O P E R A T I N G   M A N U A L

SERIES 100
OXYGEN ANALYZER
VERSION 3.0, REVISION A

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NOTE TO USER

This manual will assist in the installation and operation of the Delta F Series 100 Oxygen Analyzer. The intent is to thoroughly review all aspects of the Analyzer, allowing you to fully utilize the features offered. Check your original purchase order to determine the options that you ordered.

Every effort has been made to ensure that the information in this manual is complete, accurate, and current. However, Delta F assumes no responsibility for the results of errors that may be present and reserves the right to make changes at any time to improve the operation and quality of the product. Specifications are subject to change without notice.

WARNINGS

TO REDUCE THE RISK OF FIRE OR ELECTRIC SHOCK, DO NOT EXPOSE THIS ANALYZER TO RAIN OR WATER SPRAY UNLESS THE ENCLOSURE(S) IS RATED NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION (NEMA) 4. USE THE SERIES 100 ANALYZER ACCORDING TO ITS NEMA RATING AS SPECIFIED ON THE ORIGINAL PURCHASE ORDER.

CAUTION: POTENTIALLY HAZARDOUS AC VOLTAGES are present within this instrument. Leave all servicing to qualified personnel. Remove all AC power sources when installing or removing AC power or data signal connections as well as when installing or removing the sensor or the electronics.

RF DISCLAIMER: This instrument generates and uses small amounts of radio frequency energy. There is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off completely (removing AC power), correct the interference by one or more of the following measures:

1. Reorient the receiving antenna.
2. Relocate the instrument with respect to the receiver.
3. Change the AC outlet to the instrument so the instrument and receiver are on different branch circuits.

Explanation of Graphic Symbols


This symbol alerts you to the presence of uninsulated "dangerous voltage" within the product enclosure that may be of sufficient magnitude to constitute a risk of electrocution.


This symbol alerts you to the presence of important operating and maintenance servicing) instructions in this manual.

WARRANTY

Delta F warrants each instrument manufactured by the company to be free from defects in material and workmanship at the F.O.B. point specified in the order. Its liability under this warranty is limited to repairing or replacing, at Seller's option, items which are returned to Delta F prepaid within one year from delivery to the carrier and found, to Seller's satisfaction, to have been so defective.

Delta F's 5-year sensor warranty offers extended protection such that if any sensor of a Delta F Oxygen Analyzer fails under normal use, within four years after the expiration of the 1-year warranty, such sensor may be returned to Seller and, if such sensor is determined by Seller to be defective, Seller shall provide Buyer a replacement sensor at the then current purchase price, multiplied by a fraction thereof, in which the numerator is the number of months from the date of shipment by Seller of the defective sensor to the time it is received back at Delta F and the denominator of which is 60.

In no event shall Seller be liable for consequential damages. NO PRODUCT IS WARRANTED AS BEING FIT FOR A PARTICULAR PURPOSE, AND THERE IS NO WARRANTY OF MERCHANTABILITY. Additionally, this warranty applies only if: (i) the items are used solely under the operating conditions and in the manner recommended in Seller's instruction manual, specifications, or other literature; (ii) the items have not been misused or abused in any manner or repairs attempted thereon; (iii) written notice of the failure within the warranty period is forwarded to Seller and the directions received for properly identifying items returned under warranty are followed; and (iv) return notice authorizes Seller to examine and disassemble returned products to the extent Seller deems necessary to ascertain the cause of failure.

The warranties stated herein are exclusive. THERE ARE NO OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED, BEYOND THOSE SET FORTH HEREIN, and Seller does not assume any other obligation or liability in connection with the sale or use of said products.

TRADEMARKS

BI-STRATA™ and STAB-EL™ are registered trademarks of Delta F Corporation.
VCR™ is a registered trademark of Cajun Company.
TEFLON™ is a registered trademark of E.I. DuPont DeNemours & Co.

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SPECIFICATIONS

RANGES

Single Range

Trace Analyzers Range ppm	Percent Analyzers Range %
0 - 5,000	0 - 25
0 - 1,000	0 - 10
0 - 500	0 - 5
0 - 100	0 - 2.5
0 - 50	0 - 1
0 - 10	

Multiple Ranges

Trace Analyzers Ranges ppm	Percent Analyzers Ranges %
0 - 100/1,000/10,000	0 - 5/10/25
0 - 50/500/5,000	0 - 1/10/25
0 - 10/100/1,000	0 - 1/5/25
0 - 5/50/500	0 - 0.25/2.5/25
0 - 1/10/100	0 - 0.1/1.0/10
0 - 0.5/5/50	0 - 0.05/0.5/5

ACCURACY

$\pm$1% full scale of the analog output - all ranges (except $\pm$5% full scale on ranges of 0-2.5 ppm (parts per million) and below).

SENSITIVITY

< 5 ppb (parts per billion) on the 0-0.5 ppm range.

RESPONSE TIME

Sensor element responds instantaneously to oxygen change. Equilibrium time is dependent on specific conditions.

BACKGROUND GAS COMPATIBILITY

Standard Sensor	All inert and passive gases, including N_2, H_2, CO, hydrocarbons, etc.
STAB-EL™	Gas compositions containing "acid" gases - CO_2, H_2S, CL_2 NO_x, SO_2, etc.

GAS SAMPLE QUALITY

Temperature (Gas Sample)	Below 0°F	- Use coil heating.
	0° to 150°F	**- Standard limits.**
	Above 150°F	- Gas sample cooling required.
Temperature (Ambient)	Below 32°F	- Use temperature controller.
	32° to 120°F	**- Standard limits.**
	Above 120°F	- Case cooling required.
Inlet Pressure	Below 0.5 vacuum	- Use compressor.
	0.5 psig vacuum to 0.2 psig	- Use 1-P013 pump.
	0.2 to 1.0 psig	**- Standard limits.**
	1.0 to 5.0 psig	- Use valve or regulator.
	Above 5.0 psig	- Use 1-PR1-5 regulator.
Flow Rate	0.5 to 1.5 liters per minute (SLPM).	
Moisture	No limit (avoid condensation).	
Oil/Solvent Mist	**<0.5 mg/ft^3**	**- Standard limit.**
	>0.5 mg/ft^3	- Use 1-F2S filter.
Solid Particles	**<2 mg/ft^3**	**- Standard limit.**
	>2 mg/ft^3	- Use 1-F2S filter.

ELECTRICAL

Power Input	**115 VAC, 50/60 Hz**	**- Standard** or
	230 VAC, 50/60 Hz	- Standard (must be specified at time of order).
Output Signal	**Linear 0-10 VDC**	**- Standard** over each range.
	Also available	- mVDC: 0-5, 0-10, 0-100 VDC: 0-1, 0-5 mADC: 4-20 (double isolated) mADC: 4-20 (single isolated)

NOTE: The 4-20 mADC output is derived from the 0-10 VDC output. Conversion accuracy is $\pm$0.25% of full scale $\pm$0.05 mA).

Output Impedance: 0-10 VDC, special analog output (optional), and flow analog output (optional) minimum load impedance = 10K. 4-20 mA output maximum loop resistance = 750 Ohms.

Display: **0.5-inch high, 3 ½ digit LED, standard.**
Also available - 3 ½ digit LCD
4 ½ digit LCD
4 ½ digit LED
3 inch analog meter

ELECTRICAL (CONTINUED)

Alarm Relay	Included with option for Oxygen Alarms 1 - 3, and Low Flow Alarm; one relay per alarm; Form C relay contacts (SPDT), 120/240 VAC at 8 amps, 30 VDC at 5 amps. All relay contacts automatically assume the no alarm condition when AC power is lost or instrument is turned off.
Maximum Sensor Cable Length	1000 feet

MECHANICAL For dimensions, refer to Appendix A.

GAS FLOW SYSTEM

Construction Materials	304 and 316 stainless steel.
Gas Connections	**Standard** - Inlet and outlet are 1/4-inch tube compression fittings. **Optional** - Metal-to-metal face seal type fittings on the optional inlet and outlet such as 1/4 inch VacuSeal™ fittings with welded plumbing. For both versions, the over-pressure vent is a 1/4-inch compression fitting. NOTE: VacuSeal™ is fully compatible with VCR™ fittings
Weight	Series 100 Portable: 21 lb Series 100 with NEMA 7 Sensor Enclosure: 36 lb

LIST OF ACRONYMS

AGND - Analog Ground

cfh - Cubic Feet Per Hour

DGND - Digital Ground

DIP - Dual In-line Package

DVM - Digital Voltmeter

EMF - Electromotive Force

LCD - Liquid Crystal Display

LED - Light Emitting Diode

lpm - Liters Per Minute

mADC - Milliamps of Direct Current

mg/ft^3 - Milligrams per Cubic Foot

mVDC - Millivolts of Direct Current

NBS - National Bureau of Standards

NIST - National Institute of Standards and Technology

NEMA - National Electrical Manufacturers Association

NPT - National Pipe Thread

Ohms - A Unit of Electrical Resistance

pH - The Log of 1/hydrogen-ion concentration in moles per liter

ppm - Parts Per Million

PROM - Programmable Read Only Memory

psig - Pounds per Square Inch Gage

RAM - Random Access Memory

RSC - Remote Sensor Chamber

slpm - Standard Liters Per Minute

SPDT - Single Pole Double Throw

TTL - Transistor-Transistor Logic

VAC - Volts Alternating Current

LIST OF ACRONYMS (continued)

VDC - Volts Direct Current

VFC - Voltage to Frequency Converter

SECTION 1: UNPACKING THE DELTA F SERIES 100 OXYGEN ANALYZER

IMPORTANT

When unpacking the Series 100 Oxygen Analyzer, use procedures that are consistent with the handling of sensitive instrumentation. Do not use hooks or other penetrating implements.

A. GENERAL

1. When the Analyzer is received, note the condition of the package and the contents. If the instrument has sustained damage, notify both Delta F Corporation and the carrier.

2. Check the contents to ensure that the shipment is complete. Use the information provided on the packing slip to verify that the appropriate optional items have been included. All damage claims and shortages must be reported to Delta F within ten days after receipt of shipment.

3. Avoid damaging the packing carton(s). If either of the two enclosures has to be returned to Delta F, or sent to any other location, use the original shipping container. This container has been designed specifically for the Delta F Series 100 Oxygen Analyzer and will provide maximum protection during shipment.

4. After removing the Analyzer from the shipping container, inspect the inside of each enclosure. Note that the cell tray has been surrounded by bubble pack for maximum protection of the sensor. Slide the cell tray out of the sensor enclosure and remove all packing material. Leave the cell tray out of the enclosure.

5. When inspecting the electronics enclosure interior, press the PC board retainer and pull on the removal handle of each board to ensure that the board is firmly plugged into the backplane. Reseat any loose boards by applying firm pressure to the front edge of the board until you feel it lock into place. While inspecting both enclosures, be sure no components have become loosened or dislodged. If damage is noted contact Delta F.

6. The electrolyte fill funnel is usually located within the sensor enclosure. For instructions on filling the sensor with electrolyte, refer to Section 4, Part B-1 or B-2 (page 4-4 or 4- 5).

7. Other optional equipment not integral to the Analyzer may be found in a convenient space adjacent to the unit, or packaged separately.

B. ANALYZER CONFIGURATION

The Analyzer consists of two enclosures: one for the sensor located on the right-hand side of the instrument and the other for the electronics on the left-hand. In the standard configuration, each of the enclosures is rated as NEMA 1. An optional NEMA 4 or NEMA 7 sensor enclosure may be ordered. Enclosure ratings are defined in the glossary of this manual (Appendix J.)

The two enclosures on the standard Analyzer are fastened together. With its hide-away carrying handle, the Analyzer is ideally suited for either portable or bench-top use. Using simple tools, the handle can be removed, and the enclosures separated. This feature is particularly useful for requirements where the readout and accompanying electronics are to be installed separate from the sensor. The enclosures can be rack-panel mounted separately or together.

C. ELECTROLYTE KIT

Each Series 100 Oxygen Analyzer is shipped with two bottles of DF-E05 electrolyte – a water-based solution containing potassium hydroxide and special buffering agents.

CAUTION: **DO NOT SUBSTITUTE SOLUTIONS.** DF-E05 is a formulation made specifically for use in Delta F sensors. Do not use simple potassium hydroxide solutions as a substitute. Such solutions will cause deterioration of the sensor electrodes and will void the warranty.

Familiarize yourself with the Material Safety Data Sheet (MSDS) in Appendix B; it describes the precautions to be taken when handling this material.

D. GETTING STARTED QUICKLY

In the interest of getting the instrument running, without having to read through the entire manual, the following section is provided. If any step requires further clarification consult the appropriate detailed description. Each major step contains references to the manual section where further information is given.

It is assumed that step A, above (Unpacking) has been completed.

1. Refer to Section 4: PREPARATION FOR OPERATION (pages 4-3 and 4-4) if the Analyzer enclosure(s) requires special mounting (panel mount, rack mount, R7 enclosure mounting.)

2. The oxygen sensor is an electrochemical cell. It must be charged with electrolyte. Refer to Section 4, pages 4-4 and 4-5, for the electrolyte charging instructions applicable to your specific sensor enclosure model.

3. Install the cell tray into the sensor enclosure, and tighten the lockscrew found at the lower front section of the cell tray. Plug the sensor cable into the cell board.

4. The rear of the standard sensor enclosure provides 1/4-inch compression fittings for the sample inlet, outlet, and pressure relief. For further information, see Section 4, page 4-7 and 4-8.

<u>CAUTION:</u> The inlet pressure must not exceed 1 psig for extended periods of time because damage to the sensor may result. The over-pressure vent is intended to relieve pressure. It should not be relied upon to continuously control pressure. Gas sample temperature may range between 0°F and 150°F. Sample moisture content is not limited as long as condensation is avoided. Solid particulate should not exceed 2 mg/ft^3; oil/solvent mist must not exceed 0.5 mg/ft^3.

5. Open the sensor enclosure door and turn the flow control valve to the closed position (fully clockwise.) Then adjust the valve two turns counterclockwise.

6. Open the door of the electronics enclosure and locate the 8-position DIP switch S2 on the front edge of the leftmost printed circuit board. Set switch S2, position 8, to the OPEN position to disconnect the sensor voltage. Plug the Analyzer into an appropriate source of electrical power (115 VAC, 50/60 Hz, or if ordered specially; 230 VAC, 50/60 Hz.) It is important that the electrical power be free of voltage spikes and fluctuations. Open the electronics enclosure door and press the POWER switch into the ON position. If applicable, press the HEATER and/or PUMP switch into the ON position. For further information, refer to Section 5.

7. When the instrument is first turned on it may sound an audible alarm if the Analyzer is equipped with optional alarms. Press the ALARM/CANCEL button (located on the front of the electronics enclosure) to cancel the audible portion of the alarm. The single digit light emitting diode (LED) display will continue to display all existing alarm conditions -- alternating between the different conditions if more than one is in progress. Possible alarm condition displays are:

   1 -- OXYGEN CONCENTRATION ALARM 1
   2 -- OXYGEN CONCENTRATION ALARM 2
   3 -- OXYGEN CONCENTRATION ALARM 3
   F -- SAMPLE FLOW IS BELOW THE FLOW ALARM SETPOINT
   E -- ELECTROLYTE CONDITION ALARM (LOW ELECTROLYTE LEVEL)

   Refer to Section 5, page 5-4 for oxygen alarm setting information.

8. The Analyzer operating range may be changed by pressing the UP and DOWN arrows switches on the front panel. If the instrument is equipped with AUTO RANGING, and it is turned on, the unit will ignore all attempts to manually change range. If the Analyzer includes AUTO RANGING, it should be turned off by opening the electronics enclosure door and setting front panel DIP switch S1, position 1, into the OPEN position. Press the UP arrow switch until the instrument is operating on the highest concentration range.

9. Allow the instrument to stabilize for 5 minutes. Connect the sample line to the inlet fitting on the rear of the cell tray. Press the front panel FLOW switch to display the sample flow. The Analyzer is delivered factory set to operate with sample gas as ordered. If another gas is used in this step, refer to Section 7E, Flowmeter Recalibration (page 7-7). Adjust the flow control valve for a reading of 1 standard liter per minute. Allow the sample gas to flow through the Analyzer for 15 minutes to purge all traces of ambient air.

10. Open the electronics enclosure door and set switch S2, position 8, to the CLOSED position. The front panel oxygen display may contain blinking decimal points to indicate that the instrument is pegged out. This over range indication will continue until all residual ambient air has been purged from the cell. The amount of time required to achieve an on-scale reading lengthens as the operating range concentration decreases. An on-scale reading will be achieved within 15 minutes.

11. If the instrument is equipped with the AUTO RANGING option, open the sensor enclosure door and set front panel DIP switch S1, position 1, into the CLOSED position. The Analyzer will now automatically range-switch to the range that offers the best resolution.

12. The FLOW switch can be pressed at any time to show the sample flow rate in liters per minute (lpm). To return to reading oxygen, press the RANGE switch. If the analyzer is left in the FLOW measurement mode, it will automatically return to reading oxygen within 5 minutes.

SECTION 2: EXPLAINING THE SERIES 100 OPTIONS

A. STAB-EL™ ELECTROLYTE SYSTEM

If the sample processed through the Analyzer contains acid gas components use this option as described in detail in Section 3, Part B (page 3-1).

B. AUTORANGING

Used with multi-range analyzers, this feature provides the capability of changing ranges automatically to provide maximum resolution. For more detail, refer to Section 4, Part C, (page 4-14).

C. SAMPLE PUMP

An optional internally mounted diaphragm pump is used for samples with inlet pressures of 0.5 psi vacuum (29.0 in Hg) to 0.2 psig.

D. FRONT PANEL ANALOG METER

In place of the standard 3 ½ digit light emitting diode (LED) display, an analog meter that features a 3 inch dial having 10 major divisions and 50 minor divisions is available.

E. DIGITAL DISPLAYS

In place of the standard 3 ½ digit LED display supplied with the Analyzer, the following optional digital displays are available:

4 ½ digit LED
3 ½ digit Liquid Crystal Display (LCD)
4 ½ digit LCD

F. ALARMS

The Analyzer can be equipped with up to three fully adjustable setpoint alarms with high or low selectability. These alarms detect actual oxygen concentration, so that they trigger on the same concentration, regardless of the selected range. Form C relay contacts {Single Pole Double Throw (SPDT)} are provided for each of the three alarms.

G. FLOW ALARM RELAY

A form C (SPDT) contact closure permits local or remote alarm indication upon a low sample flow condition.

H. FLOW ANALOG OUTPUT

A linear 0-7.5 VDC analog output, corresponding to 0-1.5 slpm, is available. The flow analog output uses the special analog output signal connector pins. Consequently, the flow analog output is not available if a special analog output is ordered.

I. SPECIAL ANALOG OUTPUT

A nonstandard analog voltage output is available. Refer to the specifications to determine which nonstandard outputs are available. This option must be specified when you place your order. The special analog output uses the same signal output connector pins as the flow analog output; consequently, special analog output is not available if the flow analog output is ordered.

J. SINGLE ISOLATED 4-20 mADC OUTPUT

This output is available for applications that do not require the 4-20 mADC signal to be isolated from the 0-10 VDC signal common. This output is isolated from the chassis ground and the AC power line. Maximum loop resistance is 750 ohms.

K. DOUBLE ISOLATED 4-20 mADC OUTPUT

This output should be ordered when an output completely isolated from chassis ground, and the standard 0-10 VDC output, is required. Maximum loop resistance is 750 ohms.

L. SCALE FACTOR CONTROL

The scale factor control allows direct readout of oxygen in background gases having different diffusivity coefficients than nitrogen.

M. STRIP CHART RECORDER

The Minigraph "inkless" strip chart recorder is used to obtain a paper copy of oxygen data.

N. SENSOR HEATER

For applications where low ambient temperatures are encountered, or where constant temperature conditions within the enclosure are desired, a proportional temperature controller is available to elevate sensor temperature.

O. SAMPLE LINE FILTER

This filter consists of a high capacity borosilicate glass coalescing filter element with a 316 stainless steel housing. Use this option with samples having solid particles in excess of 2 mg/ft^3, or with oil/solvent mist in excess of 0.5 mg/ft^3.

P. PRESSURE REGULATOR

This regulator should be used when sample pressure is above 5 psig, or if the pressure is between 1.0 and 5 psig and the flow control valve is not used. The optional pressure regulator has a 3000 psig inlet capacity and a 0-5 psig adjustable outlet pressure.

Q. NEMA 4 SENSOR ENCLOSURE

This enclosure is for indoor or outdoor use, primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose directed water.

R. NEMA 7 SENSOR ENCLOSURE

This enclosure is for indoor use in locations classed as Class 1, Groups B,C,D, Div. 1, as defined in the National Electrical Code.

NOTICE FOR HAZARDOUS AREA INSTALLATIONS

The NEMA 7 Sensor Enclosure version has been constructed using an explosion-proof chamber to house the sensor cell, as well as optional equipment such as the STAB-EL™ electrolyte system, the diaphragm pump, the flow meter, and the temperature controller. The chamber itself, according to National Electrical Code Standards, is rated Class I - Groups B, C, D; Class II - Groups E, F, G; and Class III. As well, Delta F uses fittings and other materials that are compatible with the chamber for the above-stated ratings.

Thus, within rated conditions, the chamber, when properly installed, provides protection against the propagation, to ambient, of the explosive conditions that may develop within the chamber.

It is MOST IMPORTANT that the user be aware that the rating pertains only to the protection against propagation from the interior of the enclosure to ambient and does not pertain to the possible propagation of an explosive condition in the gas sample stream.

The gas flow system materials within the chamber consist of 316 and 304 stainless steel, polyethylene, epoxy, and Teflon. Pump materials include ABS plastic and butyl-rubber. The gas inlet and outlet fittings on the chamber are equipped with snubbers. Each 3/4 inch fitting contains a 1/8 inch thick x 0.25 inch diameter sintered stainless steel disc. The fittings offer damping resistance to sudden pressure changes and provide some "quenching" effect on hot gases which might suddenly penetrate the sintered disc.

S. SUPER LOUD ANNUNCIATOR

An internally mounted audible alarm provides a >80 decibel (A - weighted, at a 1-meter distance) level alarm if either an oxygen or low flow alarm condition occurs. This alarm annunciator, along with the normal internal annunciator, is canceled when the ALARM/CANCEL switch is pressed.

T. QUICK-START

The quick-start feature is used for situations where it is desirable to obtain low ppm readings in short periods of time. This feature has the ability to reject oxygen within the sensor cell which would otherwise desorb slowly as the sample gas reached the lowest levels of oxygen content. The quick-start feature should be used only when the gas sample tested is expected to be below 10 ppm. For gas compositions above that level, quick start will have little or no effect.

