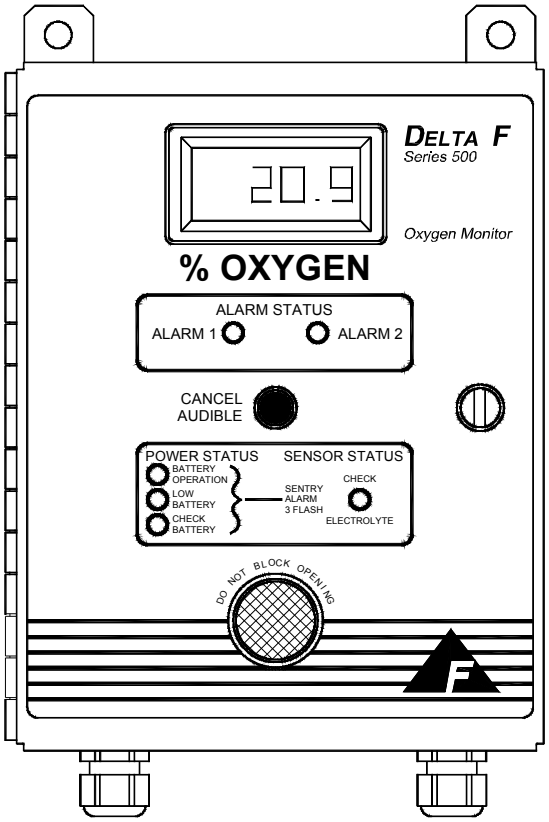
Series 500
Oxygen Monitor



Instruction Manual

Firmware Version 1.85

DELTA F CORPORATION
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P/N 99000004
091610

The Delta F Difference

Your UltraTrace Dual Analyzer has been designed, manufactured and is supported under the tightest of controls, thus helping to insure the highest possible standards of quality.

Every analyzer that Delta F manufactures is tested and operated on a variety of gas concentrations to insure that it functions properly when you receive it.

The certificate of calibration assures your analyzer has been calibrated on gases that are traceable to NIST standards. With proper maintenance, your analyzer should remain calibrated for years.

For a fast and successful startup, please read this manual carefully. There are important cautions and a number of helpful hints to help you to optimize the operation of your analyzer.

If you have questions, please do not hesitate to call the Delta F Service Line at (781) 935-5808, use our Service FAX Line at (781) 932-0053 or e-mail us at Service@Delta-F.com.

1 Read Me First…

1.1 Unpacking Procedure

Follow the procedure below to unpack your Series 500 Analyzer

1. Examine the condition of the packaging and its contents. If any damage is apparent, immediately notify the carrier and Delta F. Do not proceed with the installation.
2. Check the contents against the packing slip to make sure the shipment is complete. Unattached equipment may be shipped with the analyzer in supplemental packaging. Shortages should be reported to Delta F immediately.
3. All Series 500 Oxygen Monitors are shipped with the following:

Item	Delta F Part Number
One bottle of Delta F Electrolyte	ε-Lectrolyte Black
One bottle of Delta F Replenishment Solution	RSA
Calibration Cup	15206060
Power cord with 115 VAC connector, NOTE – No power cord is supplied with 220VAC or 24VDC units	59017237
Instruction Manual	99000004

4. Open the monitor door, remove any shipping materials and verify that nothing has come loose during transit.
5. The analyzer is set at the factory to operate on 120 VAC or 240 VAC or 24 VDC. Verify the appropriate power for your monitor by examining the label inside the enclosure top wall (above the sensor).
6. Save the original container in the event you may need to ship the analyzer to another location or back to the factory (see Shipping in the Service section).

Installation and Maintenance

The Series 500 Ambient Air Monitor will provide years of accurate and dependable service if it is set up, operated and maintained properly. It is essential to make a careful and complete installation as outlined in the *Installation and Start Up* section of this manual.

Thank You

Thank you for selecting the Series 500 Ambient Air Monitor. Delta F designs, manufactures, exhaustively tests, and supports every analyzer under the tightest quality controls. You should expect every Delta F analyzer to arrive in perfect working order and, with good maintenance, provide years of trouble-free service. Please call the Service Phone Line at (781) 935-5808 if you need assistance or if you have suggestions, or use our Service Fax Line at (781) 932-0053 or e-mail us at Service@Delta-F.com.

