital voltmeter provided during calibration.
- Built in LOW SENSITIVITY check button.
- Visual and electrical fault indication.
- Poison resistant sensor standard (not FMRC verified).

1.2 INTERCONNECT WIRING

Necessary to the installation and operation is the three conductor wiring which connects between the user's controller and the sensor module. Before this wiring is installed it is important to read the complete instruction manual to determine acceptable wire gauges and distances and also to determine if any of the warnings and cautions are applicable.

1.3 POWER REQUIREMENTS

The 4101-02 requires an input voltage of 21 to 30 VDC. Input current is 80 mA at 28 VDC. Maximum loop resistance is 400 ohms @21V.

1.4 FACTORY MUTUAL RESEARCH CORPORATION (FMRC) APPROVAL:

Factory Mutual Research Corporation (FMRC) Approval of Model 4101-02 gas sensor/transmitter does not include or imply approval of the apparatus to which it is connected. In order to retain FMRC Approval of a gas detection system, the apparatus to which the sensor/transmitter is connected to must also be FMRC Approved.

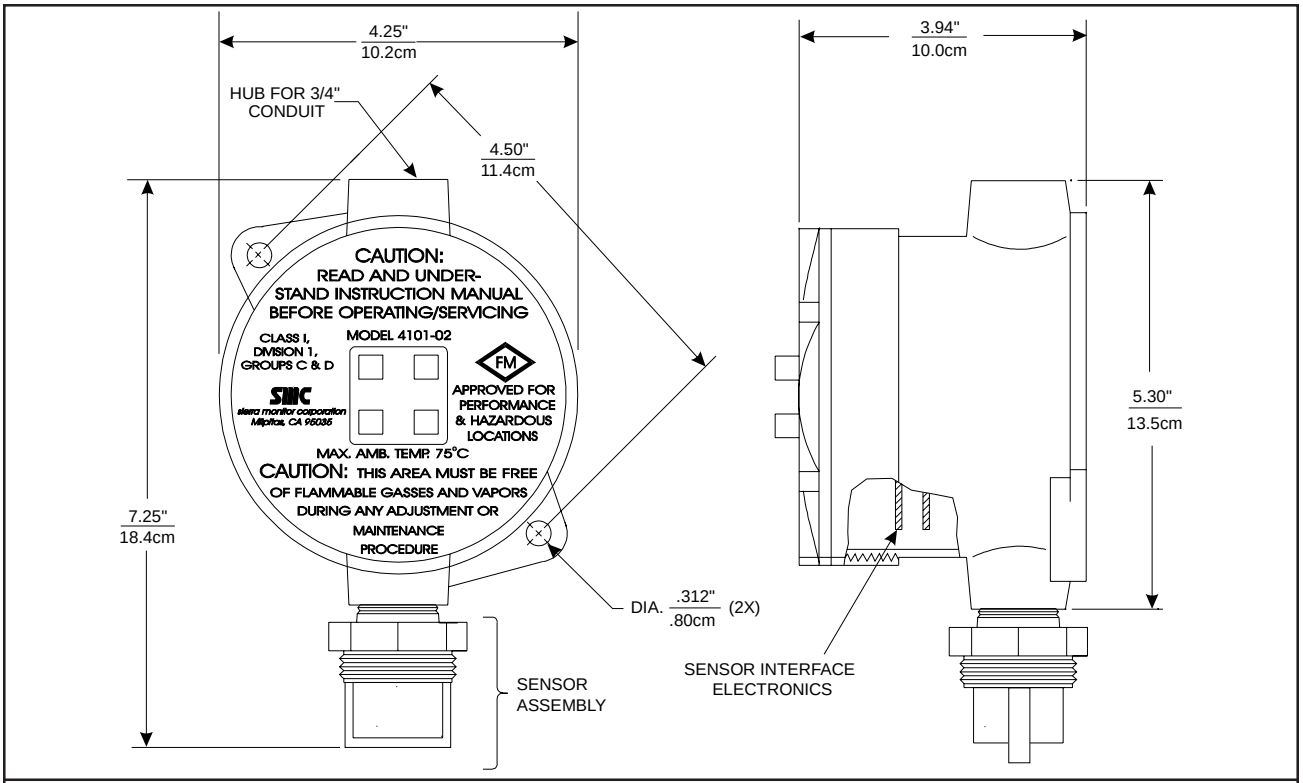

FIGURE 1.1: MODULE OUTLINE DRAWING

2. CAUTIONS WARNINGS & RECOMMENDATIONS

2.1 INTRODUCTION

Although the sensor module is designed and constructed for installation and operation in industrial applications including "hostile" environments, caution should be taken to insure that the installation is in compliance with this instruction manual and that certain procedures and conditions are avoided.