U. ELECTROLYTE CONDITION ALARM

The optional electrolyte condition alarm detects low electrolyte level and large changes of electrolyte conductivity caused by contamination.

V. PANEL MOUNTING

This option allows mounting of the NEMA 1 enclosure in a panel. Single or double enclosure mounting is available.

W. RACK MOUNTING

This option allows mounting of the NEMA 1 enclosure in a standard 19-inch instrument rack. Single or double enclosure mounting is available.

X. METAL-TO-METAL FACE SEAL FITTINGS

With this option, the inlet gas sampling line consist of 1/4-inch metal-to-metal face seal fittings in a welded assembly.

The outlet and the over-pressure relief valve connections remain as standard 1/4-inch compression.

Y. METAL-TO-METAL INLET AND OUTLET

This option provides the highest integrity gas handling components. Welded assemblies using metal-to-metal type fittings are plumbed directly to the sensor inlet and outlet. The terminations at the back of the sensor are 1/4-inch VacuSeal™ type fittings. **The pressure relief valve and flow meter are not provided with this option.**

SECTION 3: EXPLAINING THE SENSOR THEORY OF OPERATION

A. DELTA F'S PROPRIETARY ELECTROCHEMICAL SENSOR WITH THE BI-STRATA™ DIFFUSION BARRIER

The sensor in the Delta F Series 100 Oxygen Analyzer operates on a simple coulometric process whereby oxygen in the air or other sample gas is reduced in an electrochemical sensor. The use of this analytical technique is widely recognized for its ability to provide the most accurate means of oxygen measurement. Figure 3-1 depicts the essential configuration of the Delta F Sensor.

The gas stream enters the cathode cavity; oxygen is metered to the cathode through the BI-STRATA™ diffusion barrier. Oxygen is electrochemically reduced at the cathode:

$O_2 + 2H_2O + 4e$ ----------> $4OH^-$ (Cathode Reaction)

The electrolyte solution contains potassium hydroxide (KOH), which assists in the migration of hydroxyl ions (OH-) to the anode where they are oxidized to reform elemental oxygen:

$4OH^-$ ----------> $O_2 + 2H_2O + 4e$ (Anode Reaction)

An Electromotive Force (EMF) of approximately 1.3 VDC applied to the sensor electrodes is the driving force for the reduction and oxidation reactions. The resulting sensor current, which is directly proportional to the oxygen concentration in the gas stream, is measured accurately and displayed on the front panel meter.

Unlike conventional electrochemical oxygen sensors, Delta F's unique non-depleting sensor does not require periodic replacement or frequent calibration.

B. STAB-EL™ ELECTROLYTE SYSTEM (OPTIONAL)

A Series 100 Oxygen Analyzer, equipped with Delta F's patented STAB-EL™ electrolyte system, can be used on gases that contain acid components such as Cl_2, HCl, SO_2, H_2S, etc. Refer to Table 3-1 to determine the maximum allowable acid gas limits. To identify whether a Series 100 Analyzer has a STAB-EL™ system, check the original purchase order or the Delta F invoice.

For many applications, the STAB-EL™ electrolyte system, together with the unique nondepleting electrochemical sensor, eliminates the necessity of removing the acid components prior to making the oxygen measurement. The STAB-EL™ electrolyte system consists of a second pair of electrodes placed within the oxygen sensor. The STAB-EL™ anode is in the electrolyte reservoir; the cathode is in the sensor cavity (Figure 3-1). A current of approximately 10 mADC is applied to the electrodes which, in turn, establishes an electrolytic path via the electrolyte solution.

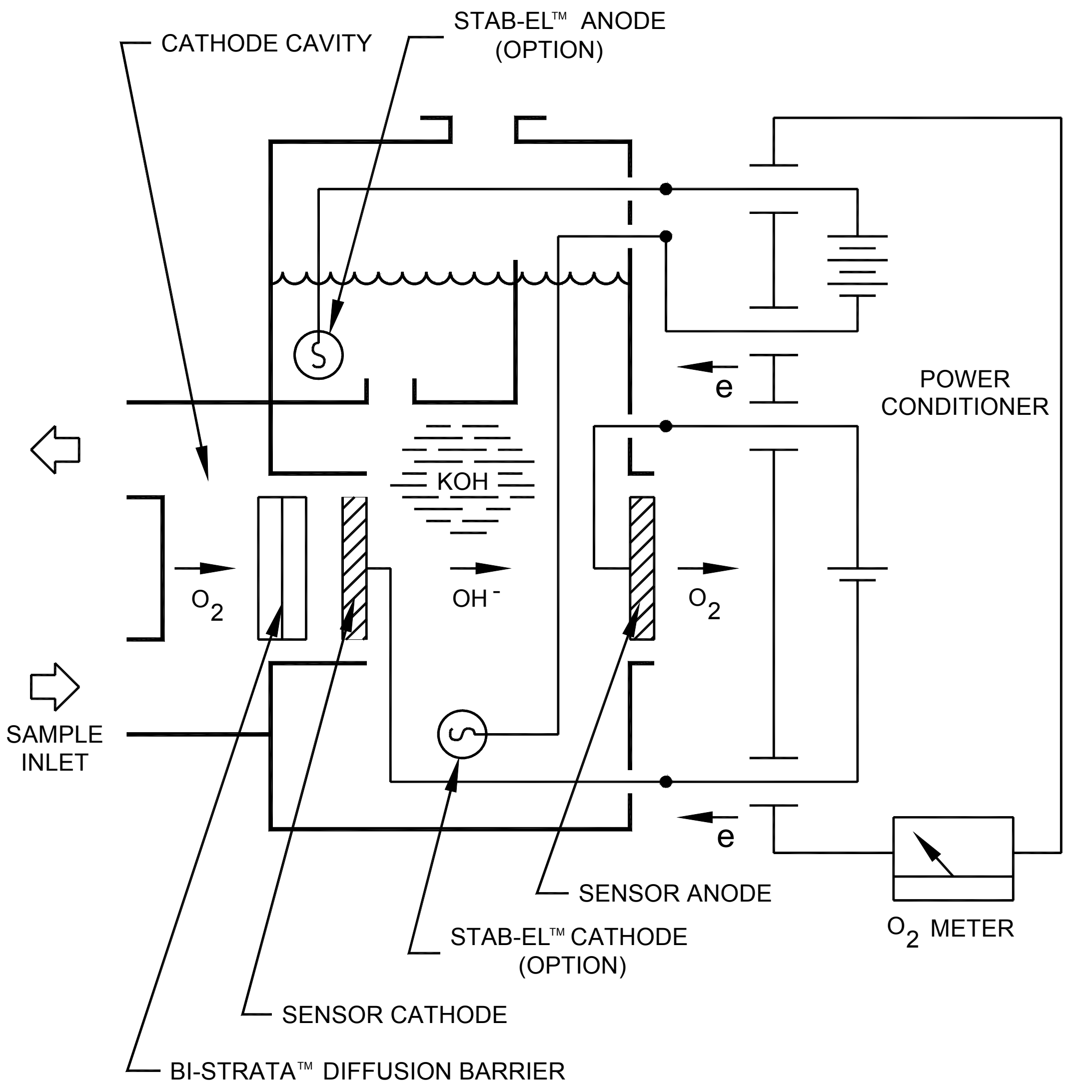


Figure 3-1: Configuration Of Delta F Sensor

Anions (negatively charged ions), formed by the reaction of the acid gases with the electrolyte, migrate to the anode; cations (positive ions) are attracted to the cathode. If the sample does not contain acid gas, the hydroxyl ions in the electrolyte migrate to the anode and potassium ions to the cathode; a modest water electrolysis reaction results. Since the potassium is unstable in an aqueous solution, it reacts to form KOH, thus allowing the sensor to maintain an adequate population of hydroxyl ions to transport oxygen between electrodes.

In a STAB-EL™ equipped oxygen sensor, acid-forming components are prohibited from excessive buildup within the electrolyte. Instead, they are induced to migrate toward the STAB-EL™ anode, where they concentrate.

In situations where the sensor is exposed to carbon dioxide (acid gas), carbonate ions are formed by reaction with the electrolyte. The anions migrate to the STAB-EL™ anode, where they increase in concentration. When the solubility limit of the carbonate ion is reached, CO_2 begins to effervesce from the reservoir solution. This mechanism is enhanced by the fact that the electrolyte solution close to the anode is normally acidic.

For gases such as chlorine, fluorine, etc., the anionic species formed when entering the sensor also migrate to the anode. However, unlike the carbonate ion, they participate directly in an oxidation reaction and evolve as a gas. For anionic species (such as the sulfate ion, which cannot be released from the reservoir either by effervescence or by direct oxidation), a gradual accumulation results. Eventually, the reservoir must be emptied to remove the product. For these situations, changing the electrolyte every 1-2 months is usually effective. Please consult the factory for specific recommendations.

The electrolyte flow path in the STAB-EL™ sensor prevents back diffusion of anionic species to the sensor cavity. Providing further protection is the fact that the electrolyte solution in the sensor cavity is of greater density than that of the reservoir. Construction of the sensor also helps reduce back diffusion of the acid components.

The STAB-EL™ sensor furnishes the ability to measure O_2 in sample gases containing varying amounts of acid gases. As a general guide, Table 3-1 represents the maximum allowable limits of acid gases tolerable with the STAB-EL™ option.

There are applications where the acid-gas components may exceed the upper limits of the STAB-EL™ system. In such circumstances, the inherent capabilities of the sensor can be enhanced by using a scrubber system so that the shortcomings of both components are lessened. First, by using the scrubber to remove the bulk of acid constituent(s), the Analyzer is now capable of continuous stable performance, despite the fact that, even during normal operation, a significant fraction of acid gas carries through the scrubber to the oxygen sensor. Second, on those occasions when breakthrough occurs and greater amounts of acid are released by the scrubber, the sensor's ability to tolerate high levels of acid gas for limited periods will avoid catastrophic loss of performance - assuming the scrubber is maintained properly.

TABLE 3-1.
Maximum Allowable Acid Gas Limits
Using the STAB-EL™ Sensor.

Measuring Range of Analyzer*	CO_2** %	SO_2 ppm	H_2S ppm	NO_X ppm	Cl_2 ppm	HCL ppm
0-100ppm	0.1	100	100	100	50	50
0-500 ppm	0.1	100	100	100	50	50
0-1000 ppm	0.2	250	250	250	100	100
0-5000 ppm	0.3	500	500	500	200	200
0-10,000 ppm	0.4	750	750	750	400	400
0-2%	0.6	1000	1000	1000	500	500
0-5%	1.0	1300	1300	1300	700	700
0-10%	2.0	2000	2000	2000	1000	1000
0-25%	3.0	3000	3000	3000	1500	1500

* Represents the highest range for multiple range analyzers.
** Concentrations of CO_2 are in percent. One percent is equivalent to 10,000 ppm.

Contact Delta F for recommendations on using the STAB-EL™ sensor on acid gases other than those mentioned above.

SECTION 4: PREPARING FOR OPERATION

A. MECHANICAL SETUP

1. Portable Handle Positions

When the Series 100 Oxygen Analyzer is ordered as a portable unit (non-remote sensor mounting), a carrying handle is provided. The handle is designed to have two rest positions and a carrying position.

a. Storage Position
When shipped, the handle is in the storage position at the rear of the instrument.

b. Carrying Position

To put the handle in the carrying position, follow the steps below while observing the diagram in Figure 4-1. Notice the guide track of the handle blade shown in the figure as this will aid in guiding the handle into its proper carrying position.

i. Pull the handle away from the rear of the instrument and upward at a 45° angle until the handle clears the rear rest pin.

ii. Rotate the handle forward until it is almost vertical. The handle then slides down between the instrument enclosures until the opening in the lower guide track is aligned with the lower guide pin, which allows the handle to go to the full vertical position.

iii. Once in this position, the handle may be raised for carrying or left to rest on top (between the enclosures). If the space above the Analyzer is limited, the handle can be returned to the storage position using the following procedure:

(1) To align the lower guide track opening with the lower guide pin, exert slight rearward pressure while raising the handle.

(2) The above procedure allows the handle to be released from the lower guide pin. To raise and restore the handle to the storage position (as originally shipped), reverse steps i and ii above.

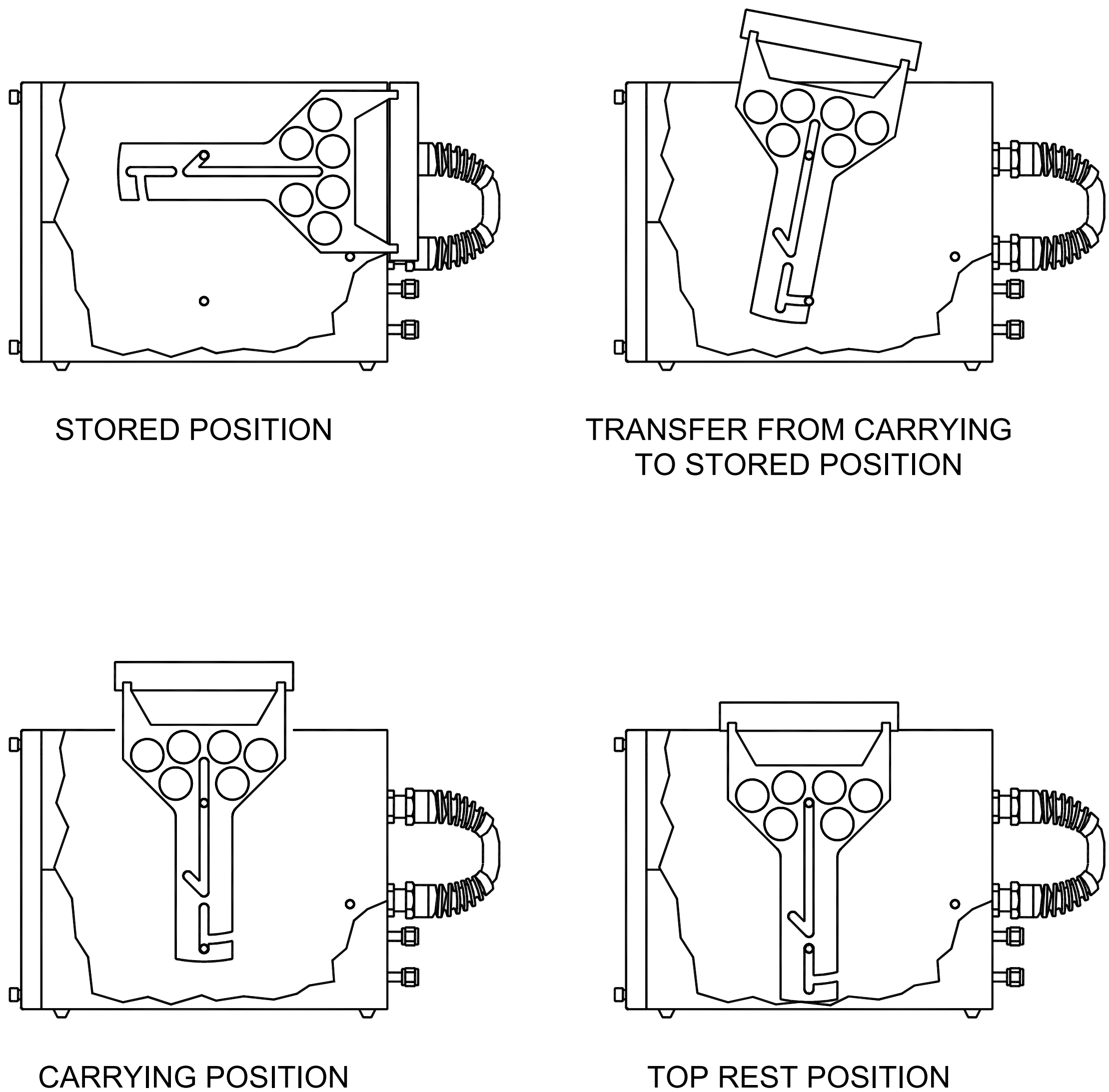


Figure 4-1: Various Positions of the Series 100 Enclosure Handle

2. Separating Enclosures for Remote Sensor Mounting (NEMA 1)

The electronics enclosure and the sensor enclosure, when ordered as a portable unit (non-remote sensor mounting) are held together by five screws and nuts. All screws have a bushing between the enclosures to provide clearance for the handle. Two of the bushings also act as bearings for the handle. Four screws are accessible from the front, one screw is accessible from the rear. To separate the enclosures, remove these five screws. It is recommended that all hardware be saved in case the enclosures will later be rejoined.

3. Panel Mounting

The NEMA 1 enclosure can be equipped for panel mounting. Sensor and electronics enclosures can be panel-mounted together or separately. If only one enclosure is chosen to be panel-mounted, it should be specified at the time of order.)

If the panel mounting option is selected, the enclosure(s) is shipped with the panel already mounted. When unpacking the Analyzer, in addition to the mounted panel, there should also be the following items:

Qty		Part Description	Delta F Part Numbers	
One*	Two**		One*	Two**
6	8	Tinnerman Nuts	80-031072	80-031072
6	8	Mounting Screws	80-103500	80-103500
6	8	Washers	83-003122	80-003122
1	1	Panel (factory mounted on Series 100)		

* If only one enclosure is panel mounted.
** If both enclosures are panel mounted.

a. To install the Analyzer in a panel, cut out the panel opening and drill the mounting holes as shown in Appendix C.

b. Install the six or eight Tinnerman nuts onto the panel over the mounting holes. All cabling (power, output, and interconnecting) must be brought in from the rear of the panel before the Analyzer can be installed.

c. After sliding the Analyzer into the panel from the front, align the mounting holes on the front of the frame with the Tinnerman nuts.

d. Using the mounting screws supplied with the panel kit, thread each screw through a washer and insert it through the frame and into the Tinnerman nut.

As stated above, if each enclosure is to be panel-mounted in a different location, follow the directions for single enclosure installation.

4. Rack Mounting

The NEMA 1 enclosure can also be equipped for mounting in a standard 19-inch instrument rack. Both electronics and sensor enclosures can be rack-mounted together or separately. (If only one enclosure is chosen to be rack-mounted, it should be specified at the time of order.)

If the rack mounting option is selected, the enclosure(s) is shipped with the rack panel already mounted. Four cutouts, on each side of the rack panel, allow mounting directly to the rack using the appropriate sized screws. For a detailed drawing, refer to Appendix D - Rack Mounting Dimensions.

5. NEMA 7 Explosion Proof Sensor Enclosure

The sensor enclosure can be purchased in an optional NEMA 7 configuration. There are mounting feet with holes on each corner of the enclosure to make it easy to mount on a wall or other flat surface. Refer to Appendix A - Mechanical Outline Drawings.

a. When mounting the NEMA 7 sensor enclosure, ensure that the sensor is in a vertical position with the sensor fill cap up.

b. Use bolts that are a minimum of 3/8 inch in diameter.

c. Confine the mounting of the enclosures to areas where there is no direct exposure to rain, snow, or sleet.

B. SENSOR AND GAS SYSTEM

1. Charging the Sensor with Electrolyte for NEMA 1 Sensor Enclosure

The Analyzer is shipped with two bottles of E-05 electrolyte. After reviewing the Material Safety Data Sheet, in Appendix B, add one bottle of E-05 electrolyte to the sensor. To do this, turn the instrument off and follow the directions below:

a. Disconnect the plumbing connections at the back of the Analyzer.

b. Open the sensor enclosure door by loosening the two latch screws.

c. Unplug the sensor cable from the cell PC board.

d. Loosen the screw lock (counterclockwise) located on the bottom front of the chassis.

e. Lift the chassis up slightly and pull it out of the enclosure.

f. Remove the sensor fill cap, by unscrewing it, and bring the chassis assembly to a sink.

g. Using the funnel supplied inside the sensor enclosure, fill the sensor with distilled water until the water level becomes visible through the clear see-through window on the front of the sensor. Allow at least 15 minutes before proceeding to step h.

h. Check for any leaks around the seams and corners of the sensor. (If a leak is detected, report it to the factory immediately.)

i. Drain the sensor by inverting it over the sink. Be certain that all water is removed.

j. If no leaks are detected, empty the contents of one bottle of E-05 electrolyte into the sensor, using the funnel. One bottle of electrolyte is sufficient to bring the electrolyte level to where it can be observed through the see-through window. The exact level is not important as long as it can be seen.

k. Replace the fill cap, being sure to tighten it securely.

l. Install the sensor chassis and tighten the screw lock.

m. Rinse the funnel with water before returning it to storage within the unit.

n. Reconnect the sensor cable and the plumbing at the back of the Analyzer.

2. <u>Charging the Sensor with Electrolyte for NEMA 7 Explosion Proof Sensor Enclosure</u>

a. To add electrolyte, remove the front access cover of the sensor enclosure by turning it counterclockwise.

b. Disconnect the electrical connection to the sensor.

c. Disconnect both inlet and outlet gas fittings and remove the four screws used to fasten the sensor support plate to the backside of the NEMA 7 enclosure.

d. Remove the sensor chassis and follow the instructions for adding water and electrolyte in the previous section.

e. After adding electrolyte, be sure to hand-tighten the sensor fill cap before reinstalling the sensor assembly into the NEMA 7 enclosure.

3. <u>Sensor Startup</u>

<u>CAUTION:</u> The sensor in the Analyzer is shipped dry (without electrolyte). BE SURE THAT THE SENSOR IS FILLED WITH ELECTROLYTE BEFORE OPERATING THE ANALYZER. To avoid damage to the sensor and enclosure, always drain the electrolyte and tighten the fill cap prior to shipment.

Before operating the Analyzer, check to ensure that the sensor is attached to the electronics enclosure and that the oxygen sensor is charged with electrolyte as described above. After the instrument is turned on, the Analyzer reads higher than normal for a brief period while the sensor comes into equilibrium with the oxygen level in the sample gas. This assumes that the oxygen level in the sample gas is within the range the instrument is set up to measure.

4. Electrolyte Replenishment

Under normal operating conditions, particularly when monitoring dry gases low dewpoints), there is a gradual loss of water in the electrolyte. Typically, when operating the unit continuously under these conditions, a monthly water loss of approximately 10 to 15 milliliters (ml) can be expected. When replenishing the electrolyte, use distilled or deionized water, if available. Good quality tap water is acceptable.

IMPORTANT: While water vapor can be lost, by diffusion, the potassium hydroxide cannot. As such, only water should be added to restore the electrolyte tank level to its original condition. Once the sensor receives its initial charge of electrolyte, do not add any more electrolyte; the exception being if the sensor is drained and requires recharging. The tank is usually only 1/3 full. It is not recommended, nor required, that it be full.