2 Table of Contents

2.1 Table of Figures

3 Cautions

There are a number of warnings and cautions that must be observed to avoid damage to the analyzer as well to insure the safety of its users. The monitor must be operated in a manner specified in this manual. Delta F cannot be responsible for direct or consequential damages that result from installing or operating the monitor in a manner not described in this manual. Importantly, the monitor has been designed for use with inert, non-toxic, non-combustible sample gases only. Delta F cannot be responsible for direct or consequential damages that result from using the analyzer with these gases.

3.1 Symbols and Explanations

Following is a list of the various symbols used throughout this manual and their definitions.

CAUTION

This symbol alerts the user to the presence of physically hazardous conditions that may be dangerous to individuals or equipment.

NOTE

This symbol alerts the user to the presence of important operations and/or maintenance information.

DANGER

This symbol alerts the user to the presence of caustic liquid. Refer to the MSDS at the back of the manual for handling instructions.

3.2 Important Warnings

CAUTION

Potentially hazardous AC voltages are present within this instrument. Leave all servicing to qualified personnel. Disconnect the AC power source when installing or removing: external connections, the sensor, the electronics, or when charging or draining electrolyte.

CAUTION

Do not setup or operate this analyzer without a complete understanding of the instructions in this manual. Do not connect this Analyzer to a power source until all signal and plumbing connections are made.

CAUTION

This analyzer must be operated in a manner consistent with its intended use and as specified in this manual.

DANGER

The electrolyte is a caustic solution. Review the Material Safety Data Sheet (MSDS) before handling the electrolyte solution.

The oxygen sensor is shipped dry and must be charged with electrolyte before it is operated.

CAUTION

DO NOT SHIP THE ANALYZER WITH ELECTROLYTE – THOROUGHLY DRAIN AND RINSE THE OXYGEN SENSOR BEFORE SHIPPING

EMI DISCLAIMER

This Analyzer generates and uses small amounts of radio frequency energy. There is no guarantee that interference to radio or television signals will not occur in a particular installation. If interference is experienced, turn-off the analyzer. If the interference disappears, try one or more of the following methods to correct the problem:

- Reorient the receiving antenna.
- Move the instrument with respect to the receiver.
- Place the analyzer and receiver on different AC circuits.

4 Specifications

RANGE:	0-25% Oxygen
ACCURACY:	± 1% of full scale
RESPONSE TIME:	Typically < 5 seconds to reach OSHA Minimum Oxygen Level for Safe Entry (19.5%)
SENSOR TYPE:	Non-depleting coulometric
MONITOR WARRANTY:	One (1) year
SENSOR WARRANTY:	Three (3) years
ELECTRONICS:	Microprocessor-based
DISPLAY:	3-digit Liquid Crystal Display (LCD). Digits are 0.5 inch (1.27 cm) high. The LCD selected for the Series 500, with a resolution of 0.1% O_2, provides good visibility under a wide range of lighting conditions.
OXYGEN ALARM RELAY:	Two fully adjustable setpoints with Form C single pole double throw (SPDT) relay contacts rated 0.3 amp at 125 VAC, 0.3 amp at 110 VDC, or 1 amp at 30 VDC. The two standard alarms are LO (alarm is activated when concentration drops below setpoint). As an option, these alarms may be ordered in any mix of HI and LO configurations and can be preset and fixed (no manual adjustment possible) at the time of order. (With the RS-232C/Current Loop Option, alarm setpoints can be changed remotely, as long as factory fixed setpoints are not ordered.)
OPERATING CONDITION RELAY:	Third relay contact for LOW BATTERY, or a need for BATTERY CHECK, ELECTROLYTE CONDITION or SENTRY ALERT.
AUDIBLE ALARM AND STATUS INDICATOR:	1. OXYGEN ALARM (sounds continuously). Two front panel LED's (light-emitting diodes). 2. LOW BATTERY (sounds intermittently). One front panel LED. 3. BATTERY CHECK (sounds intermittently). Front panel LED. An open collector (standard) or optional TTL output signal is active, when the monitor is on battery power.