READ AND UNDERSTAND THIS INSTRUCTION MANUAL BEFORE OPERATING OR SERVICING THIS EQUIPMENT.

2.2 WIRING

Electro magnetic and radio frequency interference to the analog communication between the sensor and the controller may occur. The manufacturer recommends that extra caution be taken where the installation is near any sources of these interferences:

Avoid running sensor cable close to high power cables, radio transmission lines, or cables subject to pulses of high current. Avoid running cables near large electric motors or generators.

Use shielded cable in any location which may be expected to be electrically noisy or where cable is expected to be in close contact with AC wiring. The shield should be connected to the Earth ground at both ends.

The wiring should be run in either a cable tray or conduit as required by applicable code and area classification. Control wiring should not be installed in a cable tray or conduit with higher voltage and AC circuits. See Table 2.1 for recommended wire gauge.

Wiring connections at the gas sensor module are as follows:

Wire#	Function	Terminal
1	Power	"P"
2	Signal	"S"
3	Ground	"G"

Connect an earth ground to the ground screw provided in the base of the gas sensor module enclosure.

Wire Gauge	Maximum Length
20 AWG	2,000 Ft.
18 AWG	3,000 Ft.
16 AWG	4,000 Ft.
14 AWG	6,500 Ft.
12 AWG	9,000 Ft.

Table 2.1
Recommended Wire/Cable Gauge

All splices must be via either a lug and terminal system or soldered. Improperly spliced cable can result in corrosion, resistance changes and system errors.

NOTE: Temperature rating of cable wire insulation must be above 80^{O}C (85^{O}C or greater rated wiring is recommended). If cable runs through higher temperature environments, it should be specified for that environment.

2.3 SENSOR MODULES - GENERAL

Avoid installing sensor modules where they will be unnecessarily exposed to wind, dust, water (esp. direct hose down), shock, or vibration. Observe temperature range limitations.

Sensors may be adversely affected by prolonged exposure to certain materials. Loss of sensitivity, or corrosion, may be gradual if such materials are present in low concentrations. These materials include: Halides (compounds containing chlorine, fluorine, bromine, or iodine), silicones, acid vapors, caustic liquids or vapors.

Sensor modules must not be painted. Paint may contain compounds which will contaminate the sensor. Paint will also cause clogging of the sintered metal cup and will cause difficulties during attachment of the calibration head. The module should be tagged "DO NOT PAINT".

When sensors are replaced the thread on the sensor housing **must be teflon taped** to avoid metal to metal binding which will damage the housing threads.

Catalytic type combustible gas sensors are easily poisoned by exposure to silicones. NO SILICONE CAULKING (RTV) SHOULD BE USED NEAR THE SENSORS. No other silicone based compounds should be used near the sensors unless they are fully protected during the entire cure cycle. If the sensors will be exposed to silicone during normal operation the MANUFACTURER'S SENSOR WARRANTY IS VOID.

2.4 PREVENTATIVE MAINTENANCE

DUST AND DIRT CONTROL: When calibration is performed the controller and sensors should be checked visually to determine if dust or dirt build up needs to be removed. This cleaning should be done with dry instruments such as compressed air, cloth wipes or wisk broom.

WIRING OR CABLE CONDITIONS: Any wiring or cables which are not conduited should be checked once a year for damage to insulation or corrosion of splice or terminal points.

3. INSTALLATION

3.1 SENSOR LOCATIONS

Select locations for each of the sensors based on the following:

- Consider the density of the gas to determine height of sensor above floor or ground level:
  - Methane and hydrogen are lighter than air. Gases with molecular weights greater than 29 are heavier than air.
- Sensors should be placed close to the potential source of gas.
- Sensors should be placed in areas accessible for calibration.
- Sensors must be pointed down and the conduit should include an inverse trap to reduce moisture (condensation) from accumulating in the electronics enclosure. See Figure 3.1.