5. Gas System Pressure Limits

The pressure of the gas sample at the input connection must be limited to less than 1 psig. If necessary, an optional pressure regulator may be incorporated in the inlet sampling system to meet this requirement. The flow rate must be limited to no more than 1.5 lpm. An over-pressure relief valve is provided to protect the oxygen sensor in the event of accidental over-pressure. Do not use the Analyzer with the over-pressure relief valve open.

Similarly, when a pump is used on the outlet of the sensor to pull a sample through the system, ensure that the pressure differential across the sensor does not exceed 1 psi. This could occur, for instance, if a valve upstream of the sensor was accidentally closed while a vacuum pump was being used to draw a sample through the sensor. If a pump is used that has the capacity to create a pressure drop across the sensor of >1 psi, install an external vacuum relief device in the sensor outlet plumbing.

6. Sample Line Connections (See Item 7 for NEMA 7 Connections)

a. Sample Inlet

The standard gas sample inlet is a 1/4-inch stainless steel compression fitting provided with the necessary hardware for terminating standard tubing. Stainless steel tubing is recommended for all applications. The use of quick disconnect fittings on low parts per million (ppm) reading instruments is not recommended by Delta F.

On Analyzers equipped with the metal-to-metal option, the sample inlet is a 1/4-inch VacSeal™ type fitting.

b. Sample Outlet

If it is necessary to make tubing connections to the downstream side of the sensor, use 1/4-inch stainless tubing. The instrument may be operated without any attachments to the output, if desired, as back diffusion of oxygen into the sensor is not a consideration during normal operation.

c. Over-Pressure Relief External Connections (NEMA 1)

If accidental over-pressure of the Analyzer runs the risk of releasing undesirable gas component(s) to the atmosphere, there is a provision to plumb the outlet of the pressure relief valve to a safe area. Connect the plumbing to 1/4-inch compression fitting over-pressure relief tube at the rear of the sensor enclosure. Keep the diameter of the exhaust relief line as large as possible and use a minimum length of tubing. This will minimize back pressure on the sensor.

7. Sample Line Connections for NEMA 7 Explosion Proof Enclosure

The Remote Sensor Chamber (RSC), as delivered, has hex head bushing assemblies at the inlet and outlet ports that accept 1/4-inch NPT male connections. These ports have been equipped with reducers to 1/8-inch compression fittings, which may be removed if direct connection to the NPT fittings is preferred. Use Teflon tape thread sealant on male NPT fittings.

IMPORTANT! When tightening the gas connector fittings, use a wrench to hold the 7/8-inch hex head bushings stationary. The bushings are aligned with the internal tubing, and damage will result if the alignment is altered.

Also note that the bushings are not, and need not be, tightly sealed into the chamber.

Installation of the gas sampling system can be completed by connecting tubing from the process to be monitored to the inlet tube fitting that is positioned closest to the front, at the lower left-hand side of the chamber.

The gas sample outlet, which is at the lower left-hand side of the chamber behind the inlet fitting, should be vented to a safe area.

Item 8 (Adjusting the Flow Regulator Valve) does not apply to the NEMA 7 sensor enclosure configuration.

8. <u>Adjusting the Flow Regulator Valve</u>

When a pressure drop has been set across the sensor (from inlet to outlet) of less than 1 psi, the actual flow of the sample gas can be adjusted by means of the flow regulator valve located downstream of the sensor. Open the door on the sensor enclosure and observed the knob for the flow regulator valve on the right-hand side. Clockwise rotation of the flow regulator valve reduces the flow. <u>DO NOT OVERTIGHTEN.</u> (The valve is a precision needle valve that can be damaged by overtightening.) To observe the magnitude of the flow, press the FLOW pushbutton on the electronics enclosure front panel or use an external rotameter.

C. <u>ELECTRICAL</u>

1. <u>FRONT PANEL CONTROLS (See Figure 4-2)</u>

a. <u>General Description</u>

There are three illuminated mode selection switches (RANGE, FLOW, and ALARM/CANCEL), and a set of UP and DOWN arrow switches on the front panel of the electronics enclosure. During normal operation the Analyzer automatically runs in the RANGE mode, displaying oxygen concentration, operating range, and any alarm conditions. The FLOW switch may be pressed to display sample flow in lpm. While in the FLOW mode, the Analyzer continues to measure oxygen concentration so that all analog concentration outputs remain undisturbed (0-10 V, 4-20 mA, and optional special analog output). The ALARM/CANCEL switch is used to silence the alarm when an alarm condition occurs and also initiates the Flow and Range Alarm setting mode. The UP and DOWN arrow switches are used to step through alarm selections, change range, and increase or decrease alarm setpoint values.

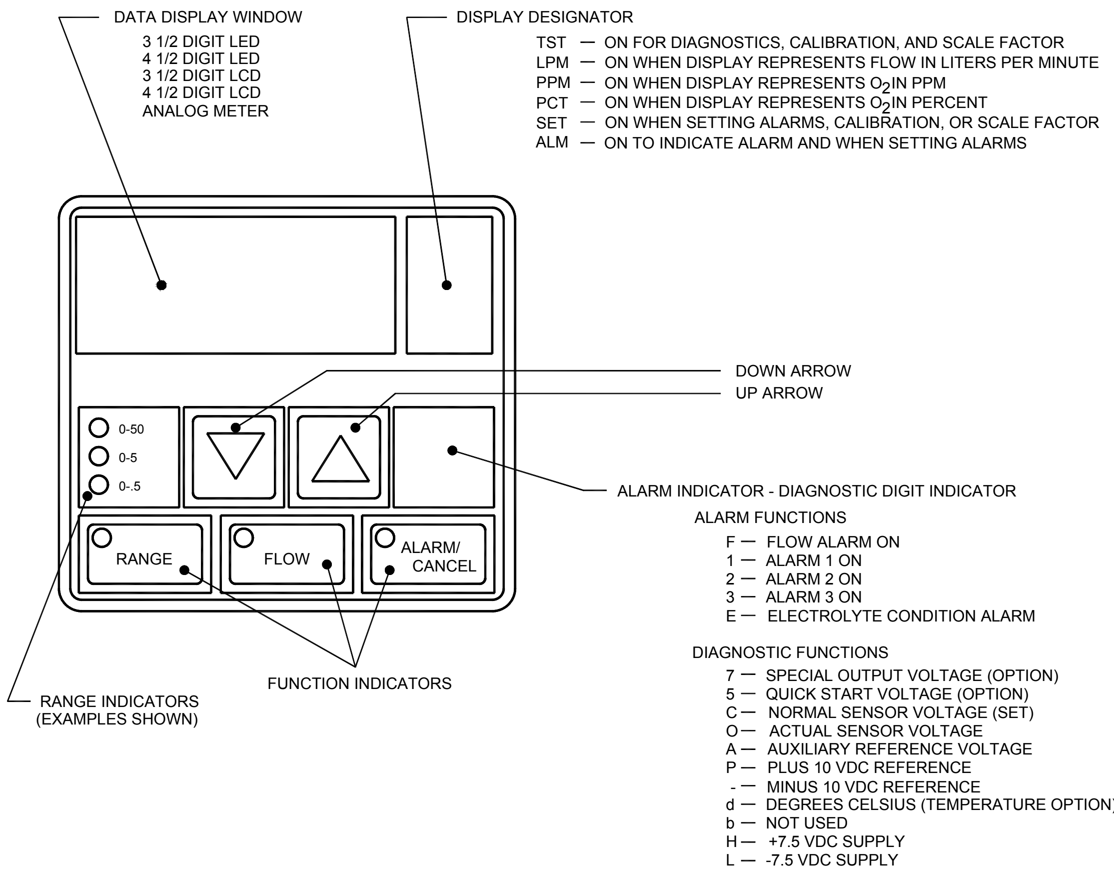


Figure 4-2: Series 100 Front Panel Display

b. Range Selection

When a 3-range Analyzer is turned on, it automatically begins to operate on range 3 (highest concentration range). The RANGE indicator light located above the range switch illuminates. At this time the UP and DOWN arrow switches may be used to change to range 2 or 1. The alarm sounds three times if an attempt is made to go to a range below 1 or above 3. (An Analyzer equipped with the AUTORANGE option automatically switches to the most accurate range and the UP/DOWN arrow switches are not recognized.) If the Analyzer is operating in the FLOW or the FLOW alarm set mode, pressing the RANGE switch returns the Analyzer to the RANGE mode. If the RANGE switch is not pressed, the Analyzer will automatically return to the RANGE mode in approximately five minutes.

c. Flow Display Selection

When in the RANGE or the FLOW alarm set mode, pressing the FLOW button selects the display of the sample flow rate in lpm. The flow rate is controlled by means of the flow regulator valve located in the sensor enclosure. (The Analyzer automatically returns to the RANGE mode after five minutes if left in this function.) Pressing the RANGE button returns the instrument to the RANGE mode. Also, pressing ALARM/CANCEL causes the instrument to enter the LOW FLOW alarm set mode. This feature makes it easy to switch back and forth between the actual flow reading and the LOW FLOW alarm set mode.

2. Electronic Data Processing

The Analyzer is a microprocessor controlled instrument designed to measure oxygen concentrations over 1 to 3 ranges. The ranges covered extend from the tenths of a part per million level to as high as 25% O_2. For operational details refer to the Series 100 block diagram, Figure 4-3.

a. Sensor Enclosure

Follow the procedures described in Section 4B (starting on page 4-4) prepare the oxygen sensor for proper operation. Assuming the sensor is charged with electrolyte, the electronics can begin the process of measuring the oxygen content of the sample gas. Optionally, a filter and/or a pressure regulator may be used on the input side of the sensor enclosure to condition the sample gas before it enters the oxygen sensor. After passing through the oxygen sensor, the sample gas travels through the flowmeter and out the sample outlet.

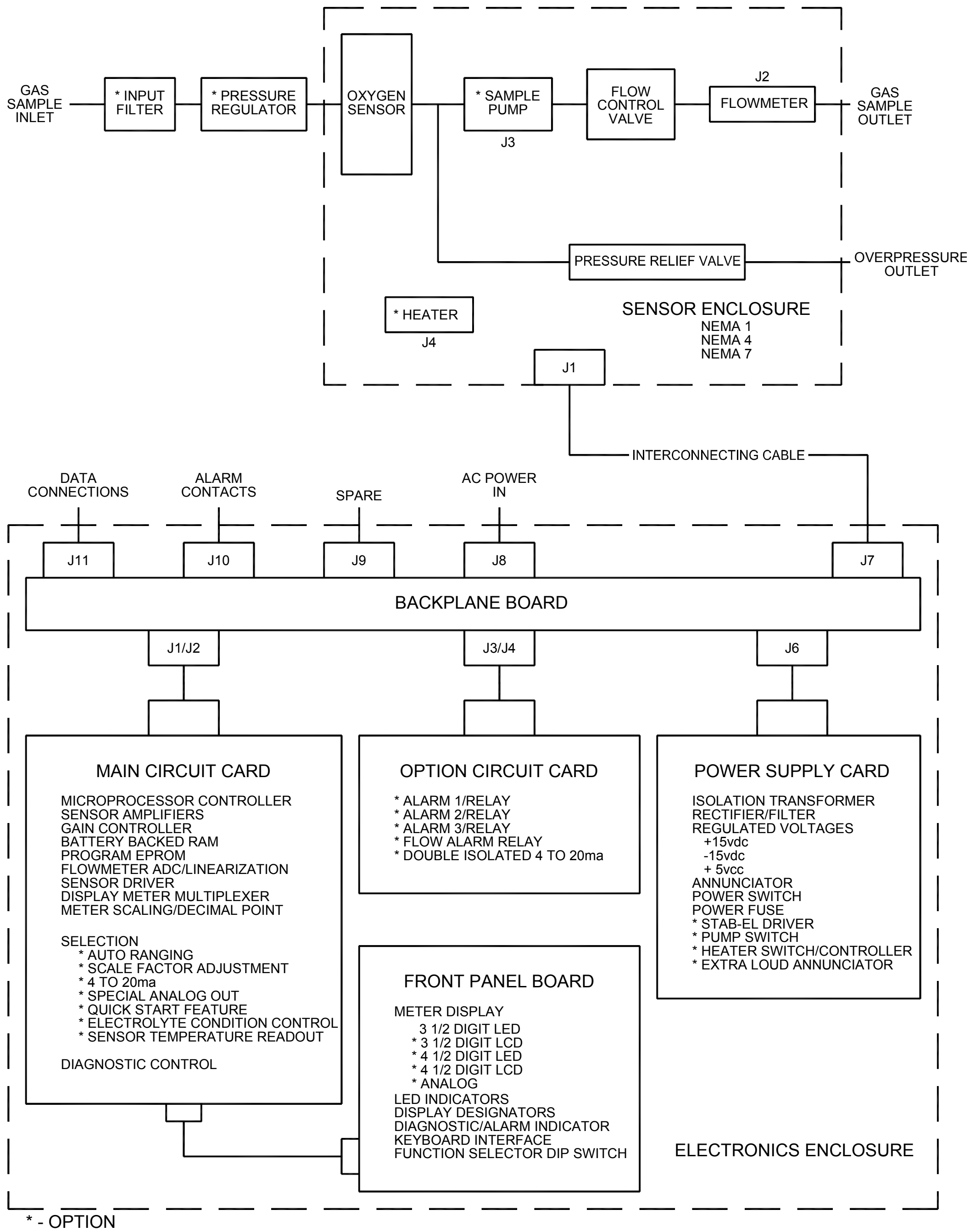


Figure 4-3: Series 100 Block Diagram

b. <u>Electronics Enclosure</u>

The electronics enclosure houses the equipment necessary to control and monitor the oxygen measuring system. The system consists of the backplane board, into which all external connections are made, and the individual printed circuit cards that contain the electronics circuitry.

i. <u>Backplane Card</u>

This printed circuit card serves as the interface between the plug-in printed circuit cards and the wiring connections that are accessible by removing the rear cover of the electronics enclosure. The main circuit card must plug into the backplane card leftmost card position. The power supply module can only be plugged into the rightmost card position. The option card must be plugged into the middle position.

The only printed circuit board that does not connect to the backplane card is the front panel board, which attaches to the front end of the main circuit card via a ribbon cable.

The backplane card interconnects all the inputs and outputs from each card and Series 100 external connectors. It also provides the means for distributing direct current (DC) power from the power supply module to the other components in the system. The backplane board contains signal conditioning circuitry for the flowmeter digital pulses, which are received from the sensor enclosure.

ii. <u>Power Supply</u>

The power supply is a plug-in module that contains components for energizing and controlling the Analyzer. The fuse and power ON/OFF switch are mounted on the power supply front panel. Primarily, the power supply converts the AC from the mains into +5 and $\pm$15 VDC. Also included in this module is a circuit that provides an additional output electrically isolated from all other circuits. This additional output is used to drive the optional STAB-EL™ circuitry in the oxygen sensor. A pump switch located in the electronics enclosure allows for optional on/off pump control. The power supply module may contain a controller in the event that the sensor is equipped with an optional heater used to maintain the sensor at a given temperature. This is useful for preventing condensation of certain sample gases or stopping the sensor electrolyte from freezing under extreme environmental conditions.

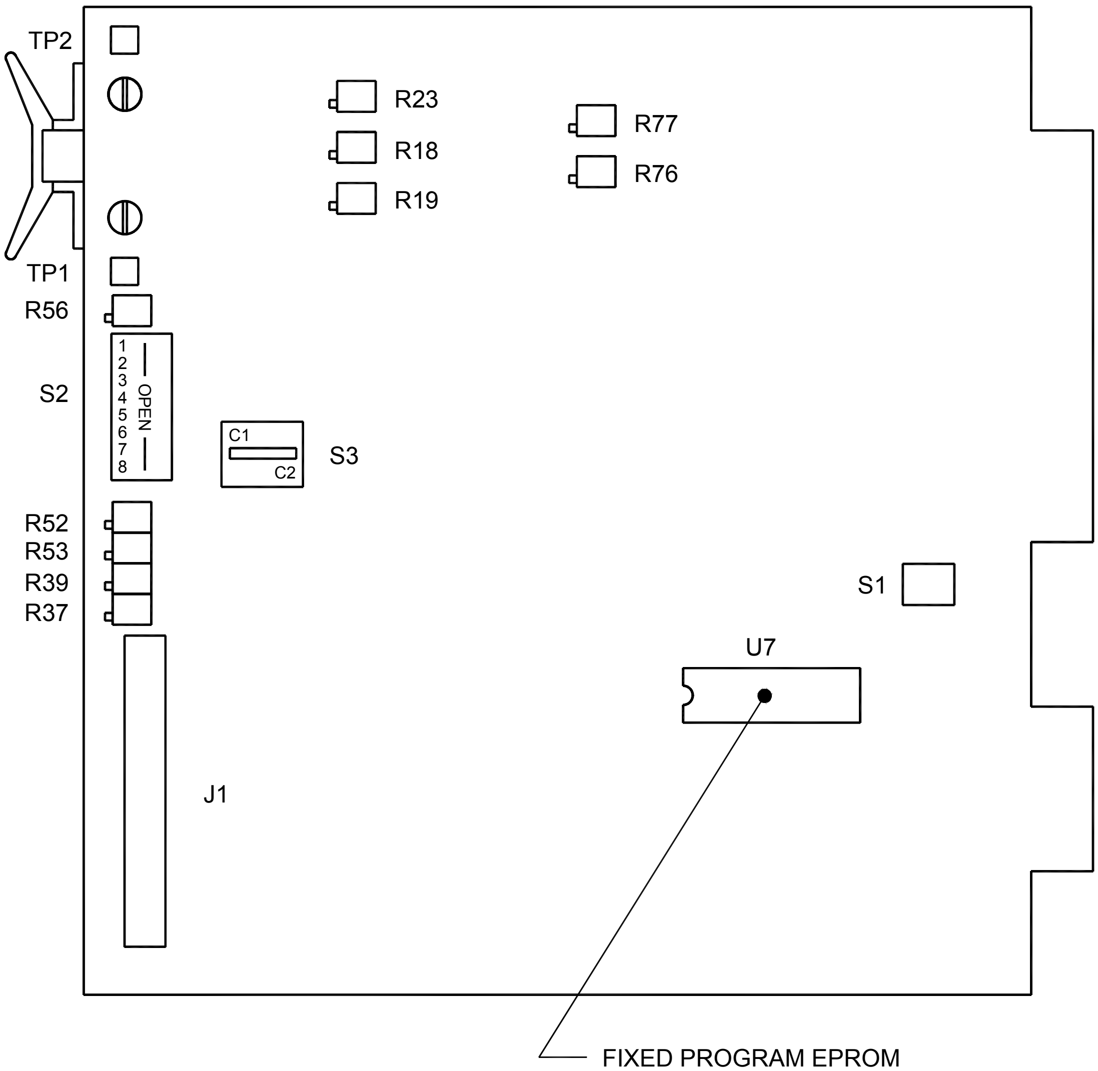


Figure 4-4: Main Circuit Card - View Of Component Side

iii. <u>Main Circuit Card (See Figure 4-4)</u>

This card functions as the control center for the Analyzer. The microprocessor operates with a fixed program to respond to input commands from the front panel keyboard and also performs automatic functions. User-entered constants, such as the setting of the flow alarm level, are remembered in a battery-backed-up Random Access Memory (RAM). Due to the presence of this RAM it is not necessary to re-enter constants or alarm setpoints after power is turned off or after a power failure.

Most of the major functions of this card, as listed on the block diagram (Figure 4-3), are self-explanatory. Of special note is that the linearization of the data from the flow meter is accomplished by means of a look-up table, which is stored in the fixed program PROM (Programmable Read Only Memory). Up to four different lookup tables are stored in the microprocessor. A particular table is selected by DIP switch S1 on the main board, see Section 3 Flow Measurements. A simple calibration procedure is necessary when changing sample gases. Ths procedure is described in Section 7E (page 7-7).

iv. <u>Front Panel Card</u>

As indicated by the block diagram, the front panel card contains the visual indicators for the Analyzer as well as the keyboard for manual control of the Analyzer. Also, the front panel card contains the 4 position Dual Inline Package (DIP) switch used to select different operational modes. Connection is made to the main circuit card via a 34-conductor ribbon cable.

c. <u>Auto Ranging Function</u>

This optional feature keeps the Analyzer operating on the lowest concentration range possible, providing the maximum resolution for the front panel display and the analog output. It performs this function by monitoring the standard 0 to 10 VDC output. If the output exceeds +10 VDC, the range is automatically switched to the next highest range (if it is not already on the highest range). Similarly, if the 0 to +10 VDC output is less than 0.9 VDC, the instrument is switched to the next lowest range (if it is not already on the lowest range).

This feature, if available, can be disabled by operating the front panel DIP switch S1, position 1, into the OPEN position.

When the auto range option is ordered, digital range indication is provided on connector J11. See "Optional Digital Range Indication," in Section 4, page 4-21.

3. Flow Measurement

The electronic flowmeter is located in the sample outlet line. The meter is calibrated to work with several gases, selected by a 4 position DIP switch, designated S1, located on the main board, see Figure 4-4. The electronic flowmeter can be calibrated for use with five different gases. The table below lists the settings on the DIP switch, S1, that select the listed gas calibration from the microprocessor.

Gas	DIP switch S1 Position			
	1	2	3	4
Nitrogen or Air	ON	OFF	OFF	OFF
Argon	OFF	ON	OFF	OFF
Hydrogen	ON	ON	OFF	OFF
Helium	ON	ON	ON	OFF

If the Analyzer is used with a gas that is not listed, it is recommended that an external rotameter be connected to the outlet. The recommended flow rate for all gases is 0.5 to 1.5 slpm.

The flowmeter electronics board, mounted on the oxygen sensor, also provides a means of terminating all of the wiring that connects the sensor enclosure to the electronics enclosure. Included in this wiring, if appropriate, are the power lines for the optional sample pump and optional sensor heater as well as the optional STAB-EL™ electrolyte conditioning leads. The sensor leads are the actual threaded studs that secure the flowmeter electronics board to the sensor.

4. AC Input Voltage

CAUTION: Before unplugging the power supply module, turn off the instrument AC POWER switch, and remove the instrument power cord from any source of AC power.

The standard Analyzer operates from 115 VAC, 50 or 60 Hz. At the time of ordering, operation on 230 VAC, 50 or 60 Hz may be selected. The configuration of the AC input is printed on the rear cable entrance plate of the electronics enclosure. Check this label before connecting the instrument to a source of AC power.