	4. ELECTROLYTE CONDITION (sounds intermittently). Front panel LED indicates need for routine maintenance. 5. SENTRY ALERT (sounds intermittently). Front panel LED indicates that Sensor calibration has changed more than +/-1% oxygen.
POWER REQUIRMENTS:	90-125 VAC, 50/60 Hz or 220-250 VAC, 50/60 Hz (Jumper selectable), <15 Watts. 24 VDC (22 – 26 VDC) Optional at time of order
BATTERY BACKUP:	Built-in nickel cadmium (NiCAD) batteries maintained on trickle charge (7.2 VDC, 700 mA-hr).
MAXIMUM OPERATING TIME ON BATTERIES:	Basic Monitor – 4 hours Monitor with 4-20 mA option – 2 hours
BATTERY RECHARGE TIME:	20 hours from a full discharge. Battery charging occurs automatically when operating on AC.
OUTPUT SIGNALS:	0-10 VDC standard (into 10K ohm load), 4-20 mADC (750 Ohm loop resistance, internally provided 30 VDC compliance voltage), and RS-232C or 20 mA/Current Loop optional. (Compliance voltage for the 20 mA Current Loop is provided by user. 28 VDC maximum.) All output signals are isolated from AC ground (chassis), but are not isolated from each other
ENCLOSURE:	General purpose NEMA 1 suitable for wall mounting. Optional panel or benchtop (handheld) versions available.
WEIGHT:	8.0 lbs. (3.62 kg.)
OPERATING TEMPERATURE:	32^{o} to 122^{o}F (0^{o} to 50^{o}C)

5 Getting Started

5.1 Introduction

The Series 500 Oxygen Monitor incorporates Delta F's unique non-depleting Sensor, in combination with a self-monitoring Sentry Circuit™, to provide accurate measurement of ambient oxygen levels with minimum maintenance.

The Sensor operates on a simple coulometric principle, measuring available oxygen through an electrochemical cell. The internal microprocessor reads oxygen levels over a range between 0% and 25% of ambient air or other gases. (Ambient breathing air should contain 20.9% oxygen.)

Due to its long-term reliability, the Series 500 is often employed for continuous monitoring; however, it is also useful for spot measurements. It is ideal for monitoring available oxygen in breathing air; for use in environmental chambers; and for other applications requiring strict control of oxygen levels.

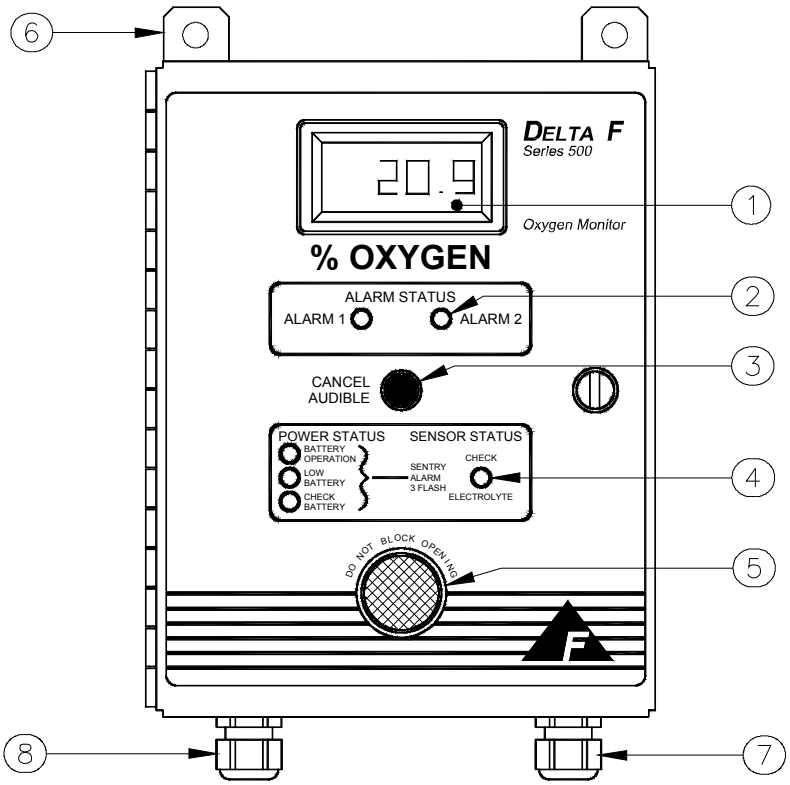

Figure 1: Overall View

1. LCD Display	5. Gas Entry
2. Warning Lights	6. Wall Mounting Brackets
3. Push Button	7. Power Cable
4. LED Indicator	8. Signal Cable