3.2 SENSOR INSTALLATION

Remove the sensor electronics (Figure 3.2) from the module enclosure by:

- Unscrew the two captive panel screws in the top plate.
- Lift the electronics out of the enclosure.
- Unplug the sensor harness from the bottom of the electronics board.

Install the module housing onto the end of the supply conduit and/or bolt into position as required.

NOTE: If enclosure grounding is required for the installation a grounding lug is located under the printed circuit assembly in the enclosure. Install the ground wire under the green lug.

Connect the three wires which run from the controller to the three position terminal strip on the bottom of the electronics assembly. The normal color code convention will be : White 1(DC+), Black 2 (signal), Green 3 (DC RET[-]). Figure 3.3 indicates the correct wiring connections and the operation of the connector mechanism.

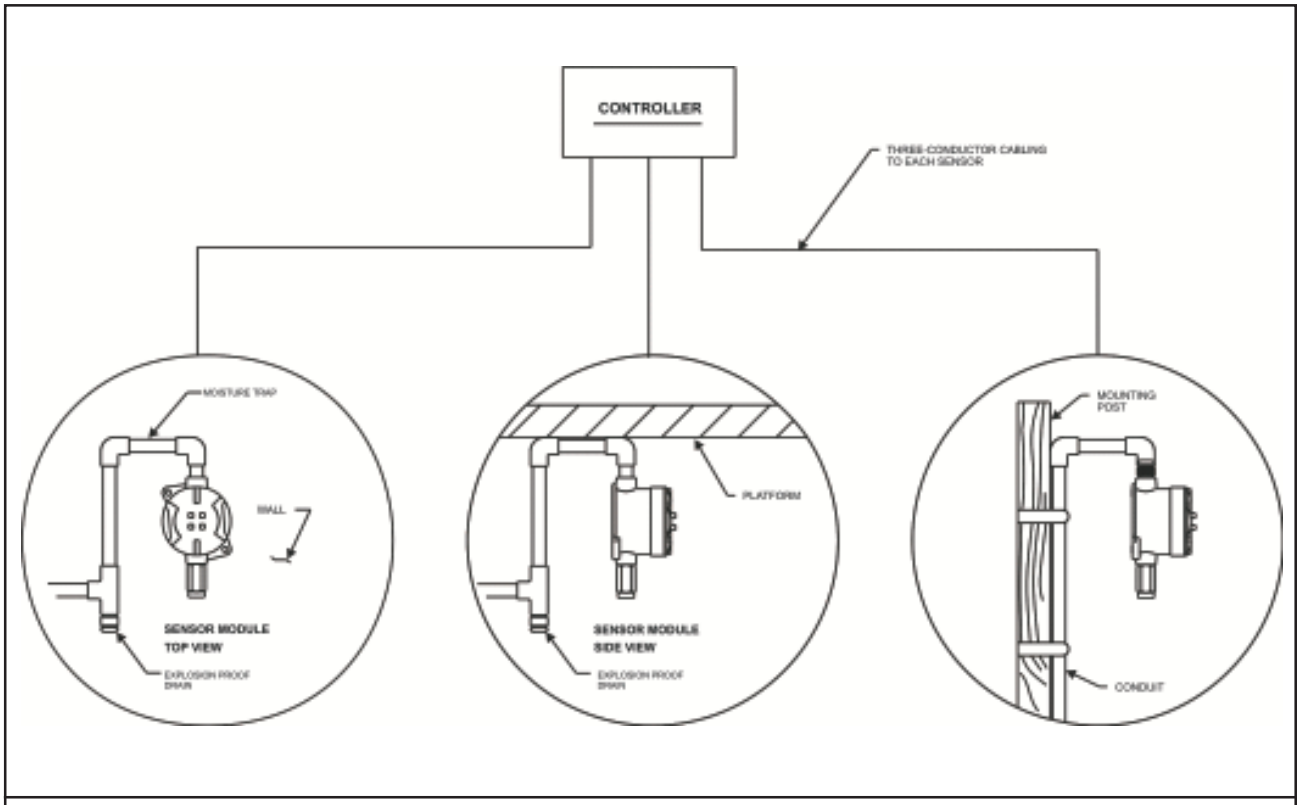

FIGURE 3.1: SENSOR MOUNTING

Reconnect the sensor harness to the sensor connector on the bottom of the electronic assembly. Figure 3.3.