5. Checking the Fuse Value

The fuse for the instrument is accessible from the front of the power supply module.

a. To check the fuse value, open the front door of the electronics enclosure and turn off the power by means of the power switch located on the power supply module.

b. Remove the fuse from the fuseholder by unscrewing the fuse cap with a small screwdriver. The fuse is a 5x20 mm fuse and should have a value, as shown below, based on the AC input voltage selected (indicated on the rear cable entrance panel).

115 VAC	1 AMP
230 VAC	½ AMP

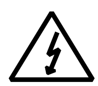
6. Wiring

a. General

All wiring to the electronics enclosure is made by means of cables that pass through the rear panel and terminate in connectors on the backplane board.

i. To access the backplane board, remove the four screws that attach the rear cover to the electronics enclosure.

WARNING: Do not make or check any connections on the rear panel of the electronics enclosure without first disconnecting the instrument from any AC power source. AC power is present within the instrument. If AC power is not removed, a dangerous situation exists.



The connector arrangement is printed on the decal located on the inside rear cover (Figure 4-5). For the decal to become visible, the rear cover must be removed per instructions above.

ii. The cables entering the instrument through the cable entrance panel should be stripped as follows:

CABLE	STRIP CABLE JACKET (in.)	STRIP WIRE INSULATION (in.)
Power	2.0	3/16
Sensor	5.0	3/16
Data	4.0	3/16

Each wire can be tinned with solder to control fraying, if desired.

iii. For proper sealing and strain relief operation of the cable entrance clamps, make sure the cables used have a round outer jacket and conform to the following outside diameter range.

CABLE	OUTSIDE DIAMETER RANGE (in.)
Power	0.090 - 0.265
Sensor	0.270 - 0.480
Data Cable	0.231 - 0.394

b. <u>Power Cord</u>

A 3-wire power cord should be used for AC power connections at J8. Connections should be as follows:

J8 Pin No.	Function	Color		Recommended Wire Size
1	Line	Brown	(Black)	#18 AWG
2	Ground	Grn/Yel	(Green)	#18 AWG
3	Neutral	Blue	(White)	#18 AWG

c. <u>Electronics to Sensor (All Sensor Enclosure Styles)</u>

When the Analyzer is ordered as a portable unit (non-remote mounted sensor), a 15-conductor cable is provided, connecting the electronics enclosure to the sensor enclosure. (This same cable is available in longer lengths as part number 13304070 for remote sensor applications.) While this cable provides the wires necessary for all possible options, they may not all be required for any given application. In table 4-1 (page 4-9) the asterisks indicate those wires used for optional features. <u>ALL WIRES NOT MARKED WITH AN ASTERISK MUST BE INSTALLED FOR PROPER OPERATION.</u>

To preserve signal integrity, the cable length should be limited to 1000 feet. If a factory cable is not purchased the following guidelines must be followed:

i. Cell leads should be separately shielded.
ii. Separate cables may be used (for instance, for each wire gauge size), but each must have an overall shield.
iii. All shields are connected to power ground on the electronics enclosure end only. To prevent ground loops do not connect the cable shield to the chassis on the sensor enclosure end.
iv. The wires sizes in the Sensor Cable Wiring table (page 4-19) are for 1000-foot service. For shorter distances, smaller cable can be specified as follows:

For 500-1000 Feet Substitute W/	For 100-500 Feet Substitute W/	For 0-100 Feet Substitute W/
#22	#22	#22
#16	#18	#22
#14	#16	#18

Replace the wire size shown under the "500-1000 Feet" column with the corresponding size under the shorter length column.

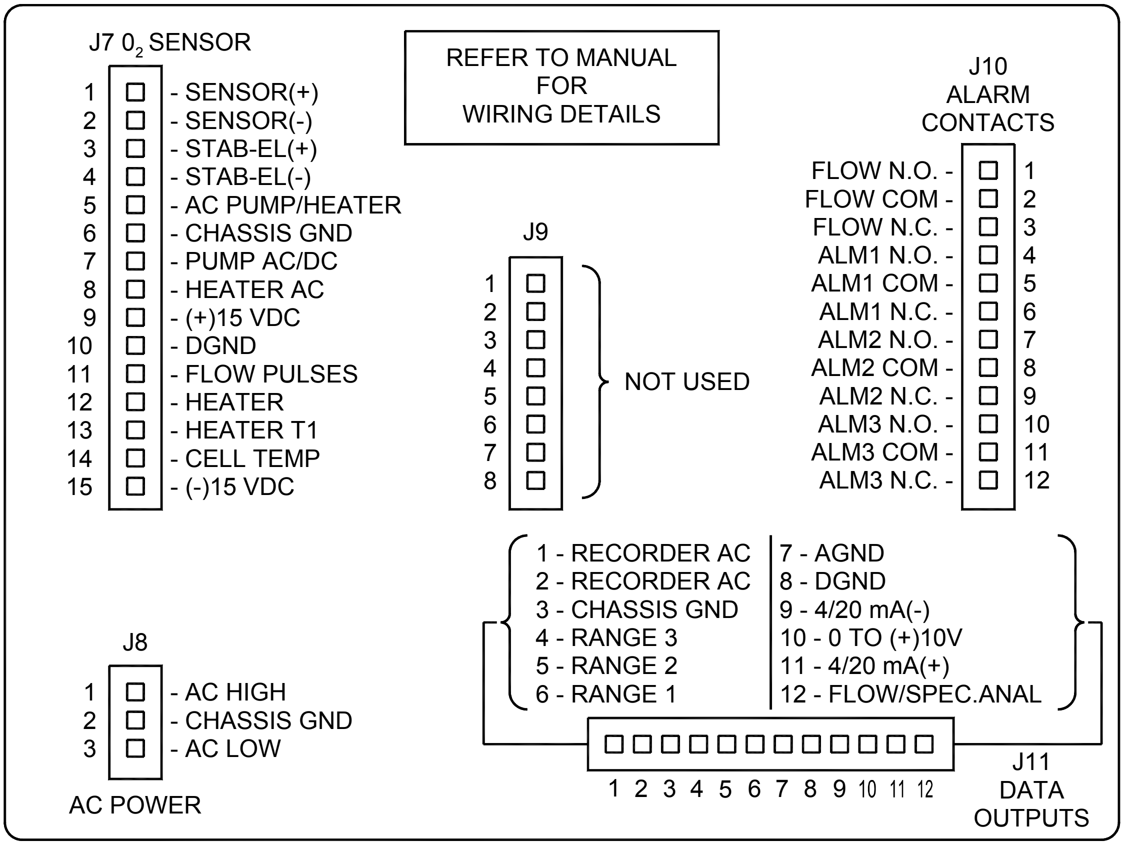


Figure 4-5: Decal Showing Connector Arrangements

Table 4-1
Sensor Cable Wiring

Pin No.	Function	Recommended Wire Size & Color	
1	Sensor (+)	#14 AWG	White/Black/Red
2	Sensor (-)	#14 AWG	White/Yellow
*3	Stab-El ™ (+)	#22 AWG	White/Red
*4	Stab-El ™ (-)	#22 AWG	White/Blue
*5	AC Pump/Heater - Neutral	#16 AWG	White
6	Chassis Ground	#16 AWG	Green
*7	Pump AC/DC - Line	#16 AWG	White/Black
*8	Heater AC - Line	#16 AWG	Red
9	+ 15 VDC	#22 AWG	Orange
10	Digital Ground (DGND)	#22 AWG	Black
11	Flow Pulses	#22 AWG	Yellow
*12	Heater	#16 AWG	Blue
*13	Heater T1	#22 AWG	Brown
*14	Cell Temperature	#22 AWG	Gray
15	- 15 VDC	#22 AWG	Violet

Connector J1: Oxygen Sensor
Connector J7: Electronics Backplane

v. Connect the two drain wires of the aluminized shields together and sleeve them so they cannot come into contact with the backplane board. Connect to pin 6 of J7.

(NOTE: The drain wires are connected to earth ground only on the electronics enclosure end.)

vi. Prior to inserting the wires into the connectors, strip them 3/16 of an inch. A small blade screwdriver is required to attach a wire to one of the connectors.

d. Explosion Proof Sensor Cable Wiring

CAUTION: IT IS IMPORTANT TO NOTE THE ORIENTATION OF PIN 1 ON THE SENSOR CABLE CONNECTORS. CONNECTOR J7 (15 PIN CONNECTOR ON THE ELECTRONICS ENCLOSURE BACKPLANE) HAS PIN 1 AT THE TOP OF THE UNIT. CONNECTOR J1 (15 PIN CONNECTOR ON THE CELL PC BOARD, IN THE EXPLOSION PROOF ENCLOSURE) HAS PIN 1 ON THE LEFT-HAND SIDE.

Except for conduit and wire, the Analyzer has been shipped with all materials necessary to complete the electrical hook-up of the electronics enclosure to the sensor enclosure.

CAUTION: Installation of conduit and sealing of conduit fittings should be performed by qualified personnel. The safety of the final system depends on a thorough knowledge of applicable electrical codes and familiarity with the materials involved.

The conduit seal (Part No. 66-000216) is a 3/4-inch female pipe thread x 3/4-inch female pipe thread fitting to be mounted on the right side of the chamber using a 3/4-inch male pipe thread nipple, which is included with the fitting.

SEALING THE FITTINGS

For applications where it is necessary to seal the fitting, a Chico Sealing Kit (Part No. DF-R024) has been provided. The fitting is a Crouse-Hinds Type EYS216. Sealing procedures specified by Crouse-Hinds should be followed carefully.

e. Electronic Data Outputs

The connectors provided on the Series 100 Analyzer to allow for connection to the instrument outputs are:

J9 - reserved for future use
J10 - optional alarm contacts
J11 - data outputs

Connections to these plug-in connectors are the same as the sensor cable and AC power cord connections. It is only necessary to strip 3/16 inch from the end of each cable conductor, insert the wire into the connector, and tighten the screw.

i. Standard Output J11-10

The standard output of the Analyzer is a 0 to +10 VDC analog signal that corresponds to the operating range of the instrument as selected on the front panel. For example: Suppose that an instrument has three ranges -- 0 to 1 ppm, 0 to 10 ppm, and 0 to 100 ppm. When operating on 0 to 1 ppm, 0 VDC corresponds to 0 ppm and +10 VDC corresponds to 1.0 ppm. Correspondingly, when operating on the 0 to 10 ppm range, 0 VDC still represents 0 ppm, but +10 VDC now represents 10 ppm.

NOTE: The load impedance attached to this output should be greater than 10K Ohms.

ii. Analog Data Ground Return (AGND) J11-7

This connector position is the analog ground return point for the analog output signal on J11-10. It is negative with respect to J11-10.

iii. 4 to 20 mADC {J11-11(+) and J11-9(-)}

The 4 to 20 mADC output follows the 0 to +10 VDC analog output on J11-10. The current (I) that flows can be related to the analog output voltage (V) by I (mA) = 4 + 1.6 V. As with the 0 to +10 VDC output, the 4 to 20 mADC output corresponds to the range that the instrument is displaying, as selected on the front panel.

There are two optional types of 4 to 20 mADC outputs. The first is a 4 to 20 mADC output isolated from the AC power mains and the chassis ground or power ground. However, it is not isolated from the 0 to +10 VDC output or the analog and digital grounds in the system. The optional 4 to 20 mADC output is double-isolated; that is, it is isolated from both the AC power mains and chassis ground as well as the 0 to +10 VDC output and the system analog and digital grounds. (The type of 4 to 20 mADC provided is determined at time of order. Note that these two 4 to 20 mADC outputs are mutually exclusive. Only one type may be provided at any time).

NOTE: The maximum load resistance for both 4 to 20 mADC circuits is 750 Ohms.

iv. Flow/Special Analog Output J11-12

This output pin serves a dual function. It provides an analog output signal of 0 to +7.5 VDC corresponding to 0 to 1.5 slpm of sample gas flow if the flow/special analog output option is available. It also provides an output for an optional special analog output voltage other than the standard 0 to +10 VDC output on J11-10; that is, 0 - +5 VDC, 0 - 100 mVDC, etc. (Note that the two outputs are mutually exclusive. Either flow or special analog output can be provided, but not both. Minimum load resistance is 10K Ohms.)

v. Optional Digital Range Indication

Range 1: J11-6 Range 2: J11-5 Range 3: J11-4

The digital range indication option is provided when the auto range option is ordered. The digital range output for the Series 100 Analyzer provides a Transistor-Transistor-Logic (TTL) level signal, indicating to external equipment which of the three ranges the instrument is operating on. The operating range is selected manually, or automatically if the auto ranging option is provided and turned on. These outputs are active high; that is, the output for the range selected will be a high; (+5 volts) while the outputs for the ranges not selected are a logical low (approximately 0 volt).

Range 1 refers to the lowest oxygen concentration range; range 3 corresponds to the highest oxygen concentration range.

vi. Recorder Switched AC J11-1 and J11-2

The input AC power furnished at J8 is switched to these outputs through the Analyzer power switch. The voltage switched, 115 VAC or 230 VAC, is the same as that provided at J8. This output is not fused separately, but is protected by the AC input fuse located on the front panel of the power supply module. (This output is provided only as a convenience for powering data recorders consuming less than 25 watts. It should only be used for that purpose.)

vii. Optional Alarm Relay Outputs J10

When an alarm is not in progress, the normally closed contact is connected to common. Turning the power off resets the relay contacts to the same condition as when an alarm is not in progress. This ensures that the alarm relays will not arbitrarily register an alarm condition when the instrument is turned off and unable to actually detect oxygen.

	J10-1	Normally Open
Flow Alarm Relay	J10-2	Common
	J10-3	Normally Closed
	J10-4	Normally Open
Alarm 1 Relay	J10-5	Common
	J10-6	Normally Closed
	J10-7	Normally Open
Alarm 2 Relay	J10-8	Common
	J10-9	Normally Closed
	J10-10	Normally Open
Alarm 3 Relay	J10-11	Common
	J10-12	Normally Closed

Up to 4 alarm relays can be provided (3 oxygen alarms and one low flow alarm). All have Form C contacts for greatest wiring flexibility. Contacts are rated: 5A at 30 VDC, 8A at 115VAC, and 8A at 230 VAC.

SECTION 5: OPERATING THE SERIES 100 ANALYZER

A. POWER ON/OFF SWITCH

Power to the Series 100 Oxygen Analyzer is controlled by the power ON/OFF switch located on the power supply module. Access to this switch is gained by opening the door on the electronics enclosure. This switch is a push-push type; that is, push it once to turn the instrument on and push it again to turn it off. When ON, the switch latches in the IN position.

B. OPTIONAL PUMP ON/OFF SWITCH

The pump ON/OFF switch is located on the front panel of the power supply module (extreme right printed circuit card).

C. OPTIONAL SENSOR HEATER

The heater ON/OFF switch is located on the front panel of the power supply module (extreme right printed circuit card). A proportional temperature controller, located in the power supply module, maintains the sensor temperature at 25°C even if the ambient temperature drops to 0°C.

CAUTION: The Analyzer has been calibrated with the heater operating. For greatest accuracy, if the ambient operating temperature is less than 25°C, the heater must be turned on and the temperature stabilized (30 minutes to an hour, depending on ambient temperature) prior to making oxygen measurements. In addition, whenever the heater is operating there should be a sample flow through the instrument. The heater causes small amounts of water vapor to diffuse from the electrolyte, through the electrode, and into the sample system. Operating the Analyzer with the heater on and no sample flow will allow water to condense in the sample system. Condensation does not result in damage, but it may cause slower response at low oxygen concentrations.

Actual sensor temperature may be verified, and adjusted, by entering the diagnostic mode as follows:

1. SETTING HEATER TEMPERATURE

i. Open the electronics enclosure door. Enter the diagnostic mode by placing front panel DIP switch S1, position 3, into the CLOSED position.

ii. The test light turns on and the diagnostic selection character "7" appears in the single digit display. The selected voltage reading displays on the meter. Use the UP arrow switch to advance to selection "d". Sensor temperature in degrees Celsius is displayed on the meter.

iii. Use a 3/32-inch wide blade screwdriver to adjust the HEAT SET potentiometer found on the lower section of the power supply module (extreme right card) front panel. Clockwise adjustment increases the temperature. Make adjustments gradually and allow ample time for the temperature to stabilize after each change. Do not exceed the temperature listed under the operating specifications.

iv. After the sensor temperature has been adjusted, place front panel switch S1, position 3, into the OPEN position. The Analyzer returns to normal operation.

D. FRONT PANEL DISPLAYS

The standard display is a 3 ½ digit LED meter with 0.5-inch high digits. Optionally, a 3 ½ and a 4 ½ digit Liquid Crystal Display (LCD) meter, a 4 ½ digit LED meter, and an analog meter are available. The liquid crystal meter is suggested for operation in an abnormally bright environment, which would make the LED display difficult to read. The 4 ½ digit display is required for analyzers having more than 3 ½ digits of resolution on the highest concentration range, such as 5000 ppm, 10000 ppm, etc., or when the application requires the ability to detect subtle changes in concentration.

E. ALARM DESCRIPTIONS (See Figure 5-1)

The Analyzer is equipped with three concentration alarms, a flow alarm, and, if applicable, an electrolyte condition alarm.

1. Optional Range Alarms 1 through 3

There are three operator-settable concentration alarms. These are true concentration alarms in that setting a 1-ppm alarm causes alarm detection at a 1-ppm concentration no matter what the operating range may be. Each alarm may be set as either a high (oxygen concentration exceeds a set level), or low (oxygen concentration decreases below a set level) alarm. In this way it is possible to set the alarms for any point over the entire range of the instrument in any combination of high or low alarm detection. On multi-range instruments, during alarm setting, the range may be changed so that each alarm can be set accurately on the most sensitive range applicable. Example: A 1%, 5%, and 25% 3-range Delta F Series 100 Oxygen Analyzer is used to verify that the oxygen content remains between 3% and 4% in a nitrogen-purged vessel. A third alarm is used to shut down the process if oxygen concentration exceeds 10%. Alarm 1 would be set as a low alarm at 3% on the 5% range. Alarm 2 would be set as a high alarm at 4% on the 5% range, and Alarm 3 would be set as a high alarm at 10% on the 25% range.

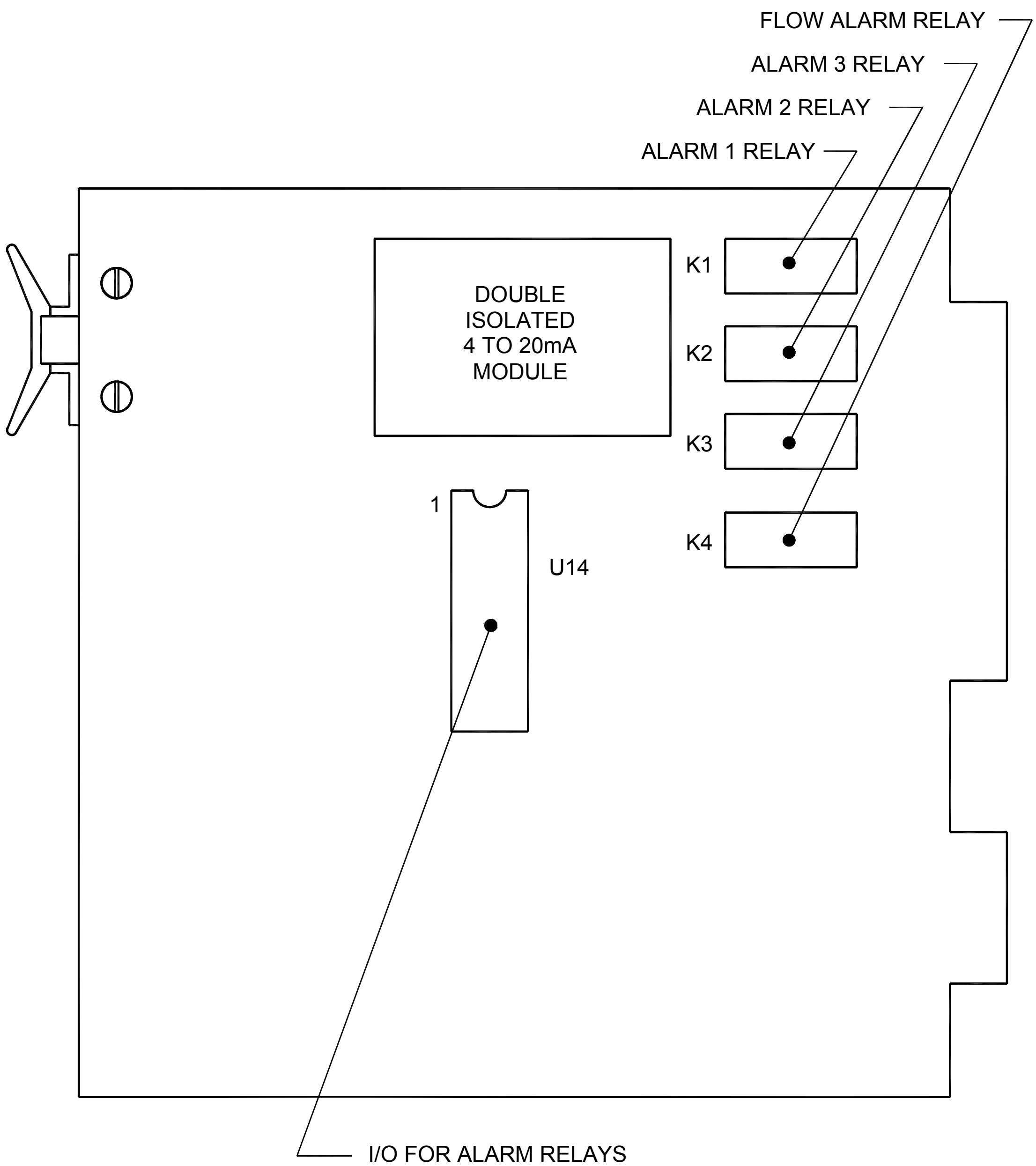


Figure 5-1: Option Card - View of Component Side

A relay provides both normally open and normally closed contact indication (Form C contacts) for each of the three alarms. Alarm occurrence results in the activation of the beeper, which may be silenced by pressing the ALARM/CANCEL button. (Use of the ALARM/CANCEL button only turns off the beeper; all other alarm indicators continue.)

During an alarm, the front panel single digit displays the alarm number, alternating between numbers if more than one alarm is occurring. The "ALM" light also turns on. When the alarm condition stops, the alarm automatically clears all alarm indicators.

Alarms 1 through 3 are suppressed for 10 seconds after power is first turned on, range changed, or the diagnostic or scale factor mode exited. This allows the Analyzer output to stabilize and prevents meaningless alarms.

2. <u>Setting Range Alarms 1 through 3</u>

   a. With the instrument operating normally, press the ALARM/CANCEL button. An "F" appears in the single digit display and the "ALM" and "SET" lights turn on. At this time, the meter indicates the flow alarm setpoint directly in "LPM".

   b. To proceed to Alarm 1, press the ALARM/CANCEL button again. Each time the button is pressed the instrument advances to the next alarm. The alarms are: (F) Flow, (1) Alarm 1, (2) Alarm 2, and (3) Alarm 3. Alarms 1-3 are options.

   c. The range indicator depicts the range with which the displayed setpoint is associated. The range may be changed to more accurately set the desired value (that is, if you had a 1%, 5%, and 25% instrument it would be more accurate to set a 2.0% alarm on the 5% range than on the 25% range.) To change the range, press the RANGE button while in the set mode for Alarm 1,2, or 3. While in the range changing mode the RANGE button light blinks. At this point, the UP and DOWN arrow switches may be used to change the range. Press the RANGE button again to return to the alarm setpoint adjustment mode.

   d. The UP and DOWN arrow switches may be used for setpoint adjustment. For ease of setting, as each arrow continues to be pressed, the rate of change increases.

   e. To alternate between high and low alarm type, press the FLOW button. A high alarm is signified by a dot appearing at the upper left of the range number digit in the single digit display.

   f. To set Alarms 2 and 3, repeat steps b through e. The single digit displays the alarm number. If an alarm is not going to be used, adjust the alarm setpoint to zero on range 1 and make it a low alarm.

g. To exit the alarm setting mode, press the ALARM/CANCEL button until the flow alarm setting mode is reached ("F" is in the single digit display.) Press the RANGE button to leave the alarm setting mode. Alternatively, the FLOW button may be pressed to examine the current flow value.

NOTE: If alarm setting is not completed within five minutes, the instrument automatically leaves the alarm setting mode. Any changes made are saved.

3. Flow Alarm

The flow alarm occurs when sample flow decreases below an operator-settable alarm flow rate. An optional relay provides either normally open or normally closed contact indication (Form C contacts) of the alarm condition. Alarm occurrence results in the activation of the beeper, which may be silenced by pressing the ALARM/CANCEL button. The use of the ALARM/CANCEL button only turns off the beeper; all other alarm indications continue. During a flow alarm the front panel single digit displays an "F" and the "ALM" light turns on. When the alarm condition disappears, the alarm automatically clears all applicable alarm indicators.

4. Setting the Low Flow Alarm

a. With the instrument in normal operation, press the ALARM/CANCEL button. An "F" appears in the single digit display and the "ALM" and "SET" lights turn on. At this time the meter indicates the flow alarm setpoint directly in lpm.

b. To change the set point value, use the UP and DOWN arrow switches, while observing the display. For ease of setting, as each arrow switch continues to be pressed, the rate of change increases.

c. When the alarm value is set, press the RANGE button to leave the alarm setting mode. Alternatively, the FLOW button may be pressed to examine the current flow value.

NOTE: The flow alarm may be disabled by setting the alarm setpoint to 1.50 slpm. If alarm setting is not completed within 5 minutes the instrument automatically leaves the alarm setting mode. Any changes made are saved.

5. Optional Electrolyte Condition Alarm

The electrolyte condition alarm detects low electrolyte level or large changes in electrolyte conductivity caused by contamination. This alarm turns on the beeper, the "ALM" light, and an "E" in the single digit display. To silence the beeping, press the ALARM/CANCEL button. (An alarm relay is not available for this alarm.) When the alarm condition is resolved, the alarm automatically clears all alarm indicators.

F. BACKGROUND GAS CORRECTION AND OPTIONAL SCALE FACTOR CONTROL

Factory calibration is a standard procedure comprised of a series of tests designed to measure oxygen in a background of nitrogen gas.

Background gas has significance in the measurement of oxygen because of its effect on the transport rate as oxygen moves through the diffusion barrier into the electrochemical sensor. The diffusion barrier consists of apertures that become occupied by the background gas. Since the oxygen must migrate through the background gas, it meets with resistance that is predominantly a function of the molecular weight of the gas through which it travels.

The typical background gases encountered form stable and predictable resistance paths for the diffusion of oxygen. Consequently, it is possible to develop coefficients for the various gases as they relate to nitrogen.

Note that an oxygen analyzer that has been calibrated using a specific background gas can be used to monitor oxygen in a wide variety of other gases by employing the appropriate coefficient. This coefficient is more suitably termed the background gas correction factor or scale factor.

Scale factors for several gases have been experimentally determined and are listed in Appendix E. If an analyzer is equipped with the scale factor option, direct readout of oxygen in the carrier gas can be made. Accomplish this readout as follows:

1. Open the electronics enclosure door. Press the instrument power switch to the OFF position. Unplug the extreme left printed circuit board (main control board -- see Figure 4-4). Place switch S3 (near front edge of card) in the C1 position. Place S2 DIP switch, position 8, into the OPEN position to disconnect the cell. Re-install the printed circuit board into the Analyzer.

2. Turn the instrument power back on. Enter the scale factor setting mode by placing front panel DIP switch S1, position 2, into the CLOSED position.

3. The "TST", "PCT", and "SET" lights turn on and the current scale factor reading (in percent) appears on the meter (normally 100% for nitrogen). Using a 3/32-inch wide screwdriver, adjust R56 for the desired scale factor. Allow sufficient time for the value to stabilize. Example: Suppose the background gas is hydrogen and this is a 1/10/100 ppm analyzer. Appendix E shows that the hydrogen scale factor for analyzers under 500 ppm is 0.62. In other words, for an analyzer that has been calibrated on nitrogen, if you change to a hydrogen background gas, the displayed oxygen reading must be multiplied by 0.62 to be accurate. In this case the scale factor would be adjusted to 62% and the Analyzer switch settings returned to normal. From this point, the Analyzer will automatically display an oxygen value that has been multiplied by 0.62.

4. Turn the instrument power off and return front panel switch S1, position 2, to the OPEN position. Unplug the main control board, return S3 to the C2 position, and CLOSE switch S2, position 8. Install the main control board and turn the instrument power on.

G. OPTIONAL QUICK-START FEATURE

The quick start feature is used for situations where it is desirable to obtain low ppm readings with the Analyzer in the shortest period of time. This feature has the ability to displace oxygen within the sensor cell, which would otherwise desorb slowly as the sample gas reaches the lowest levels of oxygen content. Use quick-start only when the gas sample tested is expected to be below 10 ppm. For gas compositions above that level, the quick-start feature has little or no effect.

OPERATION

The quick-start feature is most effectively used by following the steps indicated below:

1. After the Analyzer has been connected to the sample gas, observe the decline in oxygen concentration until it has reached 100 ppm or less.

2. Initiate the quick-start sequence by pressing the RANGE switch with your left hand. Continue to press the RANGE switch and press the ALARM/CANCEL switch with your right hand. Once initiated, an "S" flashes in the diagnostic digit on the front panel display and the meter display indicates a quick-start voltage of 1.50 volts. This quick-start sequence lasts for approximately 20 seconds.

3. After the quick-start sequence finishes, the instrument automatically returns to normal operation and the meter again indicates the actual O_2 reading. In some cases, the meter indicates a negative reading immediately following a quick-start sequence. This essentially means that the sensor electrode is filled with excess hydrogen as a result of the quick-start sequence. This condition, however, should correct itself in minutes as incoming oxygen from the gas sample stream neutralizes the hydrogen.

SECTION 6: PERFORMING FIELD MAINTENANCE

A. GENERAL

The Delta F Series 100 Oxygen Analyzer is designed to make maintenance, when required, an easy task. To this end, the oxygen sensor has been placed on a chassis for easy access (after disconnecting the sample lines). The electronics are all located on plug-in cards with the exception of the front panel card, which is easily disconnected from the main circuit card by means of a ribbon cable connector. Consequently, should trouble occur, service can be limited to simply replacing a failed card, power supply, or oxygen sensor module, to get back into operation in the shortest time. Procedures for locating the source of possible problems, are outlined below.

B. DIAGNOSTIC CHECKS

A series of internal voltages may be measured by entering the diagnostic mode by placing the front panel DIP switch S1, position 3, into the CLOSED position. (Return instrument to normal operation by placing the front panel DIP switch S1, position 3 into the OPEN position.)

1. Open the electronics enclosure door. Enter the diagnostic mode by placing front panel DIP Switch S1, position 3, into the CLOSED position (see Figure 6-1).

2. The "TST" light turns on, the diagnostic selection character appears in the single digit display, and the first voltage reading displays on the meter. Use the UP and DOWN arrow switches to step through these selections:

TABLE 6-1 INTERNAL VOLTAGE MEASUREMENTS

Voltage Measured	Character Displayed	Expected Value
SPECIAL OUTPUT VOLTAGE	7	(OPTIONAL)
QUICK-START VOLTAGE	S	1.480 - 1.520 V
NORMAL SENSOR VOLTAGE	C	1.290 - 1.310 V
ACTUAL SENSOR VOLTAGE	O	1.290 - 1.310 V
AUXILIARY REF VOLTAGE	A	-4.980 - -5.020 V
+ 10 VDC REFERENCE	P	9.90 - 10.10 V
- 10 VDC REFERENCE	-	-9.90 - -10.10 V
SENSOR TEMPERATURE	d	(OPTIONAL)
RESERVED FOR FUTURE USE	b	NA
+ POWER SUPPLY	H	7.000 - 7.700 V
- POWER SUPPLY	L	-7.000 - -7.700 V

3. After completing the diagnostic checks, return DIP switch S1, position 3 to the OPEN position.

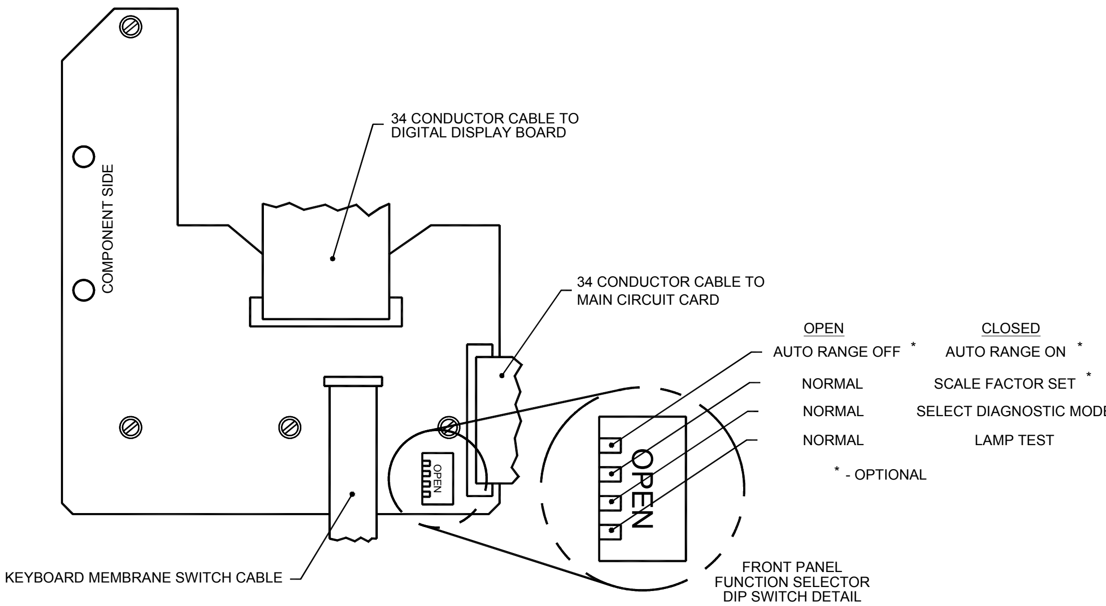


Figure 6-1: Front Panel Board Outline

C. POSSIBLE PROBLEMS AND SOLUTIONS

	Problem Indication	Possible Solution
1.	Power switch ON, but no front panel lights or other indications are lit.	Check fuse on power supply card. Make sure power plug on rear of backplane card is plugged in. Ensure integrity of AC power source. Ensure that power supply module and main circuit board are fully plugged into backplane board.
2.	Power is turned on and a beep heard, but there are no front panel lights or other indicators lit.	Check that the cable from the front panel card to the main circuit card is securely plugged in.
3.	No oxygen indication when unit is energized.	Check the following places for condition indicated: a. Ensure that position 8 of S2 on the main circuit card is closed. b. Ensure that the cabling from the electronics enclosure to the sensor enclosure is secure on each end. c. Check for proper electrolyte level in the oxygen sensor.
4.	No flow indication.	Check that the connector to the flowmeter in the sensor enclosure (J2) is fully installed. Check the connection at the flow meter. Check for possible blockage of the sample gas flow path, such as a clogged filter, flow control valve turned off, or sample lines disconnected.
5.	Autoranging option not working.	Check that the front panel card function selector switch S1, position 1, is in the CLOSED position.

	Problem Indication	Possible Solution
6.	One or more LEDs on front panel do not light.	Perform lamp test by closing front panel function selector switch S1, position 4, to light all front panel LEDs.
7.	Instrument will not respond to front panel switches. Incorrect front panel lights may be illuminated.	Turn POWER switch off, wait a moment, and turn POWER back on. Stored constants, in battery-backed memory, may have been lost. Call the factory for the calibration values and use the instructions on page 7-6 to check the sensor zero value. If the value <u>has</u> changed, be sure to reset it before returning to normal operation. Also, flow and oxygen alarm setpoints may have to be reset. The problem is typically caused when the microprocessor is interfered with by an electrical transient. Such a transient can be caused by high-current equipment operating on the same AC power feed as the Series 100, or by high-current equipment operating near the analyzer and setting up large magnetic fields. The solution is to use AC power line conditioning equipment to power the Series 100, or to make sure that the Series 100 operates from a separate AC power circuit. As with all sensitive measurement equipment, it is recommended that the Series 100 not be operated in the proximity of high current, magnetic interference generating equipment.

SECTION 7: PERFORMING CALIBRATION

A calibration record is attached to the inside door of the sensor enclosure on the standard unit. On a remote option, the calibration record is attached to the side of the power supply in the electronics enclosure.

The calibration record contains factory calibration information on the sensor and flowmeter. Additional space is provided for user calibration information.

A. BACKGROUND INFORMATION

The Delta F sensor uses a 2-section diffusion barrier, Bi-Strata™, developed to resist the problems commonly encountered with membrane barriers, such as foreign matter accumulation and heat and pressure distortion. To realize the long-term stability that the Delta F sensor is designed to offer, maintain the Analyzer within prescribed ambient conditions, and use appropriate gas conditioning.

If it becomes necessary to make adjustments in calibration, there are provisions in the Analyzer to adjust both zero and span.

B. ZERO ADJUSTMENT

In factory calibration, the zero adjustment is used to compensate for two inherent sensor characteristics. The first characteristic is a trickle current within the sensor caused by the imposed DC voltage as it maintains the electrodes in a polarized condition. The second limitation is the penetration by oxygen (in air) into the sensor and plumbing system.

Typically, the combination of the two characteristics requires that an offset in reading be made equivalent to approximately 0.1% of the top scale value (that is, an analyzer with ranges of 0-10, 0-100, 0-1000 ppm O_2 would likely require an offset of under 1 ppm).

The offset required to compensate for the current generated within the sensor does not change to any noticeable degree over the life of the sensor. However, shock, vibration, temperature and pressure cycling, aging, and other wear and tear factors may change the rate of oxygen penetration.

After verifying that any shift in zero reading is not due to either circuit malfunction or plumbing leakage, perform the following procedure to adjust the zero:

a. Select a sample gas that contains oxygen in an amount less than 0.5% of the Analyzer's lowest range; that is, if the Analyzer has a lowest range of 0 to 10 ppm O_2, for the purpose of resetting the zero point, the sample gas should contain no more than 0.05 ppm O_2.

To generate a zero gas, Delta F recommends a cylinder gas composition of 2% hydrogen with a balance of nitrogen. That the gas may include a few ppm of oxygen is of no consequence as long as a catalytic hydrogen reaction chamber is installed directly at the inlet of the Analyzer. The oxygen in the gas, or that which may be picked up from any imperfections in the gas delivery system, reacts with hydrogen to form water. Water in the gas stream has no effect on the Analyzer reading. Reaction chambers are commercially available - Engelhard Industries in Union, NJ, markets a chamber called a "DEOXO" catalytic hydrogen purifier.

For percent oxygen analyzers or for any analyzer with a lowest range of 0-0.1% O_2 or higher, standard pre-purified nitrogen (with O_2 level at approximately 5 ppm) is more than sufficient for adjusting the zero point. No catalytic reactor is necessary, but take proper precautions to deliver the gas to the Analyzer free of contamination.

b. Set a flow rate of approximately 1.0 lpm when using pre-purified nitrogen. If 2% H_2 with a balance of N_2 and a catalytic reactor are used, set a flow between 0.25 and 0.5 lpm and make provision to safely dispose of the Analyzer exhaust.

c. Maintain the flow conditions established in the previous step until the Analyzer exhibits a steady reading. The time required to establish a reliable zero point depends primarily on the Analyzer range. The lower the range, the longer the period necessary to reach stability. Typically, resetting of the zero point for a 0 to 25% range should not take more than 10 to 15 minutes. However, reaching stability at zero for the very lowest range of 0 to 0.5 ppm may require as long as 24 hours. It is recommended that, where possible, a recorder be used to chart the zero point, especially for low trace units. (Charting the zero point is helpful in avoiding a premature readjustment.)

   CAUTION: Do not attempt to adjust the zero setting unless the quality of the zero gas sample can be assured to be as described above and that sufficient time has elapsed for stabilization.

d. To make an adjustment to the zero setting:

   i. Open the electronics enclosure door.

   ii. Select the diagnostic mode by placing front panel DIP switch S1, position 3, into the CLOSED position. The special analog voltage out symbol "7" appears in the single digit display.

   iii. Press the RANGE, FLOW, and RANGE buttons, in that order, within a 5-second period. The digit "1" appears in the single digit display and the beeper sounds. You are now in Calibration Selection 1. If you do not succeed, repeat this step. This calibration mode is intentionally difficult to enter.

iv. Step up to Calibration Selection 2 by pressing the UP arrow switch once.

v. At this point, the meter displays the oxygen zero level in volts, not in oxygen concentration. (If the Analyzer is equipped with an analog meter rather than a digital meter, use a customer-supplied digital meter for these adjustments. The external digital meter can be clipped across the analog meter terminals at the back side of the front door.) This voltage is related to the oxygen concentration by this relationship:

$$\frac{\text{Volts X Range Selected}}{10} = \text{Oxygen Concentration}$$

For instance, if checking the zero point of a 1, 10, and 100 analyzer on the 1 ppm scale and the zero indication is 1 volt, the 1 volt would indicate a 0.1 ppm oxygen concentration.

The 0-10 VDC output produced during this alignment routine may be negative. This does not indicate a negative oxygen concentration, but only demonstrates that the oxygen sensor seals have improved with age so that the residual zero current is smaller than it used to be. The adjustment purposely has the capability to over-compensate and go negative.

vi. To allow the sensor zero value to be changed, press the ALARM/CANCEL switch. The switch light turns on. Use the UP and DOWN arrow switches to adjust the displayed value to match the desired setting. For ease of adjustment, the displayed value changes faster the longer the UP or DOWN arrow switch is held. Allow sufficient time for values to stabilize after each adjustment. Set the voltage to the equivalent oxygen concentration level produced by the zero gas sample applied.

Note: This is not normally 0.0 volts since it is virtually impossible to achieve oxygen free zero gas.

vii. Once the sensor zero value has been properly set, press ALARM/CANCEL again to leave the sensor zero setting mode. The ALARM/CANCEL light turns off.

viii. Leave the Calibration mode by returning front panel DIP switch S1, position 3, to the OPEN position.

The instrument now returns to normal operation.

C. SPAN ADJUSTMENT

At the factory span calibration has been performed using NIST (formerly NBS) traceable calibration standards. Due to the inherent linearity of the sensor, only a single calibration gas concentration is required as long as the calibration is performed accurately.

The oxygen level in the calibration gas can be any amount within the range of the Analyzer. However, it is customary to select an oxygen content (in the proper background gas) that approximates the level encountered in the process to be monitored. Although this is a valid method, it takes longer as the lowest levels of oxygen are approached.

For checking the span or making a span adjustment, a calibration gas with an oxygen content of approximately 10% of the high range scale is recommended.

Resetting of the span for a 0-25% range analyzer can be accomplished in 10 to 15 minutes, while at a range of 0-10 ppm the time required for the sensor to reach equilibrium and thus be ready for span reset may be as much as one hour.

When it is established that recalibration of span is necessary, the following steps are recommended:

a. Select a cylinder of background gas in which the oxygen concentration has been certified.

b. Pay particular attention when connecting the certified cylinder gas to the Analyzer. If the oxygen level in the cylinder gas is above 1%, then it is permissible to use standard plumbing equipment that may include plastic and rubber components. However, if the oxygen content in the certified cylinder gas is less than 1%, and particularly if below 0.1% (1000 ppm), eliminate all plastic and rubber components. Do not neglect the selection of a proper pressure regulator for the cylinder; that is, one with a metal diaphragm. Once the gas delivery system is complete, perform a thorough leak check.

c. Turn on the Analyzer. Set a flow of 1.0 lpm. This is the exact rate at which all factory calibrations are performed. If, however, the application in which the Analyzer is being used requires a flow rate as high as 1.5 lpm, then best accuracy is achieved by matching the calibration gas flow to the process level.

d. Monitor the Analyzer response to the certified gas until a stable reading is obtained. (The use of a chart recorder is beneficial in verifying that the sensor has reached an equilibrium point.)

e. The span value is affected by the scale factor setting. If oxygen in nitrogen is used as the span gas, and the scale factor is set for a value other than 100%, it is necessary to reset the scale factor to 100% prior to adjusting the span setting. If the span calibration gas is not primarily nitrogen, then the proper scale factor setting for the span calibration gas can be used. See Section 5, Part F (page 5-6) for details on setting the scale factor.

f. The meter now displays the oxygen concentration level of the span calibration gas flowing through the Analyzer. Be sure to allow the reading to come into equilibrium before proceeding with any adjustments.

g. The span adjustment is made by adjusting one of two potentiometers. The potentiometer to be adjusted is determined by which of two switches on S2 (located on the main control card) is closed. Use R53 if S2, position 7, is closed or R52 if S2, position 6, is closed. Adjust the appropriate potentiometer until the displayed value matches the known value of the span calibration gas. Allow sufficient time for values to stabilize after each adjustment.

h. Resetting the span potentiometer affects the zero value. It is recommended that the zero adjustment procedure be performed following a span adjustment. Preferably, calibration should consist of a span adjustment, a zero adjustment (if required), and another span.