Twist the assembly 180^{o} to take up the service loop on both the incoming wire and the sensor harness. With the sensor facing down the wording on the cover plate will be correctly oriented.

Carefully fit the electronics over the two posts in the enclosure and tighten the captive panel screws.

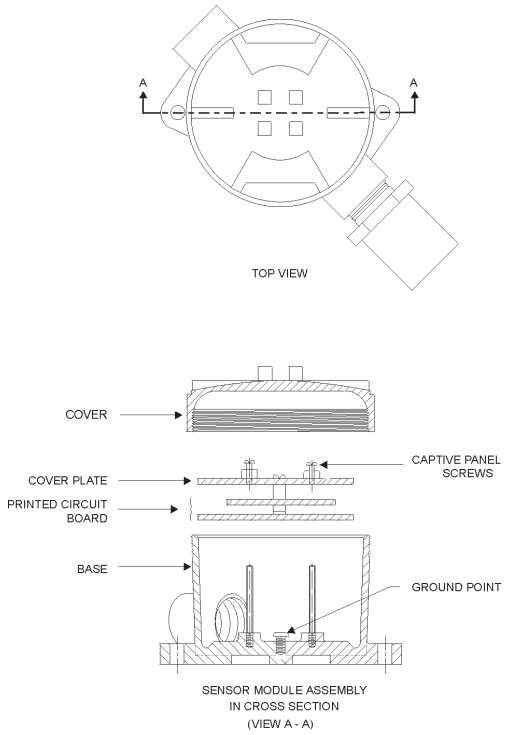

FIGURE 3.2: SENSOR ASSEMBLY CROSS SECTION

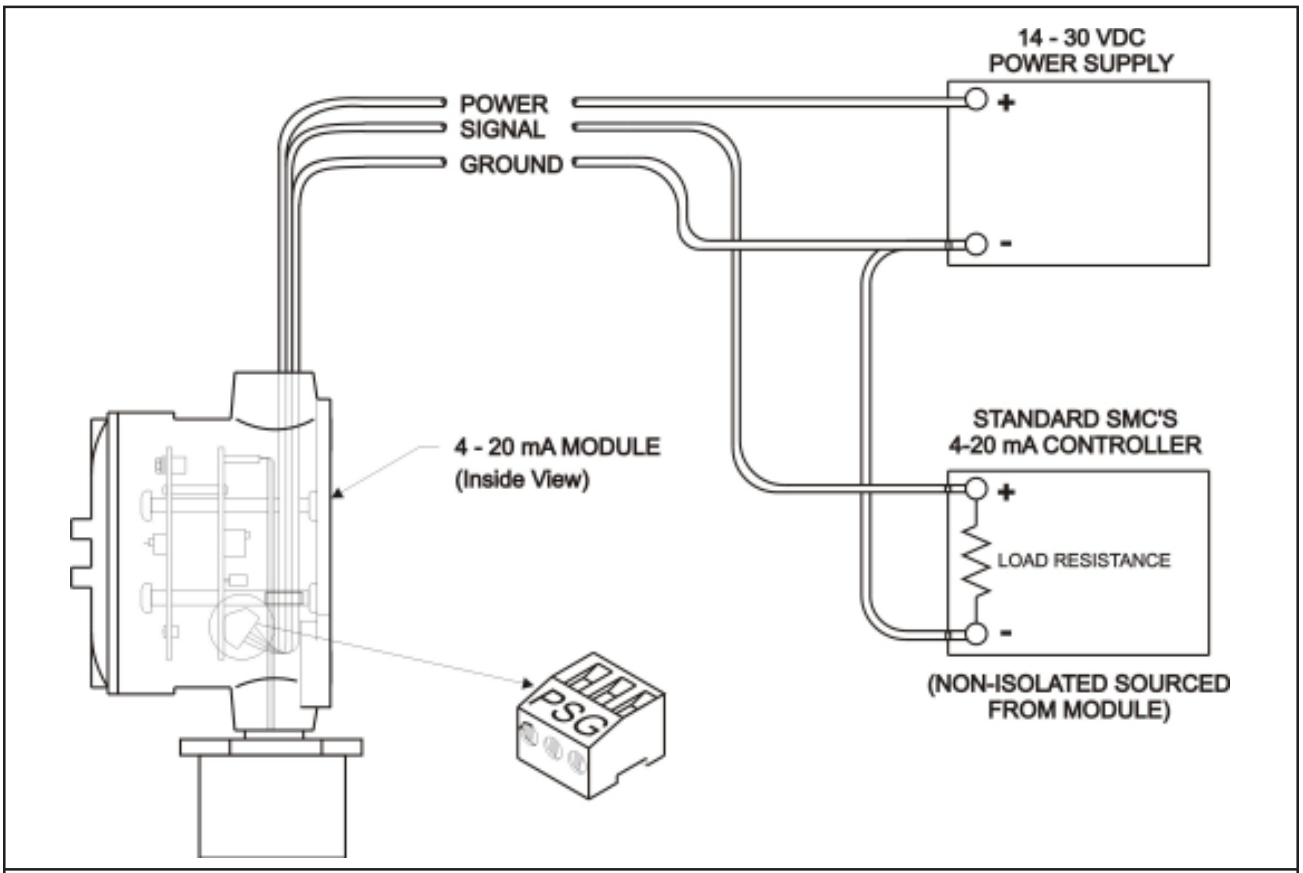

FIGURE 3.3: TYPICAL INSTALLATION CIRCUIT

4. CALIBRATION

4.1 MODULE CALIBRATION - AN OVERVIEW

The calibration procedure follows these simple steps:

- Declassify the hazardous area if required.
- Open the module enclosure and connect a voltmeter to the jacks on the coverplate.
- Apply zero gas and adjust the meter reading.
- Apply span gas and adjust the reading.
- Press the sensitivity check button and make sure the warning light does not come on.
- Remove the voltmeter and close the module enclosure.

4.2 CALIBRATION PROCEDURE

Use Figure 4.1 to identify the test points and adjustments referenced in this procedure.

Insure that the location has been de-classified and remove the module cover. Remove the rainshield from the sensor (if necessary) and screw in the calibration adaptor, Part Number 5358-01, (without any gas delivery connection). If the controller and alarms are not to be active during calibration use magnetic calibration adaptor, Part Number 5358-00. This will lock the current loop at 4 milliamps for the duration of the calibration and for four minutes after calibration to avoid false alarms.

Connect the negative lead of a volt meter to the GROUND test point (labeled "GND") and connect the positive lead to the BRIDGE VOLTAGE test point. Use the BRIDGE VOLTAGE ADJUSTMENT (labeled "BRDG ADJ") potentiometer to adjust the meter to read +2.0 volts (± 0.002V).

Move the positive meter lead to the BRIDGE CURRENT test point. Verify that this voltage is greater than +.300 volts and less than .360 volts. The sensor must be replaced if the bridge current is out of this range.