D. ELECTRICAL CALIBRATION

If a new sensor is installed in a Delta F Series 100 Oxygen Analyzer, use the following procedures to adjust the electronics to the new zero and span numbers provided by the factory on the new Series 100 Data Sheet.

1. Setting the Span Value

The electronic calibration of the Analyzer must be matched to the new sensor. After calibration at the factory, the sensor was disconnected from the Analyzer and a resistance decade box installed in its place. The decade box was adjusted until the Analyzer 0-10 VDC output read full scale on the lowest concentration range. This resistance value may be used as an accurate transfer standard to allow recalibration of the target analyzer.

It is necessary to have a resistance decade box (1% accuracy) and a 4.5-digit digital voltmeter (DVM) to perform the following:

a. The span value is affected by the scale factor setting. If the scale factor is set for a value other than 100%, it is necessary to reset the scale factor to 100% prior to comparing your span value with that of the factory. See Section 5, Part F, page 5-6.

b. Open the sensor enclosure door and use a screwdriver to unloosen, and allow removal, of the first and second wires on the cell connector (white/black/red and white/yellow.) Set your decade box to the resistance value shown on the Series 100 Data Sheet. Connect the resistance decade box to the two cable wires.

c. Ensure that the Analyzer is operating on the lowest concentration range. Connect a 4.5-digit digital voltmeter (set to read 10 volts) to backplane data connector J11, pins 7 (-) and 10 (+).

d. Consult the factory-provided calibration information and set main control board S2 (8 position DIP switch on front edge) switches to the same configuration as shown.

e. Using span potentiometer R52 or R53 (the calibration data indicates which one is applicable), adjust the displayed value until it matches the calibration data. Allow sufficient time for values to stabilize after each adjustment.

f. Perform a sensor zero setting procedure. Now, repeat the electrical span setting. Repeat both the electrical span and electrical zero setting procedures until both values match the factory-provided settings.

g. Disconnect the DVM and the decade box and reconnect sensor cable wires to the cell board connector (white/black/red to position 1 and white/yellow to position 2).

2. <u>Setting the Sensor Zero Value</u>

a. Open the electronics enclosure door.

b. To select the diagnostic mode, place front panel DIP switch S1, position 3, into the CLOSED position. The special analog voltage out symbol "7" appears in the single digit display.

c. Press the RANGE, FLOW, and RANGE buttons, in that order, within a 5-second period. The digit "1" appears in the single digit display and the beeper sounds. You are now in Calibration Selection 1. If you do not succeed, repeat this step. This calibration mode is intentionally difficult to enter.

d. Step up to Calibration Selection 2 by pressing the UP arrow switch once.

e. Locate the main control board (leftmost printed circuit Board). Disconnect the sensor by placing S2 DIP switch, position 8, into the OPEN position.

f. Use a 4.5-digit DVM, set to read up to 10 volts, to measure the voltage between the black (-) and the red (+) testpoints on the front edge of the main control board. This reading is the sensor zero value.

g. Consult the Series 100 Data Sheet to determine the new sensor zero value. To allow the sensor zero value to be changed, press the ALARM/CANCEL switch. The switch light turns on. Use the UP and DOWN arrow switches to adjust the displayed value to match the factory-provided setting. (For ease of adjustment, the displayed value changes faster the longer the UP or Down arrow switch is held.) Allow sufficient time for values to stabilize after each adjustment.

h. Once the sensor zero value is set properly, press ALARM/CANCEL again to leave the sensor zero setting mode. The ALARM/CANCEL light turns off.

i. Reconnect the sensor by placing the main control board switch S2, position 8, in the CLOSED position. Leave the calibration mode by returning front panel DIP Switch S1, position 3, to the OPEN position.

j. The instrument now returns to normal operation.

E. FLOWMETER RECALIBRATION

In the Series 100 the sample flow measurement is made with an electronic mass flowmeter. The flowmeter uses a heated temperature sensor which is cooled by the sample flow. By measuring the amount of cooling the actual flow rate can be calculated and linearized by the microprocessor. However, the specific amount of cooling will vary according to the heat conduction properties of the sample gas. If a gas is used that is different from that used to calibrate the instrument, and the gas is listed below, it will be necessary to switch to a different flow linearization table and recalibrate the flow meter.

Recalibration consists of resetting main board DIP switch S1 to the appropriate position, and adjusting the flowmeter span pot for a front panel full scale reading while applying a known full scale sample flow. The electronic flowmeter can be adjusted to read correctly for any listed gas by recalibrating as described below.

Nitrogen or Air
Argon
Hydrogen
Helium

SERIES 100 FLOWMETER RECALIBRATION PROCEDURE

Equipment Required:

1. New background gas supply that has an oxygen concentration less than the full scale measuring capacity of the Analyzer.

2. A 0-5 psi regulator and appropriate fittings to attach to the sensor inlet.

3. A primary flow calibration device, such as a rotameter, that has an accuracy of +/- 10%. Note that flowmeters are characteristically calibrated on one type of gas. A correction factor must be applied to the measured value for other gases.

   NOTE: It is imperative that the proper gas calibration factor be applied to the primary calibration device when setting the full scale gas flow.

Procedure:

1. Consult page 4-15 for DIP switch setting information. Depress the Analyzer power switch into the off position. Remove the main board (leftmost pc board) by depressing the card retainer and pulling on the card removal handle. It may be necessary to rock the board up and down while pulling.

2. Consult Figure 4-4 on page 4-13 and locate DIP switch S1. Set the switches according to the information on page 4-15. Install the main board into the analyzer, making sure that the board is firmly seated into the backplane. There will be a noticeable feeling of locking when proper seating takes place.

3. The Analyzer sensor enclosure door and locate the cell board (facing the operator, mounted on the sensor). Loosen the sensor tray locking screw at the lower front of the sensor tray. Slide the tray out to access the potentiometers located at the right side of the cell board.

4. Connect the Analyzer to the gas supply. Depress the instrument POWER switch into the on position. To assure calibration accuracy, allow the Analyzer to warm-up for five minutes.

5. Set the primary gas flow to 1.50 slpm. Allow the flowmeter time to stabilize (about 30 seconds.) Press the front panel FLOW switch to display flow in slpm. If the reading is not under 1.50 slpm, adjust cell board potentiometer R7 (rightmost top pot) until the reading is under 1.50 slpm. Now, readjust potentiometer R7 until the displayed value is exactly 1.50 slpm. Note that the flowmeter display cannot read higher than 1.50 slpm, so it is important to avoid increasing the gain beyond this point.

SECTION 8: PERFORMING MAINTENANCE

A. ROUTINE PROCEDURES

1. Electrolyte Level Check

The Delta F Series 100 Oxygen Analyzer, once prepared for operation, requires no routine maintenance in most applications. Only when dry gases (low dewpoint) are monitored for an extended time does it become necessary to periodically maintain the Analyzer. The dry gas stream, which passes across the diffusion barrier, evaporates water from the electrolyte. Consequently, water must be occasionally replenished.

The sensor assembly consists of two interconnected chambers. The lower section actually contains the sensing electrodes, and is the critical portion requiring total immersion in electrolyte to be operable. The upper chamber is the reservoir; its purpose is to hold excess liquid, making it available to the sensing chamber as the dry sample gas extracts moisture through the diffusion barrier. As long as there is liquid in the reservoir, the sensor will operate satisfactorily.

a. The reservoir holds at least 65 ml of liquid. (The sensor cavity holds an additional 15-20 ml.) Since a dry gas continuously passing through the sensor extracts no more than 10-15 ml per month, check the reservoir water level every 2-3 months.

b. Note that once the sensor is charged with electrolyte, no further addition of electrolyte solution is required. The dissolved components in the electrolyte are neither consumed nor converted during operation; only periodic replenishment of water is necessary. The exception to this is for applications where the electrolyte is contaminated by noncompatible gas components. In such cases, replacement of the electrolyte is recommended. A good example of this is when an analyzer is equipped with the STAB-EL™ system, and is exposed to gases such as H_2S, SO_2, SO_3, etc. Because these acid components cannot be released from the sensor reservoir either by effervescence or by direct oxidation, a gradual accumulation results. Eventually, the electrolyte must be changed. The frequency of change is directly related to the level of acid gases. Consult Delta F for recommendations regarding electrolyte replacement frequency for your particular application.

c. When adding water to the reservoir, use distilled or deionized water. However, good quality tap water is acceptable.

d. Avoid filling the reservoir to capacity. When adding water, it is good practice not to fill beyond 1/3 capacity. To determine capacity, a clear liquid level window on the sensor is provided. When adding water, use the funnel supplied with the Analyzer. This eliminates having to remove the sensor chassis from its enclosure.

2. <u>Servicing of Sample Conditioning Equipment</u>

If the Analyzer is used to monitor nonideal gas streams, ensure that proper sample conditioning equipment is installed to protect the sensor. Service any conditioning equipment that has been installed as specified in the manufacturer's manual.

Filtration of particulates and condensable materials is the most frequently encountered sample conditioning requirement. Accordingly, proper maintenance of filtration equipment is the most vital factor in securing long-term stability in analyzer performance. For this reason, it is recommended that a servicing program, for the sample conditioning system, be developed which is commensurate with the quality of the gas to be handled. The frequency of this servicing program should be based on experience.

3. <u>Frequency of Calibration Checks</u>

Except for applications where periodic water replenishment is required, there is no routine maintenance necessary to keep the Analyzer operable over extended periods because the sensor system has <u>no</u> <u>consumable</u> <u>components</u> or components that wear away.

Frequency of calibration check becomes a matter of judgment for the operator and should reflect the importance of the process being monitored. Nevertheless, regardless of the type of application, it is recommended that some form of calibration check be performed at least once every two months for any continuous operation.

B. <u>OVERALL SYSTEM CHECKOUT</u>

1. <u>Preliminary System Checkout</u>

If the Analyzer readout shows deviation when checked with certified calibration gases, perform the following preliminary checkout procedures prior to making any changes to the zero or span adjustments (Section 7).

a. <u>External and Internal Plumbing</u>

If the Analyzer readout is reading low, and the flow rate of sample gas is proper, then it is unlikely that plumbing leakage is the problem. High readout error, however, is commonly caused by leakage in the plumbing system.

In most cases, a simple test can be performed to identify leakage of oxygen into the gas stream.

i. Observe the readout at two flow levels: 0.5 and 1.0 lpm. Only a slight increase, if any, in readout is expected in a tight system as the flow is increased to 1.0 lpm. Conversely, if leakage in the plumbing system exists, then the increase of flow from 0.5 to 1.0 lpm likely results in a substantial <u>decrease</u> in oxygen readout (typically dropping in level by as much as 25 to 50%).

ii. A leak in the flow system does not always adversely affect analyzer readout. In fact, by-pass connections, which in essence create controlled leakage conditions, are commonly installed in gas delivery lines to reduce lag time in analyzer response. When installing by-pass connections, avoid the possibility of oxygen, from ambient air, leaking into the gas delivery lines, particularly in those systems where step changes in conditions occur periodically.

iii. When flow sensitivity is observed, as described above, check the external plumbing for leaks. If the gas delivery lines are tight, disconnect the sensor chassis and remove it from the sensor enclosure so that the internal connections can be checked. Analyzer internal gas lines and connections are minimal, reducing the potential for leakage. Be certain to include the stem on the flow control valve when checking for internal leaks since the valve depends on a metal-to-polycarbonate seal, which may relax over an extended period of time.

The Analyzer gas flow system also includes an internal relief valve assembly. Checkout of this assembly is covered separately in the following subsection.

b. <u>Relief Valve Assembly</u>

A relief valve is installed in each Analyzer downstream of the sensor. Its purpose is to protect the sensor if the inlet port pressure becomes excessive. The relief valve uses a spring to compress a plunger against an O-ring to accomplish the seal. At a pressure of 10 psig, the plunger begins to unseat, allowing the sample stream to vent to ambient air.

It is possible for leakage to develop in the relief valve and, generally, if it does, it is for one of the following reasons:

If the valve is over-pressured, the plunger may not reseat properly. The valve is mounted in a position permitting the vent to protrude through the rear of the sensor enclosure (rear of the sensor chassis). As a result, if a leak does result from over-pressure, it usually can be corrected by inserting a rod into the vent and tapping gently against the back end of the plunger. The rod should be at least 4 inches long with a diameter no greater than 1/8 inch.

If leakage is due to the second cause - dirt build-up between the O-ring and plunger - disassemble the valve. Disconnect the sensor fittings and connector and remove the chassis from the enclosure. The relief valve can be removed only after the sensor with its inlet and outlet fittings are disconnected. The screws that hold the sensor to the chassis must be removed after the inlet (top) and outlet (bottom) lines have been disconnected.

<u>CAUTION</u>: Do not invert the chassis to loosen the sensor screws, electrolyte may leak from the sensor reservoir.

It is important that back-up wrenches be used on the lower sensor fitting to avoid stressing the connections at the sensor.

After the sensor is disconnected, remove the locknut from the bulkhead fitting on the pressure relief line. It may be necessary to loosen the connection at the flow control valve, and the bulkhead fitting assembled with the flow control valve plumbing before the relief valve assembly can be removed.

The pressure relief valve can be disassembled by using two 5/8 inch wrenches on the valve body.

When the pressure relief valve is disassembled, clean the components and examine the sealing surfaces to ensure that there are no permanent marks or grooves. Pay particular attention to the O-ring to verify that it is in no way distorted or cracked or otherwise deteriorated.

As the valve is being reassembled, apply a very thin film of grease (preferably a silicone vacuum sealing grade) onto the O-ring. Wipe off any visible excess grease.

Assembly is accomplished by reversing the procedure stated above. Securely tighten, but do not OVERTIGHTEN compression fittings.

c. <u>Sensor Input Voltage</u>

In function, the Delta F Oxygen Sensor reacts in a manner similar to a variable resistor. As the cathode of the sensor is exposed to greater amounts of oxygen, the resistance of the sensor decreases. A direct current voltage is applied to the sensor and is the driving force to complete the electrode reactions. This voltage must be regulated within reasonably strict limits. For example, if the voltage is too low (less than 1.20 VDC), then the sensor lacks sufficient potential to maintain a linear response to oxygen, particularly at the highest levels. On the other hand, a high sensor voltage (above 1.34 VDC) is corrosive to the sensor and may cause premature failure.

For satisfactory performance, it is important that the sensor voltage be maintained between 1.25 and 1.31 VDC.

The sensor input voltage can be measured according to the procedures given in step d below:

d. Setting Voltages

Refer to Figure 4-4 (page 4-13) for the location of voltage setting potentiometers.

i. Setting the Sensor Voltage

Enter the diagnostic mode by placing the front panel DIP switch S1, position 3, into the CLOSED position. (See Section 6, Part B, Page 6-1 for more information on the diagnostic mode.) Use the UP arrow switch to step to selection "C" in the character display and use a 3/32-inch wide screwdriver to adjust R18 for a display of 1.300 VDC.

ii. Setting the Optional Quick-Start Voltage

Enter the diagnostic mode as stated above. Step to selection "5" in the character display and use a 3/32-inch wide screwdriver to adjust R19 for a display of 1.500 VDC.

iii. Setting the Auxiliary Reference Voltage

Enter the diagnostic mode as stated above. Step to selection "A" in the character display and use a 3/32-inch wide screwdriver to adjust R23 for a display of -5.00 VDC.

2. Draining and Rinsing of the Sensor

If the sensor must be drained, for any reason (for instance shipping), remove the sensor chassis assembly from its enclosure. The instructions for removal of the sensor chassis assembly can be found in Section 4, Part B-1 or B-2 of the Sensor and Gas System section (Page 4-4 or 4-5). Prior to removing the sensor chassis, be sure to identify whether the enclosure is NEMA 1 or 7. (The instructions for removing the sensor chassis are different for NEMA 1 and NEMA 7 sensor enclosures.) Drain the electrolyte and refill the sensor with deionized water and drain again. Repeat two more times. Hand tighten cap on sensor when done

C. ELECTRONICS MAINTENANCE

1. Circuit Card Removal/Installation

The main circuit card, the power supply module, and the option card can be easily removed and re-inserted. Each of these printed circuit cards plugs into the backplane card and each is provided with card finger clips to assist in card removal/insertion. Note the caution below when a card has to be removed or inserted for any reason.

CAUTION: ALWAYS turn off the power switch to the instrument prior to removing or inserting printed circuit boards, or doing any assembly or disassembly of any portions of the Series 100 Analyzer.

a. Power Supply Module

i. To remove the power supply module, press the card retainer bar in front of the printed circuit cards, allowing the power supply to pass over the top as it comes forward.

ii. Holding onto the card finger clips on the power supply module, pull the module forward while gently rocking the card up and down until it is free of its connector on the rear. At this point, the card easily slides out and can be examined or replaced.

Insertion of the power supply module is essentially the reverse of the above.

i. While pressing the card retainer bar, insert the power supply module into the rightmost position of the electronics enclosure.

ii. Be sure to align the power supply module guides before sliding the card into the rack. This is the most difficult card to insert since both the printed circuit card and aluminum frame must be aligned.

iii. Push on the card to ensure that it is properly seated in the backplane card connector. When it is fully inserted, it should drop in behind the card retainer bar.

b. Main Circuit Card

i. Prior to removing the main circuit card, disconnect the 34- conductor ribbon cable going to the front panel card.

ii. Press the card retainer bar in front of the printed circuit cards, allowing the main circuit card to pass over the top of it as it comes forward.

iii. Holding onto the card finger clips on the main circuit card, pull forward on the main circuit card while gently rocking the card up and down until it is free of its connectors on the rear. At this time, the card easily slides out and can be examined or replaced.

Insertion of the main circuit card is essentially the reverse of the above.

i. While pressing the card retainer bar, insert the main circuit card into the leftmost set of card guides of the electronics enclosure.

ii. Be sure that both the top and the bottom of the card are engaged in the card guides and that the components on the card are facing to the right. When the card is fully inserted, it should drop in behind the card retainer bar.

iii. Once behind the bar, reattach the 34-conductor cable from the front panel card to the main circuit card.

c. <u>Front Panel Card</u>

i. The front panel card is secured to the rear of the front panel door with four #6 nuts.

ii. Prior to removing the front panel card, disconnect the 34-conductor ribbon cable connecting the front panel card to the main circuit card. This cable unplugs at the main circuit card end. Also disconnect the keyboard membrane switch cable that comes up over the bottom of the front panel board and the cable that connects the front panel card to the display meter. Remove the nut that secures the front panel ground wire to the right side of the meter bracket.

iii. Remove the four nuts retaining the front panel card to the rear of the front door. Remove the front panel card by lifting it straight backward until the LEDs mounted on the keyboard side of the front panel board clear the cutouts in the keyboard mounting plate. Place the board in a safe place using extra care; there are components mounted on both sides of this card.

iv. To reassemble, ease the front panel card into place (being careful to insert the card such that the LEDs mounted on the backside of the card are guided into their respective cutouts in the keyboard mounting plate). Attach the four nuts and tighten them evenly. Reattach the cables to the keyboard, the display device, and the main circuit card. Also, reconnect the ground wire to the display bracket.

d. <u>Option Card</u>

i. To remove the option card, press the card retainer bar in front of the printed circuit cards to allow the option card to pass over the top of the bar as it comes forward.

ii. Holding onto the card finger clips on the option card, pull forward on the option card while gently rocking the card up and down until it is free of its connectors on the rear. At this time, the card easily slides out and can be examined or replaced.

iii. To insert the option card, simply reverse the removal procedure. Press the card retainer bar and align the card in the second set of card guides from the left.

Make sure that the card is engaged in both the top and the bottom card guides and that the components on the card are facing to the right. When the option card is fully inserted, it should drop in behind the card retainer bar.

SECTION 9: RETURNING THE ANALYZER TO THE FACTORY

1. Notify Delta F's Customer Service before returning the Analyzer to Delta F for repair or modification.

   Written or verbal communication should include all of the following information:

   a. Model number of the Series 100 Analyzer.

   b. Serial number of the Series 100 Analyzer.

   c. Customer contact with telephone number.

   d. A brief description of why the Analyzer or parts thereof are being returned.

   Photocopy and fill out the CUSTOMER INSTRUMENT EVALUATION FORM provided in Appendix J.

2. COMPLETELY DRAIN THE ELECTROLYTE SOLUTION FROM THE SENSOR PRIOR TO PACKING. THIS IS VERY IMPORTANT. DAMAGE CAUSED BY THE LEAKAGE OF ELECTROLYTE, DURING SHIPMENT, IS NOT COVERED BY THE WARRANTY. CARRIERS WILL NOT ACCEPT CLAIMS FOR SUCH DAMAGE. Refer to Section 8 Maintenance, Part B.2 Draining and Rinsing of the Sensor (Page 8-5).

3. To pack the Analyzer, use the same packing material and carton(s) in which the unit was originally shipped. These materials are designed specifically for the Analyzer and provide maximum protection during shipping. If not available, use equivalent packing material that surrounds and protects the cell tray within the cell enclosure (NEMA 1 configuration). Pack extra materials between the sensor and the enclosure walls. The sensor enclosure door should be closed and secured with its cover screws. The analyzer should be wrapped in shipping materials to protect it while in transit.

Once the unit evaluation is finished, Delta F's Service Department will notify the user as to the actions required and the charges involved, if any.

APPENDIX A
MECHANICAL OUTLINE DRAWINGS

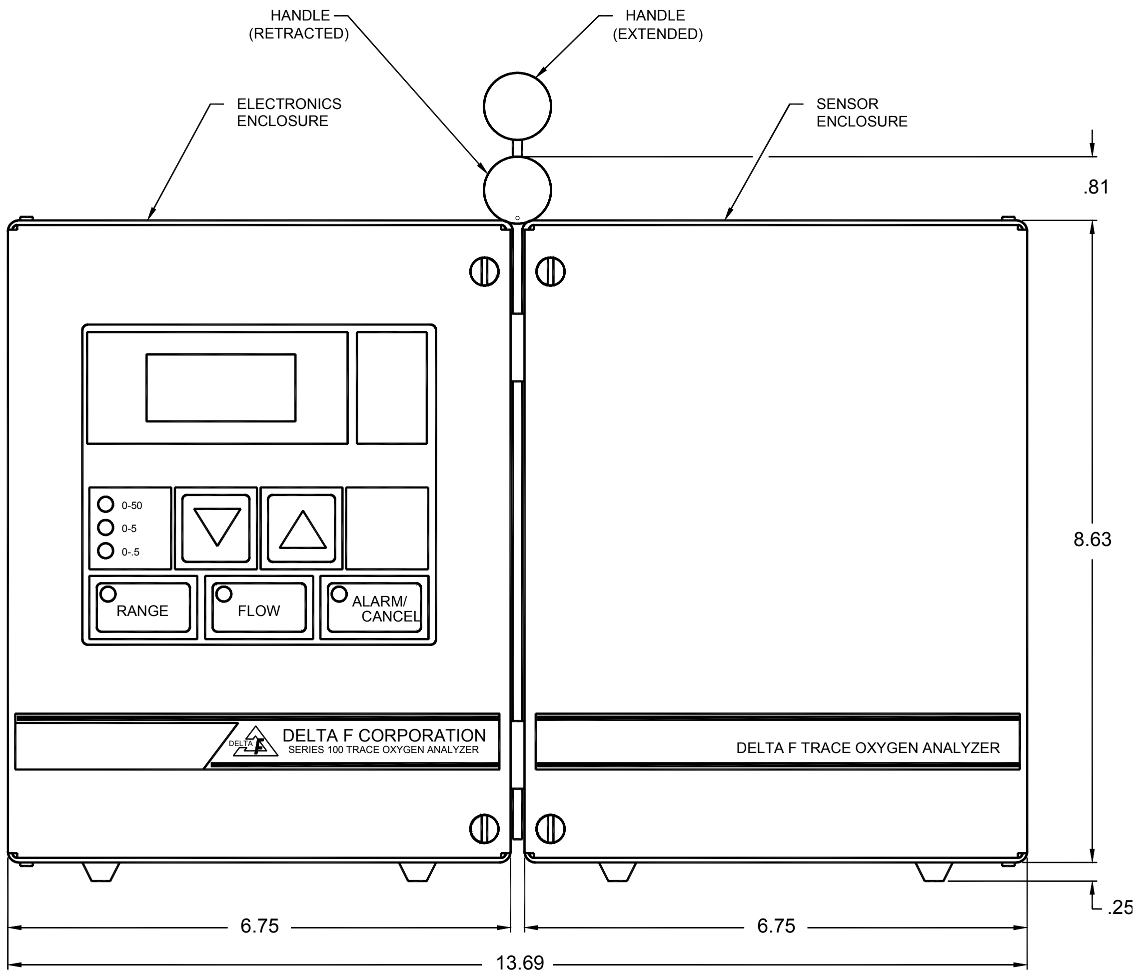


Figure A-1: Front View, Delta F Series 100 Oxygen Analyzer

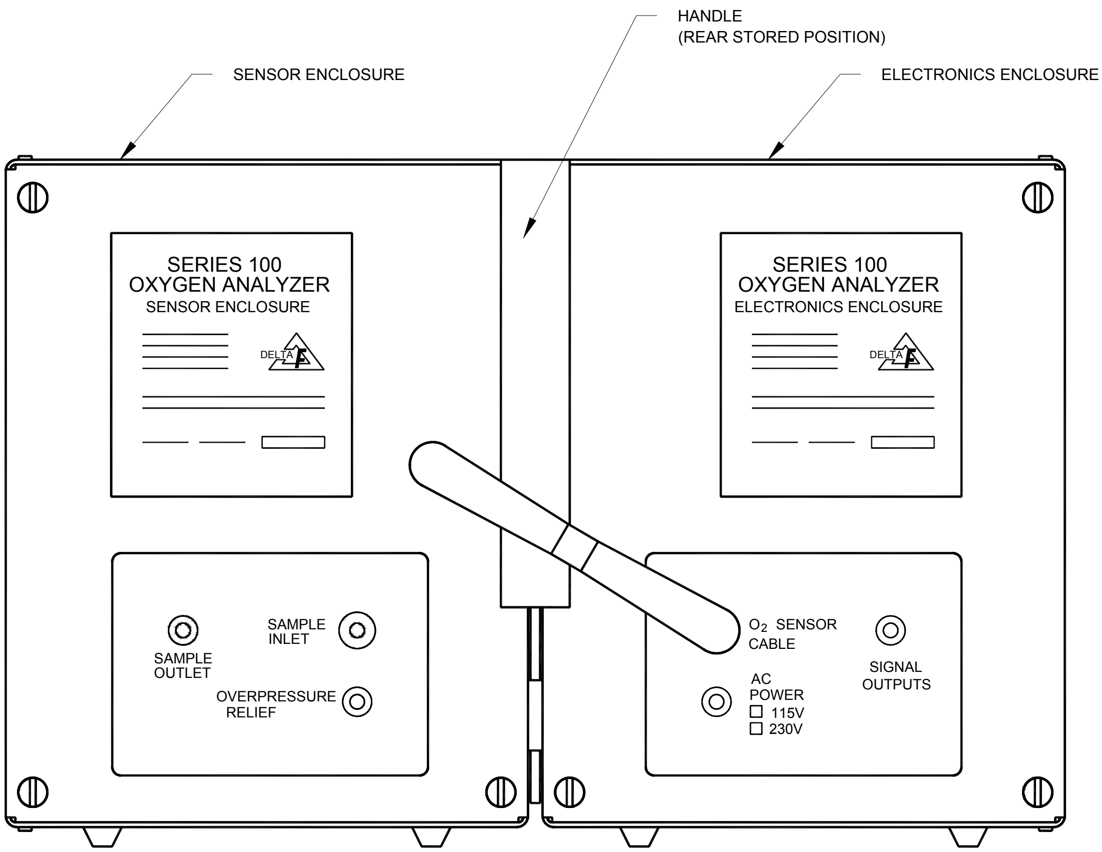


Figure A-2: Rear View, Delta F Series 100 Oxygen Analyzer

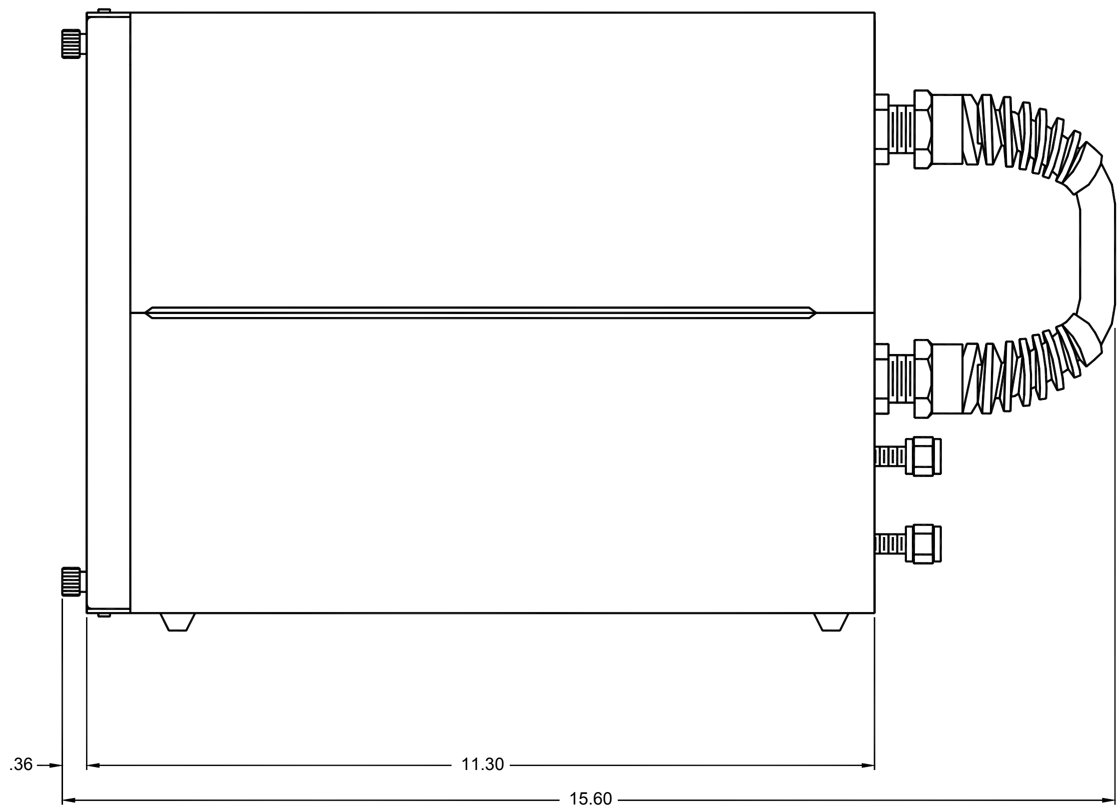


Figure A-3: Side View, Delta F Series 100 Oxygen Analyzer

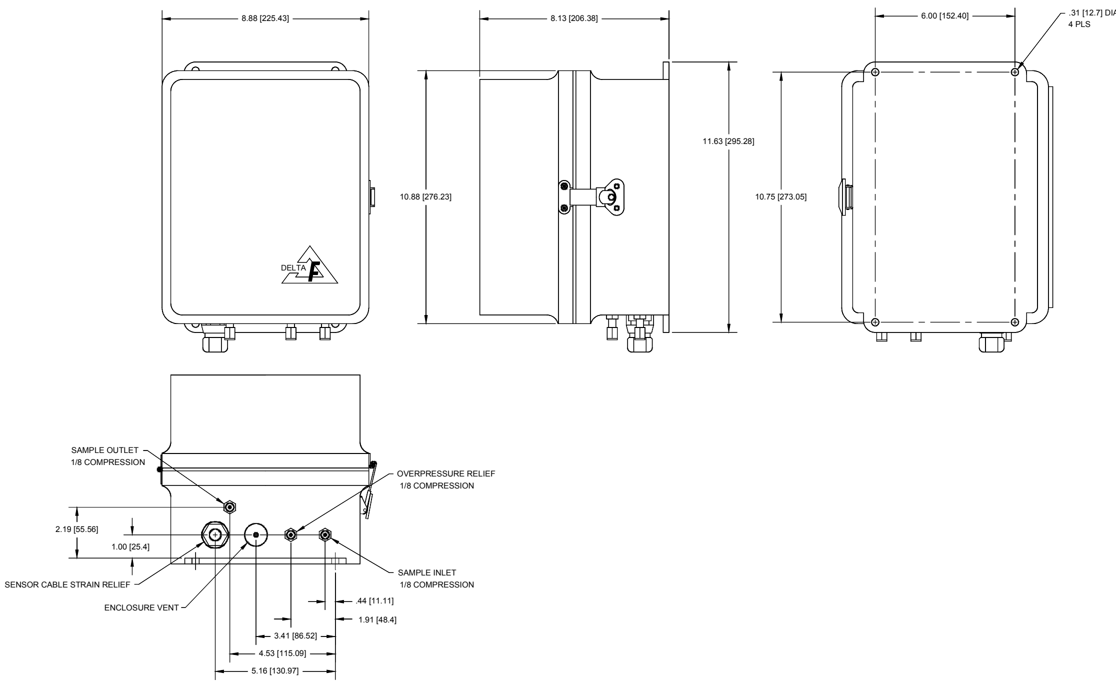


Figure A-4: NEMA 4 Sensor Enclosure

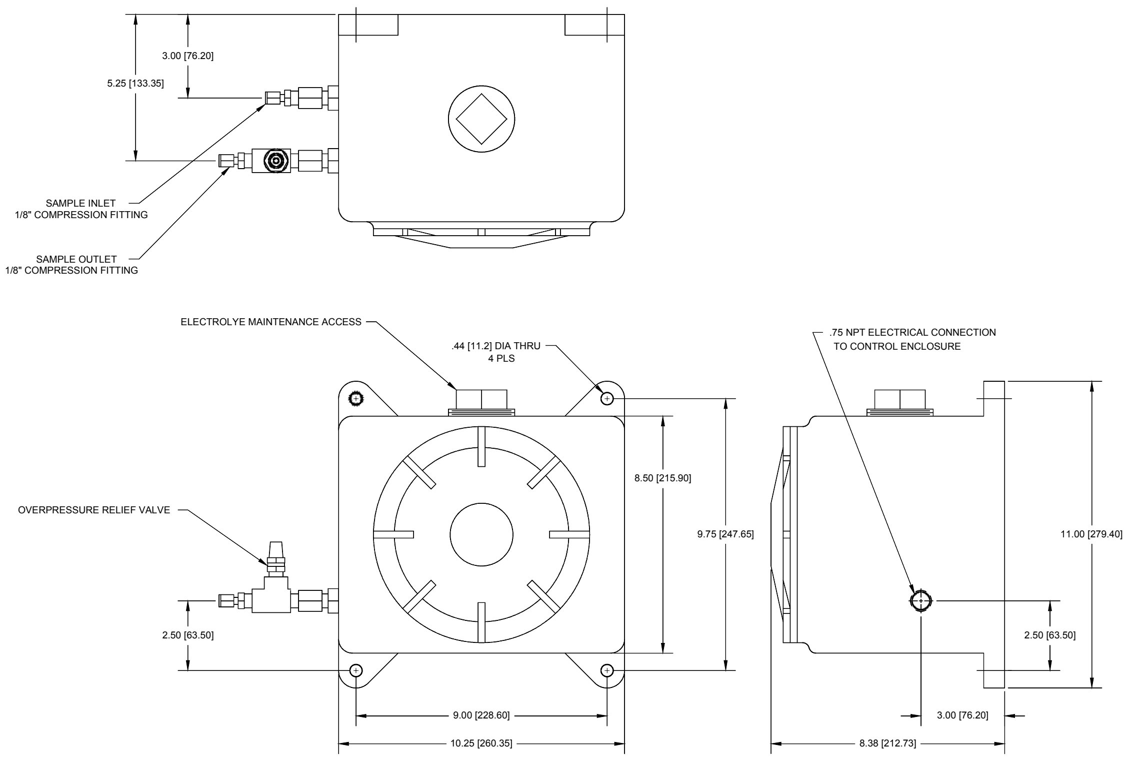


Figure A-5: NEMA 7 Sensor Enclosure

APPENDIX B

ELECTROLYTE SOLUTION

MATERIAL SAFETY DATA SHEET (MSDS)

THE INFORMATION BELOW IS BELIEVED TO BE ACCURATE AND REPRESENTS THE BEST INFORMATION CURRENTLY AVAILABLE TO DELTA F CORP. HOWEVER, WE MAKE NO WARRANTY OF MERCHANTABILITY OR ANY OTHER WARRANTY, EXPRESS OR IMPLIED, WITH RESPECT TO SUCH INFORMATION, AND WE ASSUME NO LIABILITY RESULTING FROM ITS USE. USERS SHOULD MAKE THEIR OWN INVESTIGATIONS TO DETERMINE THE SUITABILITY OF THE INFORMATION FOR THEIR PARTICULAR PURPOSES.

SUBSTANCE IDENTIFICATION

SUBSTANCE: POTASSIUM HYDROXIDE SOLUTION, 1N

CHEMICAL FAMILY: INORGANIC BASE

MOLECULAR FORMULA: MIXTURE

CERCLA RATINGS (SCALE 0-3): HEALTH=U FIRE=0 REACTIVITY=1 PERSISTENCE=0

COMPONENTS AND CONTAMINANTS

COMPONENT: POTASSIUM HYDROXIDE PERCENT: 5.0-6.0

COMPONENTS: WATER & NEUTRAL SALTS PERCENT: 94.0-95.0

OTHER CONTAMINANTS: NONE

EXPOSURE LIMITS (POTASSIUM HYDROXIDE): 2 MG/M^3 ACGIH CEILING

PHYSICAL DATA

DESCRIPTION: COLORLESS LIQUID BOILING POINT: NOT AVAILABLE

MELTING POINT: NOT AVAILABLE SPECIFIC GRAVITY: 1.05

SOLUBILITY IN WATER: COMPLETE

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD: NEGLIGIBLE FIRE AND EXPLOSION HAZARD WHEN EXPOSED TO HEAT OR FLAME.

FLASH POINT: NONCOMBUSTIBLE

FIREFIGHTING MEDIA: DRY CHEMICAL, CARBON DIOXIDE, WATER SPRAY OR FOAM (1984 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.3).

FOR LARGER FIRES, USE WATER SPRAY, FOG, OR ALCOHOL FOAM (1984 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.3).

FIREFIGHTING: MOVE CONTAINERS FROM FIRE AREA IF POSSIBLE. COOL CONTAINERS EXPOSED TO FLAMES WITH WATER FROM SIDE UNTIL WELL AFTER FIRE IS OUT (1984 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.3).

EXTINGUISH USING AGENTS INDICATED; DO NOT USE WATER DIRECTLY ON MATERIAL. IF LARGE AMOUNTS OF COMBUSTIBLE MATERIALS ARE INVOLVED, USE WATER SPRAY OR FOG IN FLOODING AMOUNTS. USE WATER SPRAY TO ABSORB CORROSIVE VAPORS. COOL CONTAINERS WITH FLOODING AMOUNTS OF WATER FROM AS FAR AS A DISTANCE AS POSSIBLE. AVOID BREATHING CORROSIVE VAPORS; KEEP UPWIND (BUREAU OF EXPLOSIVES, EMERGENCY HANDLING OF HAZARDOUS MATERIALS IN SURFACE TRANSPORTATION, 1981).

TRANSPORTATION DATA

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49CFR172.101: CORROSIVE MATERIAL

DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49CFR172.101 AND 172.402: CORROSIVE

TOXICITY

POTASSIUM HYDROXIDE: 5 MG/24 HOURS SKIN-RABBIT MODERATE IRRITATION; 1 MG/24 HOURS EYE-RABBIT MODERATE IRRITATION; CARCINOGEN STATUS: NONE. CONCENTRATED POTASSIUM HYDROXIDE SOLUTION IS A SEVERE EYE, MUCOUS MEMBRANE, AND SKIN IRRITANT.

HEALTH EFFECTS AND FIRST AID

INHALATION: IRRITANT.

ACUTE EXPOSURE - CONCENTRATED SOLUTION MAY CAUSE IRRITATION, SORE THROAT, COUGHING, DYSPNEA, AND PULMONARY EDEMA.

CHRONIC EXPOSURE - REPEATED OR PROLONGED EXPOSURE TO CONCENTRATE MAY CAUSE BRONCHIAL IRRITATION, COUGHING, BRONCHIAL PNEUMONIA, AND GASTROINTESTINAL DISTURBANCES.

FIRST AID - REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP AFFECTED PERSON WARM AND AT REST. GET MEDICAL ATTENTION.

SKIN CONTACT: IRRITANT.

ACUTE EXPOSURE - MAY CAUSE IRRITATION, AND SOFT NECROTIC DEEPLY PENETRATING BURNS ON CONTACT. PENETRATION MAY CONTINUE FOR SEVERAL DAYS.

CHRONIC EXPOSURE - REPEATED OR PROLONGED EXPOSURE MAY CAUSE DERMATITIS.

FIRST AID - REMOVE CONTAMINATED CLOTHING WHILE RUNNING STREAMS OF WATER UNDER CLOTHING. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OR CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). IN CASE OF CHEMICAL BURNS, COVER AREA WITH STERILE, DRY DRESSING. BANDAGE SECURELY, BUT NOT TOO TIGHTLY. GET MEDICAL ATTENTION.

EYE CONTACT: IRRITANT.

ACUTE EXPOSURE - CONTACT WITH VAPORS AND/OR FUMES MAY CAUSE IRRITATION, REDNESS, PAIN, BLURRED VISION, CONJUCTIVITIS AND BURNS. DIRECT CONTACT MAY CAUSE CONJUNCTIVAL EDEMA AND DAMAGE AND CORNEAL AND EPISCLERAL DAMAGE OR DESTRUCTION.

CHRONIC EXPOSURE - REPEATED OR PROLONGED EXPOSURE TO VAPORS AND/OR FUMES MAY CAUSE CONJUCTIVITIS AND CORNEAL BURNS.

FIRST AID - WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). IN PRESENCE OF BURNS, APPLY STERILE BANDAGES LOOSELY WITHOUT MEDICATION. GET MEDICAL ATTENTION.

INGESTION:

ACUTE EXPOSURE - SEVERE PAIN IN MOUTH, THROAT, AND ABDOMEN, VOMITING, HEMATEMESIS, DIARRHEA, ANOREXIA, DIZZINESS, COLLAPSE, COMA AND DEATH ARE POSSIBLE. IF DEATH DOES NOT OCCUR IN THE FIRST 24 HOURS, GASTRIC OR ESOPHAGEAL PERFORATION MAY CAUSE SEVERE ABDOMINAL PAIN, RIGIDITY AND SUDDEN HYPOTENSION AFTER 2-4 DAYS. ESOPHAGEAL STRICTURE MAY OCCUR LATER, EVEN AFTER SEVERAL YEARS.

CHRONIC EXPOSURE - NOT REPORTED IN HUMANS.

FIRST AID - DILUTE THE ALKALI BY GIVING WATER OR MILK IMMEDIATELY AND ALLOWING VOMITING TO OCCUR. EXAMINE VICTIM FOR POSSIBLE CORROSIVE INJURY TO MOUTH AND THROAT AND IRRIGATE AFFECTED AREAS WITH 1% ACETIC ACID UNTIL ALKALI IS COMPLETELY NEUTRALIZED. DO NOT USE GASTRIC LAVAGE OR EMESIS. GET MEDICAL ATTENTION. (DREISBACH, HANDBOOK OF POISONING, 11TH ED.)

ANTIDOTE: NO SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

REACTIVITY

REACTIVITY:
EXOTHERMIC REACTION WITH WATER. IT GENERATES CONSIDERABLE HEAT AND FORMS CORROSIVE FUMES.