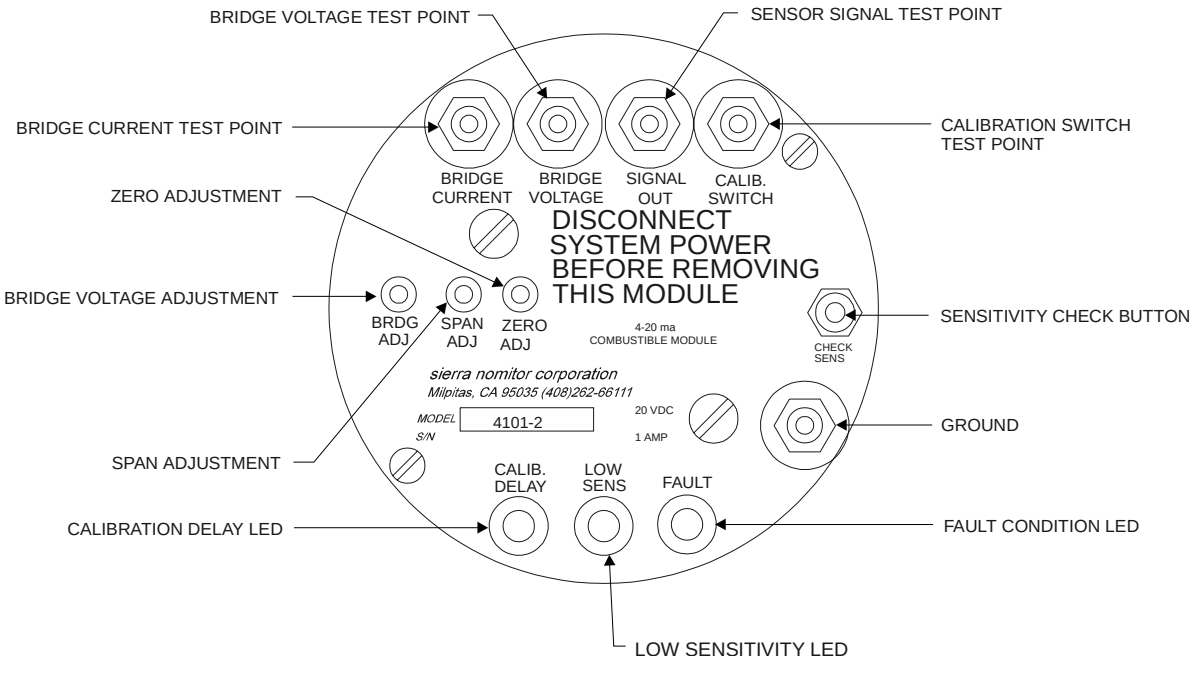

FIGURE 4.1: TOP PLATE DETAIL

Move the positive lead of the meter to the BRIDGE SIGNAL test point (labeled "SIGNAL OUT").

NOTE: Turn the SPAN ADJUSTMENT potentiometer (labeled "SPAN ADJ") twenty turns counter-clock-wise then adjust the ZERO ADJUSTMENT potentiometer (labeled "ZERO ADJ") to read 0.001 volts. If the area is not free of combustible gas apply clean air through the delivery head during zero adjustment).

Determine the concentration of span gas to be used for the calibration and use the following formula to calculate the corresponding signal voltage:

Signal voltage = Concentration / 100
Example: If span gas is 50% of LEL, the signal voltage will be 50/100 or +0.50 volts.

Note that if a gas other than the one which is to be detected is used for calibration, the factor (see Appendix A) must be used to convert to the correct concentration prior to this calculation.

Apply the span gas through the magnetic delivery head. The Calibration gas (2.5% Methane, balance air, $\pm$ 2% analyzed) should be at a flow rate of 100cc/minute using the gas sensor calibrator, Model 1200-26.

Turn the SPAN ADJUSTMENT (clockwise to increase) so that the signal voltage equals the value determined in the previous step. The Gas should be applied for approximately 4 minutes to insure that the sensor stabalizes.

Remove the gas and verify that the signal voltage returns to +0.001 volts. If not, then re-adjust the Zero and repeat the span adjustment step.

Press the SENSITIVITY CHECK button (labeled "CHECK SENS"). If the light does not turn on the calibration is complete. If the light **does** turn on **and stay on** the sensor has low sensitivity and should be replaced to avoid false alarms.

Remove the calibration adaptor and replace the rainshield and module cover.

5. OPERATION

5.1 SIGNAL VALUE

During normal operation the current loop between the sensor module and the controller will be between 4 mA (indicating no gas) and 20 mA (indicating 100% LEL). The signal is proportional to the concentration between these conditions.

5.2 FAULT INDICATION

When a fault condition occurs in the module the current is forced to zero mA. Most controllers will detect zero as a fault condition. When the controller indicates a fault the location can be determined by checking the FAULT INDICATOR LED (labeled "FAULT") on the module.

If the Fault Indicator LED is on, the wiring between the controller and the module is OK and the problem is in the module. (The most likely faults are that the sensor connector is loose or the sensor has failed).

If the Fault Indicator LED is **not** on, then the problem is likely to be in the wiring between the controller and the module.

5.3 SENSITIVITY CHECK

The sensitivity check is designed to be used only after calibration is completed. As the check verifies the signal amplification which has been set during calibration the result will be the same immediately after calibration and a long period after calibration (even if the sensor has deteriorated). The sensitivity check confirms that the sensor was OK after the last calibration.

5.4 TIME DELAYS

Time delays are designed into the module to avoid transmission of false alarms caused after a power loss or application of calibration gas. In both cases the module holds the current loop at 4 mA for approximately four minutes to allow time for the sensor signal to stabalize. The CALIBRATION DELAY LED (labelled "CALIB. DELAY") is on during these periods.