INCOMPATIBILITIES:
POTASSIUM HYDROXIDE
NITRIC TRICHLORIDE: EXPLOSIVE REACTION
PHOSPHORUS: EXPLOSIVE REACTION
CHLORINE: EXPLOSIVE REACTION
N-METHYL-N-NITROSOUREA& METHYLENE CHLORIDE: EXPLOSIVE REACTION
N-NITROSOMETHYLENE: EXPLOSIVE REACTION
NITROBENZENE: EXPLOSIVE REACTION ON HEATING
MALEIC ANHYDRIDE: EXPLOSIVE REACTION
TETRAHYDROFURAN: POSSIBLE EXPLOSIVE REACTION
CHLORINE DIOXIDE: POSSIBLE EXPLOSIVE REACTION
ACROLEIN: VIOLENT POLYMERIZATION
ACRYLONITRILE: VIOLENT POLYMERIZATION
CHLOROFORM AND METHANOL: INTENSE EXOTHERMIC REACTION
BENZOYL CHLORIDE AND SODIUM AZIDE: VIOLENT EXOTHERMIC REACTION
O-NITROPHENOL (MOLTEN): VIOLENT REACTION
POTASSIUM PEROXODISULFATE: IGNITION REACTION
POTASSIUM PERSULFATE AND WATER: IGNITION REACTION
2,2,3,3-TETRAFLUOROPROPANOL: IGNITION REACTION
HYPONITROUS ACID: IGNITION REACTION
TETRACHLOROETHANE: IGNITION ON HEATING
THORIUM CARBIDE: INCANDESCENT REACTION ON HEATING
AMMONIUM HEXACHLOROPLATINATE: FORMATION OF EXPLOSIVE PRODUCT
1,2-DICHLOROETHYLENE: FORMATION OF EXPLOSIVE PRODUCT
NITROPARAFFINS(NITROETHANE; NITROMETHANE): FORMATIONOF EXPLOSIVE PRODUCT
NITROALKANES: FORMATION OF EXPLOSIVE PRODUCT
CALCIUM CARBIDE AND CHLORINE: FORMATION OF EXPLOSIVE PRODUCT
2,4,6-TRINITROTOLUENE & METHANOL: FORMATION OF EXPLOSIVE PRODUCT
TRICHLOROETHYLENE: FORMATION OF EXPLOSIVE PRODUCT ON HEATING
TETRACHLOROETHANE: FORMATION OF FLAMMABLE PRODUCT

ACIDS: REACTS VIOLENTLY
METALS: CORROSIVE REACTION WITH FORMATION OF FLAMMABLE HYDROGEN GAS
GERMANIUM: INCANDESCENT REACTION

DECOMPOSITION:
THERMAL OR CHEMICAL DECOMPOSITION MAY RELEASE TOXIC FUMES OF POTASSIUM OXIDE WHICH CAN REACT WITH WATER OR STEAM TO PRODUCE HEAT AND FLAMMABLE HYDROGEN.

POLYMERIZATION:
NOT KNOWN TO OCCUR.

CONDITIONS TO AVOID

MAY BURN BUT DOES NOT IGNITE READILY. FLAMMABLE, POISONOUS GASES MAY ACCUMULATE IN TANKS AND HOPPER CARS. MAY IGNITE COMBUSTIBLES (WOOD, PAPER, OIL, ETC.)

SPILL AND LEAK PROCEDURES

SOIL SPILL:
DIG AHOLDING AREA SUCH AS A PIT, POND, OR LAGOON TO CONTAIN SPILL AND DIKE SURFACE FLOW USING BARRIER OF SOIL, SANDBAGS, FOAMED POLYURETHANE OR FOAMED CONCRETE. ABSORB LIQUID MASS WITH FLY ASH OR CEMENT POWDER.

ADD DILUTE ACID TO NEUTRALIZE.

AIR SPILL:
APPLY WATER SPRAY TO KNOCK DOWN AND REDUCE VAPORS. KNOCK-DOWN WATER IS CORROSIVE AND TOXIC AND SHOULD BE DIKED FOR CONTAINMENT.

WATER SPILL:
NEUTRALIZE WITH DILUTE ACID OR REMOVABLE STRONG ACID.

OCCUPATIONAL SPILL:
DO NOT TOUCH SPILLED MATERIAL. STOP LEAK IF YOU CAN DO IT WITHOUT RISK. FOR SMALL SPILLS, TAKE UP WITH SAND OR OTHER ABSORBENT MATERIAL AND PLACE INTO CONTAINERS FOR LATER DISPOSAL. FOR SMALL DRY SPILLS, WITH CLEAN SHOVEL PLACE MATERIAL INTO CLEAN, DRY CONTAINER AND COVER. MOVE CONTAINERS FROM SPILL AREA. FOR LARGER SPILLS, DIKE FAR AHEAD OF SPILL FOR LATER DISPOSAL. KEEP UNNECESSARY PEOPLE AWAY. ISOLATE HAZARD AREA AND DENY ENTRY.

PROTECTIVE EQUIPMENT

VENTILATION:
PROVIDE LOCAL EXHAUST VENTILATION SYSTEM TO MEET PERMISSIBLE EXPOSURE LIMITS.

RESPIRATOR:
HIGH LEVELS - SUPPLIED-AIR RESPIRATOR WITH A FULL FACEPIECE,
HELMET, OR HOOD. SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE.

FIREFIGHTING - SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

CLOTHING:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE CLOTHING AND EQUIPMENT TO PREVENT ANY POSSIBILITY OF SKIN CONTACT WITH THIS SUBSTANCE.

GLOVES:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT CONTACT WITH THIS SUBSTANCE.

EYE PROTECTION:
EMPLOYEE MUST WEAR SPLASH-PROOF OR DUST-RESISTANT SAFETY GOGGLES AND A FACESHIELD TO PREVENT CONTACT WITH THIS SUBSTANCE.

WHERE THERE IS ANY POSSIBILITY THAT AN EMPLOYEE'S EYES MAY BE EXPOSED TO THIS SUBSTANCE, THE EMPLOYER SHALL PROVIDE AN EYE-WASH FOUNTAIN WITHIN THE IMMEDIATE WORK AREA FOR EMERGENCY USE.

AUTHORIZED - DELTA F CORPORATION
CREATION DATE: 7/24/86

APPENDIX C
PANEL MOUNTING CUTOUT DIMENSIONS

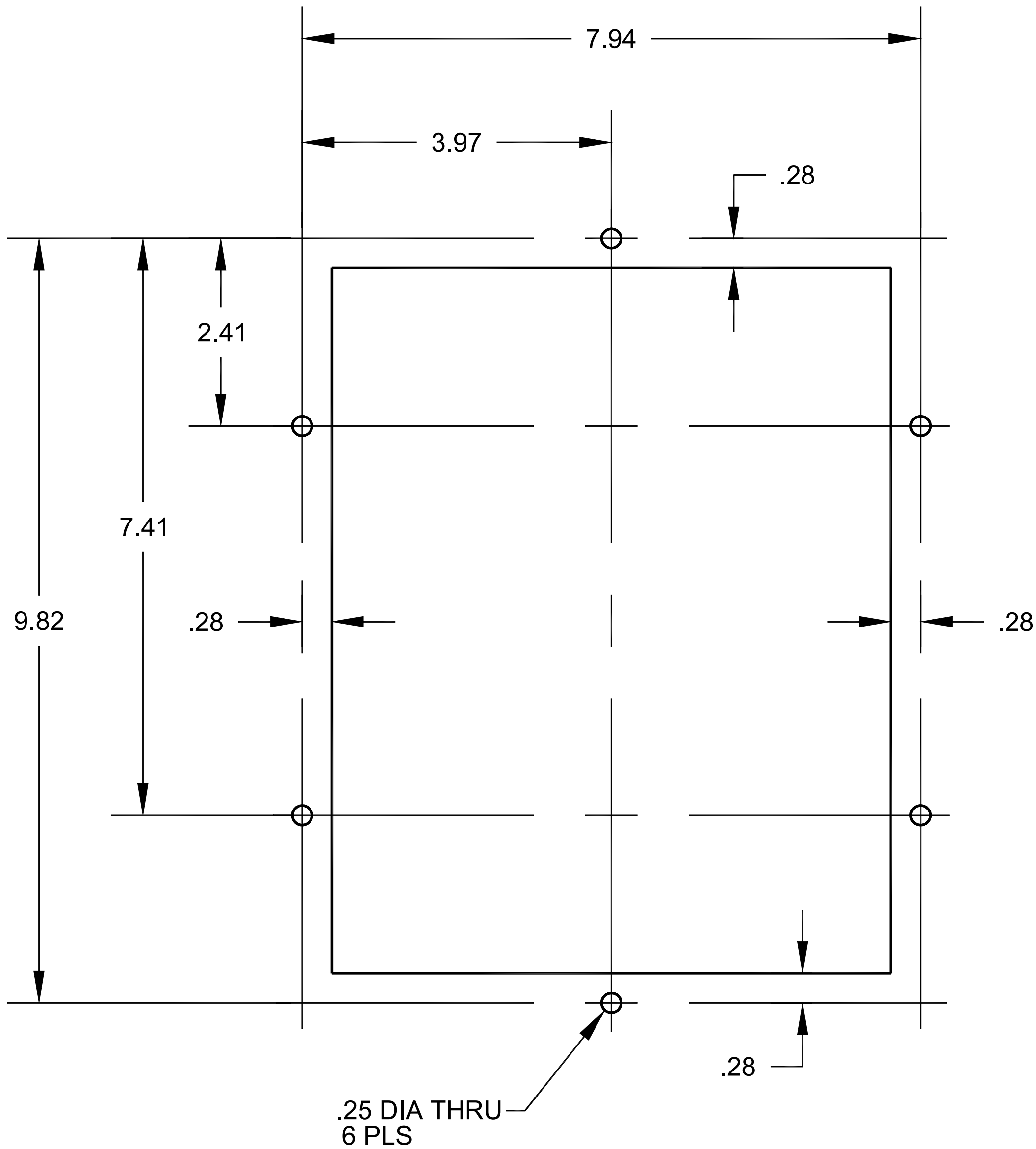


Figure C-1: Panel Mounting Cutout Dimensions, One Enclosure

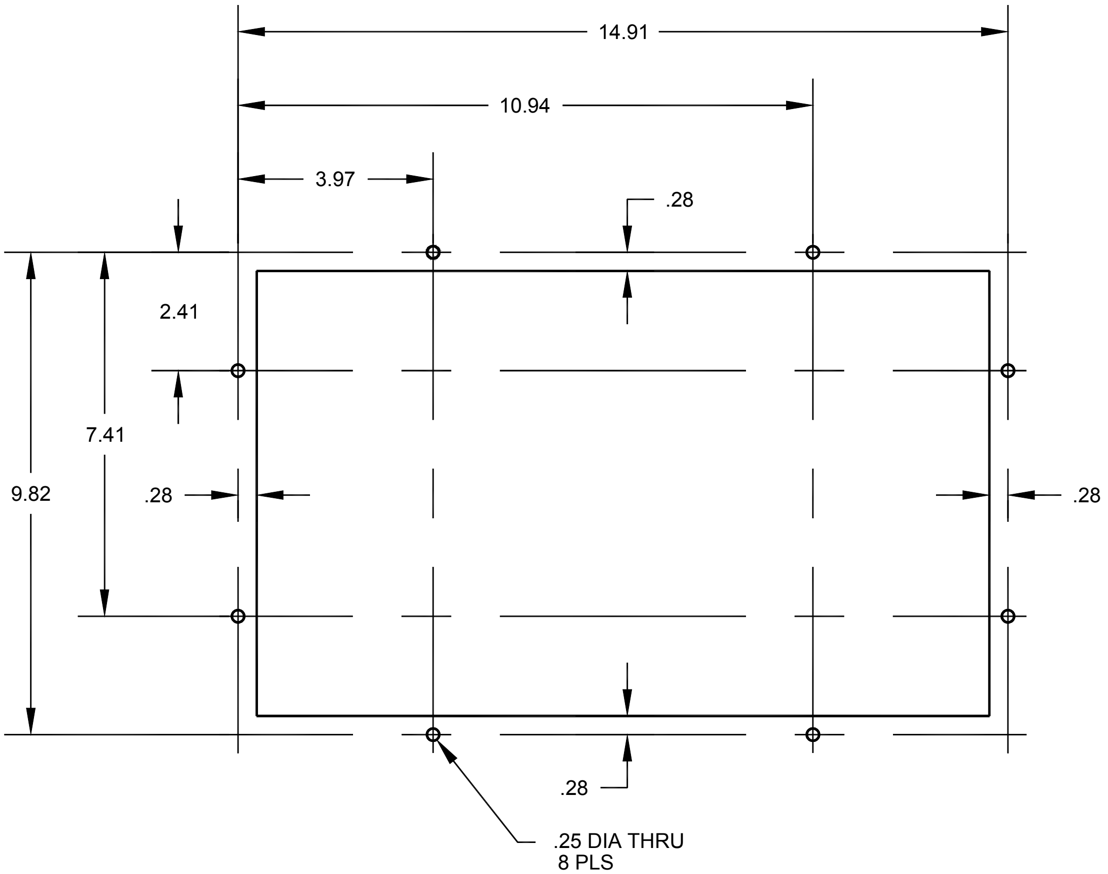


Figure C-2: Panel Mounting Cutout Dimensions, Two Enclosures

APPENDIX D
RACK MOUNTING DIMENSIONS

Figure D-1. Rack Mounting Dimensions (Panel available from Delta F)

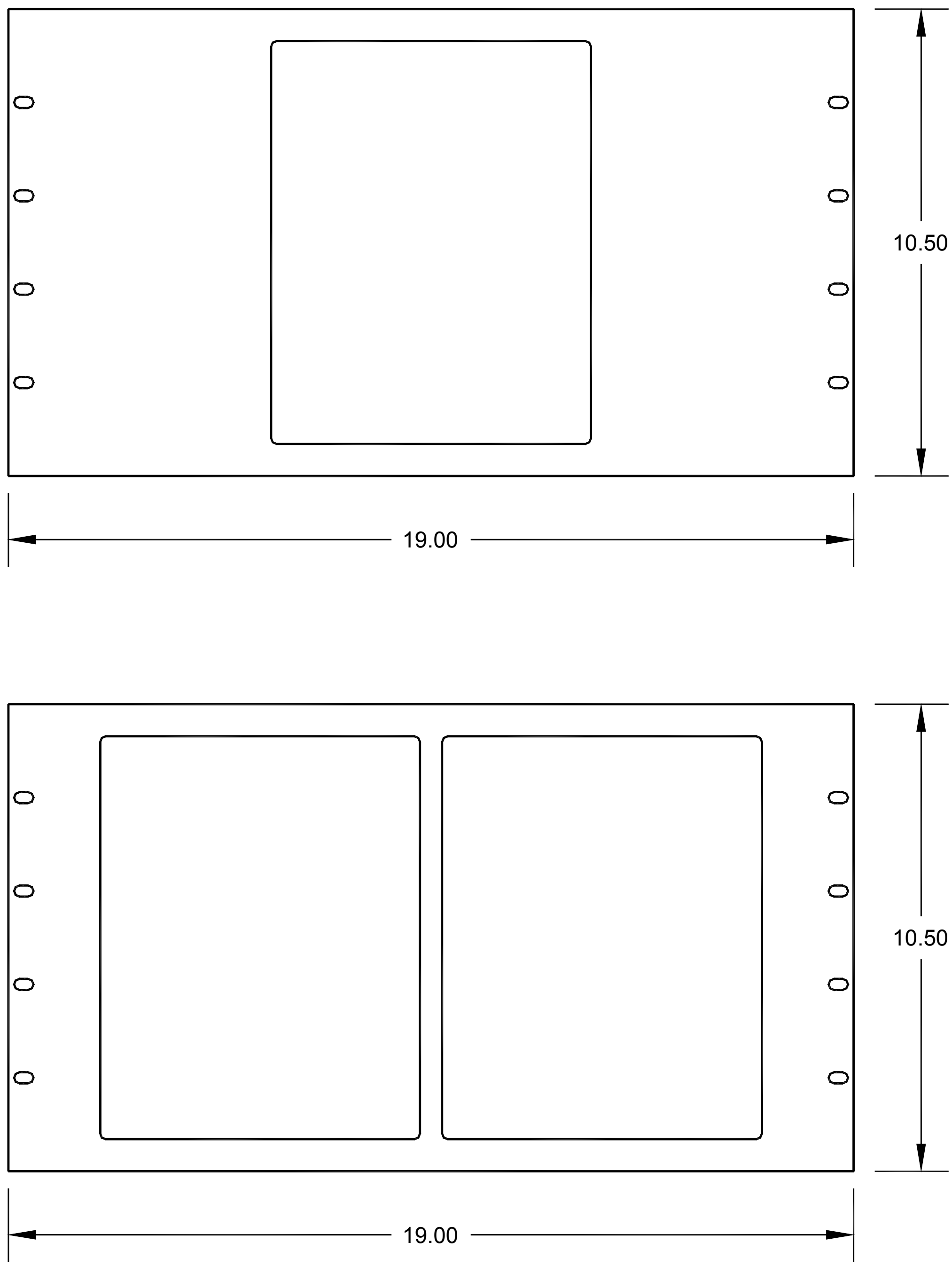


Figure D-1: Rack Mounting Dimensions (Panel Available From Delta F)

APPENDIX E
GAS SCALE FACTORS

GAS TYPE	MULTIPLIER
Argon	1.01
Ethylene	1.00
Nitrogen*	1.00
Carbon Monoxide	0.99
Methane	0.96
Hydrogen	0.41 0.62**
Helium	0.35 0.54**

* Analyzer has been calibrated using nitrogen as the background gas.

** Used for analyzers with full scale ranges of 500 ppm or less.

APPENDIX F
VOLUMETRIC CONVERSION TABLE

lpm*	cfh*	cfh	lpm
0.1	0.2	0.2	0.1
0.2	0.4	0.4	0.2
0.3	0.6	0.6	0.3
0.4	0.8	0.8	0.4
0.5	1.1	1.0	0.5
0.6	1.3	1.2	0.6
0.7	1.5	1.4	0.7
0.8	1.7	1.6	0.8
0.9	1.9	1.8	0.8
1.0	2.1	2.0	0.9
1.1	2.3	2.2	1.0
1.2	2.5	2.4	1.1
1.3	2.7	2.6	1.2
1.4	3.0	2.8	1.3
1.5	3.2	3.0	1.4
1.6	3.4	3.2	1.5
1.7	3.6	3.4	1.6
1.8	3.8	3.6	1.7
1.9	4.0	3.8	1.8
2.0	4.2	4.0	1.9

* Cubic feet per hour
** Liters per minute

APPENDIX G

LIST OF REPLACEABLE PARTS

NOTE: PLEASE SPECIFY THE INSTRUMENT SERIAL NUMBER WHEN ORDERING REPLACEMENT PARTS. THIS WILL ENSURE THAT THE PROPER OPTIONS ARE INCLUDED ON REPLACEMENT ASSEMBLIES.

ELECTRONICS ENCLOSURE

ITEM DESCRIPTION	QUANTITY	PART NUMBER	REV
FRONT PANEL ASSEMBLY consisting of:			
Front Panel Circuit Board	1	15302850	C
Keypad membrane	1	49001132	-
3.5 LED Display	1	54218505	-
POWER SUPPLY ASSEMBLY consisting of:			
Power Supply Main Circuit Bd	1	15302750	D
Power Supply AC Subassembly	1	47230067	-
MAIN CIRCUIT BOARD ASSEMBLY	1	10403290	E
OPTION BOARD ASSEMBLY	1	15404170	B
BACKPLANE BOARD ASSEMBLY	1	10403750	E

SENSOR ENCLOSURE

ITEM DESCRIPTION	QUANTITY	PART NUMBER	REV
OXYGEN SENSOR	1	CONSULT FACTORY	
SENSOR INTERFACE/FLOWMETER CIRCUIT BD	1	15302310	E
FLOWMETER ASSEMBLY	1	15406570	B
SENSOR BOARD CONNECTOR, 15 PIN	1	50980651	-

MISCELLANEOUS HARDWARE AND FITTINGS

ITEM DESCRIPTION	QUANTITY	PART NUMBER	REV
SENSOR TRAY RAIL	4	83800800	-
RESERVOIR CAP ASSEMBLY	1	1520700	-
1/8-inch TUBE FITTING NUTS	4	60005007	-
1/8-inch TUBE FERRULE SETS	4	60005008	-
	4	60005009	-
E-05 ELECTROLYTE	1	DF-E05	-
FUSE, 1 AMP., 120 VOLT	1	45002421	-
FUSE, 2 AMP., 120 VOLT, R7 ONLY	1	45002501	-
FUSE, ½ AMP, 230 VOLT ONLY	1	45002361	-

APPENDIX H

RECOMMENDED SPARE PARTS FOR ONE YEAR OF SERVICE

QTY	ITEM DESCRIPTION	DELTA F PART NUMBER
1	E-05 ELECTROLYTE	DF-E05
5	FUSE, 1 AMP, 120 VAC (STANDARD)	45002421
5	FUSE, 0.5 AMP, 250 VAC (240 VAC OPTION)	45002361
10*	FILTER ELEMENT FOR 1-F2S (FILTER OPTION)	1-F2R
1	CHART PAPER, BOX OF 6 ROLLS (CHART RECORDER OPTION)	1-R018

*SAMPLE FILTER ELEMENT USAGE WILL BE DETERMINED BY SAMPLE GAS PARTICULATE LEVEL. A BOX OF 10 ELEMENTS WILL PROBABLY LAST MORE THAN 1 YEAR.

APPENDIX I

GLOSSARY

Chemical Symbols used in this Manual:

- CO_2 - Carbon Dioxide
- CL_2 - Chlorine
- H_20 - Water
- H_2S - Hydrogen Sulfide
- HCL - Hydrogen Chloride
- NO_x - Oxides of Nitrogen
- O_2 - Oxygen
- OH^- - Hydroxyl ions
- SO_2 - Sulfur Dioxide
- e - Electron
- KOH - Potassium Hydroxide

NEMA Type Enclosures:

NEMA 1: NEMA 1 enclosures are intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment.

NEMA 4: NEMA 4 enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose-directed water. They are not intended to provide protection against conditions such as internal condensation or internal icing.

NEMA 7: NEMA 7 enclosures are for indoor use in locations classed as Class 1, Groups B,C or D, Division 1, as defined in the National Electrical Code.

NEMA 7 enclosures shall be capable of withstanding the pressures resulting from an internal explosion of specified gases, and shall contain such an explosion sufficiently so that an explosive gas-air mixture existing in the atmosphere surrounding the enclosure shall not be ignited. Enclosed heat generating devices will not cause external surfaces to reach temperatures capable of igniting explosive gas-air mixtures in the surrounding atmosphere.

APPENDIX J

DELTA F CORPORATION
CUSTOMER INSTRUMENT EVALUATION FORM

Please provide complete descriptions of application, and problems observed with the instrument. (Form to accompany instrument being returned.)

Company: ____

Address: ____

____

Contact: ______________________________ Tel. ______________________________

Model No. ______________________________ Serial No. _________________________

Problem(s) observed: ____

____

____

____

____

____

What type of process is the instrument being used on? _______________________

____

____

____

What type of environment is the unit operating in (location, temperature, etc.)?
____

____

____

Gas Constituents: Max. Conc. Min. Conc. Normal Conc.

1. Oxygen ____

2. ____

3. ____

4. ____