6. SPECIFICATIONS

SENSOR

TYPE:	Catalytically aided platinum
RANGE:	0 - 100% LEL
RESPONSE:	Step to 50% LEL within 10 sec., Recovery to 10% LEL within 30 sec.
ACCURACY:	3% of full scale or ± 10% of applied concentration, whichever is greater
TYPICAL LIFE:	Three years in normal service
ZERO DRIFT:	Less than 5% per year
STORAGE TEMPERATURE:	(-40^{O}F to 131^{O}F) (-40^{O}C to 55^{O}C)
OPERATING TEMPERATURE:	(-40^{O}F to 176^{O}F) (-40^{O}C to 80^{O}C)
HUMIDITY:	10% RH to 95%RH

ELECTRICAL DATA

WIRING:	3 wire non-isolated
INPUT VOLTAGE:	24 VDC Nominal, 21 to 30 VDC
INPUT CURRENT:	80 mA at 28 VDC Typical, 1.4A at 28 VDC Maximum
INPUT POWER:	2.3 W
OUTPUT RANGE:	4 mA = 0%, 20 mA = 100% LEL
MAXIMUM LOOP RESISTANCE:	400 Ohms (max @ 21VDC)

CALIBRATION

CALIBRATION FREQUENCY:	Monthly recommended
ADJUSTMENTS:	Zero, Span, Bridge Voltage
TEST POINTS:	Bridge: Current, Bridge: Voltage, Output
CALIB. SWITCH:	External Magnet locks 4 mA output

CONSTRUCTION

ELECTRICAL CLASS:	Division 1, Class I, Groups C&D
MOUNTING:	Conduit
PHYSICAL:	7.5" x 4" x 4" (19 cm x 10 cm x 10 cm)
WEIGHT:	32 oz (904 g)

ACCESSORIES AND SPARE PARTS

Calibration Accessories

1200-26	Model 26 Gas Sensor Calibrator w/2 gas cylinders (specify gas type/conc)
1250-01	Gas Sensor Calibrator Kit, Type A (w/o gas cylinders)
1260-02	Gas Cylinder - Methane 50% LEL, (Type A), 105 liters
1290-02	Gas Cylinder - Methane 50% L.E.L.
5358-00	Calibration Adapter - Direct, Magnetic
5358-01	Calibration Adapter - Direct, Standard
5360-00	Calibration Gas Delivery Fitting - Fixed

Replacement Parts

4201-02	Sensor Assembly, 4-20 mA Combustible Gas
SPM27004	Assy, Electronic for 4101-02
SPL21767	Enclosure, Sensor Electronics

Accessories

5311-00	Rainshield (Not FMRC Approved)

LIMITED WARRANTY

SIERRA MONITOR CORPORATION warrants its products to be free from defects in workmanship or material under normal use and service for two years after date of shipment. SMC will repair or replace without charge any equipment found to be defective during the warranty period. Final determination of the nature and responsibility for defective or damaged equipment will be made by SMC personnel.

All warranties hereunder are contingent upon proper use in the application for which the product was intended and do not cover products which have been modified or repaired without SMC approval or which have been subjected to accident, improper maintenance, installation or application, or on which original identification marks have been removed or altered. This Limited Warranty also will not apply to interconnecting cables or wires, consumables (ie. calibration gases, batteries, sensors), nor to any damage resulting from battery leakage.

In all cases SMC's responsibility and liability under this warranty shall be limited to the cost of the equipment. The purchaser must obtain shipping instructions for the prepaid return of any item under this warranty provision and compliance with such instruction shall be a condition of this warranty.

Except for the express warranty stated above, SMC disclaims all warranties with regard to the products sold hereunder including all implied warranties of merchantability and fitness and the express warranties stated herein are in lieu of all obligations or liabilities on the part of SMC for damages including, but not limited to, consequential damages arising out of/or in connection with the use or performance of the product.

APPENDIX A
COMBUSTIBLE GAS SCALING FACTORS

NOTE: The Combustible Gas Scaling Factors in this Appendix are not FMRC Approved

Where possible, calibration gas should be the same as the gas to be detected. If this is not possible then a scaling factor should be used to determine the “equivalent value” of the calibration gas in terms of the gas to be detected.

The formula for calibration is as follows:

V = (Cal gas) / Factor

where: V is the adjusted signal voltage when the span gas is applied.
Cal gas is the percent methane used for calibration.
Factor is a number that corresponds to the gas to be measured. (see Table 1)

Example: The application is for measurement of Propane and Methane is the calibration gas.

The factor for Propane (from Table 1) is 55.

For the example, calibration gas is Methane at 40% LEL.

V = 40% LEL Methane / 55

V = .73 The signal voltage will be adjusted to .73 volts during application of span gas.

COMBUSTIBLE GAS SCALING FACTORS

For combustible gas monitoring, a calibration standard of Methane or Propane my be used in conjunction with scaling factors to cause alarm function in %LEL scale of another gas as follows:

GAS	METHANE FACTOR	PROPANE FACTOR
Acetaldehyde	60	109
Acetic Acid	54	98
Acetic Anhydride	46	83
Acetone	52	94
Acetylene	57	103
Alkyl Alcohol	51	92
Ammonia	126	229
n-Amyl Alcohol	33	59
Aniline	39	71
Benzene	41	74
Biphenyl	25	45
1,3-Butadiene	56	101
n-Butane	58	106
iso-Butane	52	94
Butene-1	45	82
cis-Butene-2	48	88
trans-Butene-2	51	92
n-Butyl Alcohol	34	62
iso-Butyl Alcohol	53	96
tert-Butyl-Alcohol	74	134
n-Butyl Benzene	31	57
iso-Butyl Benzene	32	58
n-Butyric Acid	38	69
Carbon Disulfide	18	32
Carbon Monoxide	75	137
Carbon Oxysulphide	93	169
Chlorobenzene	34	62
Cyanogen	89	162
Cyclohexane	41	74
Cyclopropane	62	113
n-Decane	33	59
Diethylamine	49	88
Dimethylamine	58	105
2,3-Dimethylpentane	40	72
2,3-Dimethylpropane	40	72
Dimethylsulphide	43	79
1,4-Dioxane	45	81
Epichlorohydrin	45	82
Ethane	68	123
Ethyl Acetate	51	93
Ethyl Alcohol	73	132
Ethylamine	53	95
Ethyl Benzene	36	65
Ethyl Bromide	91	165
Ethyl Chloride	57	103
Ethylcyclopentane	40	72
Ethylene	71	128
Ethylenedichloride	66	120
Ethyleneoxide	52	94

GAS	METHANE FACTOR	PROPANE FACTOR
Diethyl Ether	46	84
Dimethoxyethane	42	75
Dimethyl Ether	63	113
Dimethylformamide	46	83
Ethyl Formate	44	80
Ethylmercaptan	56	102
n-Heptane	39	70
n-Hexane	37	67
Hydrazine	45	82
Hydrogencyanide	48	86
Hydrogen	77	139
Hydrogen Sulfide	41	74
Methane	100	181
Methyl Actetate	50	90
Methyl Alcohol	86	156
Methylamine	77	140
Methyl Bromide	90	162
Methyl Chloride	102	186
Methylcyclohexane	44	80
Methylenedichloride	93	168
Methylethylether	44	80
Methylethylketone	41	75
Methyl Formate	67	121
Methylmercaptan	61	110
Methylpropionate	51	93
Methyl n-propylketone	40	73
Napthalene	34	62
Nitromethane	34	62
n-Nonane	31	57
n-Octane	37	68
n-Pentane	46	83
i-Pentane	46	84
Propane	55	100
n-Propyl Alcohol	47	85
n-Propylamine	48	88
n-Propylchloride	50	90
Propylene	52	93
Propyleneoxide	46	83
iso-Propylether	44	79
Propyne	42	75
Toluene	40	73
Triethylamine	40	72
Trimethylamine	48	88
Vinylethylether	42	76
o-Xylene	36	65
m-Xylene	39	71
p-Xylene	39	71
JP-4 (Jet Fuel)	41	73

NOTES:

1. Scaling factors are not FMRC approved.
2. Base data source: EEV sensor specification catalog. (EEV claims some data is the result of specific tests, other data is empirically derived.)
3. Display = Cal Gas / Factor = % LEL
   => must be less than 1

TABLE 1
COMBUSTIBLE GAS SCALING FACTORS