5.2 Getting Started Quickly

This section will help you to get the monitor running quickly. However, it is not intended to discourage you from reading the entire Instruction Manual. The Series 500 Oxygen Monitor has many features that are not discussed in this section. To get the most benefit from the instrument, read the entire manual.

To get the Series 500 Oxygen Monitor into operation quickly, follow the simple steps listed below. It is assumed that the monitor has been mounted securely (according to the instructions in section 5.4 of this Instruction Manual) and wired (according to the instructions in section 5.6).

DANGER

The electrolyte is a caustic solution. Review the Material Safety Data Sheet (MSDS) before handling the electrolyte solution.

NOTE

The oxygen sensor is shipped dry and must be charged with electrolyte before it is operated.

NOTE

Use only Delta F Electrolyte p/n ℰ-Lectrolyte Black in the oxygen sensor. Failure to do so will void warranty. Install one bottle only.

NOTE

Do not apply power before adding electrolyte to the oxygen sensor and thoroughly purging the sample line if applicable.

1. Before powering the Oxygen Monitor, charge the Sensor with electrolyte as described in section 5.5.
2. Plug in the two-pin battery pack connector.
3. Apply power to the Oxygen Monitor. (110/220 VAC or 24 VDC optional)
4. Allow the Oxygen Monitor to warm-up from 15 to 60 minutes.
5. No adjustments should be necessary.

At the initial start-up, the Oxygen Monitor will display "2.5.0.". This is a normal over-range display. The oxygen reading will come on scale in 15-30 minutes and will continue to stabilize over the next one to two hours.

5.2.1 Calibration

Calibration, if required, should be performed only after the warm-up period. It is important to have a stable output reading before calibration. To calibrate the Oxygen Monitor, the Sentry Circuit™ must be reset. Press and hold the front panel CANCEL AUDIBLE button and then press any other push button (ALARM 1 SET, DIAGNOSTICS, or ALARM 2 SET) to cause the instrument to restart its program (reboot). The Sentry Circuit™ will be inactive for one hour. Calibration must be performed during this inactive period. The Sentry Circuit™ will automatically engage after one hour.

Adjust the span pot, item 4 in Figure 2, to achieve a display of 20.9%

5.2.2 Setting Alarm Setpoints

To set the alarm setpoints, follow this procedure:

1. Push the desired "Alarm Set" button on the back of the monitor door (item 1 in Figure 2). The display will show the current setpoint.
2. Adjust the indicated setpoint (item 2 in Figure 2), using a small screwdriver, until the display shows the new setpoint.
3. Push the "DIAGNOSTICS" button (item 3 in Figure 2). The monitor will beep and return to normal operation.

5.2.3 Quick Reference and Miscellaneous

Alarm contacts are rated 0.3 Amps at 125 VAC or 110 VDC, and 1 Amp at 30 VDC. The relay wiring connections for the alarms are listed in section 5.9.1.

The electrolyte level drops slowly due to evaporation. The level should be maintained near the MAX line on the Sensor label. Add only Delta F Replenishment Solution to the Sensor to restore the electrolyte to the correct level. ***Never add electrolyte to replenish liquid level.***

Diagnostics are explained on page 31 of this manual.

5.3 Inside the Monitor

The non-depleting Sensor is located directly behind the diffuser opening in the front panel. The electrolyte reservoir is above the sensing electrodes, in the Sensor. The Sensor is shipped dry (please see the instructions below before filling the tank with electrolyte). Also within the main enclosure are the electronics, and a reserve-power battery pack that automatically takes over in the event of AC power failure.

Additional controls, including alarm adjustments and diagnostic checking, are located on the back of the door. (Refer to Figure 2.)

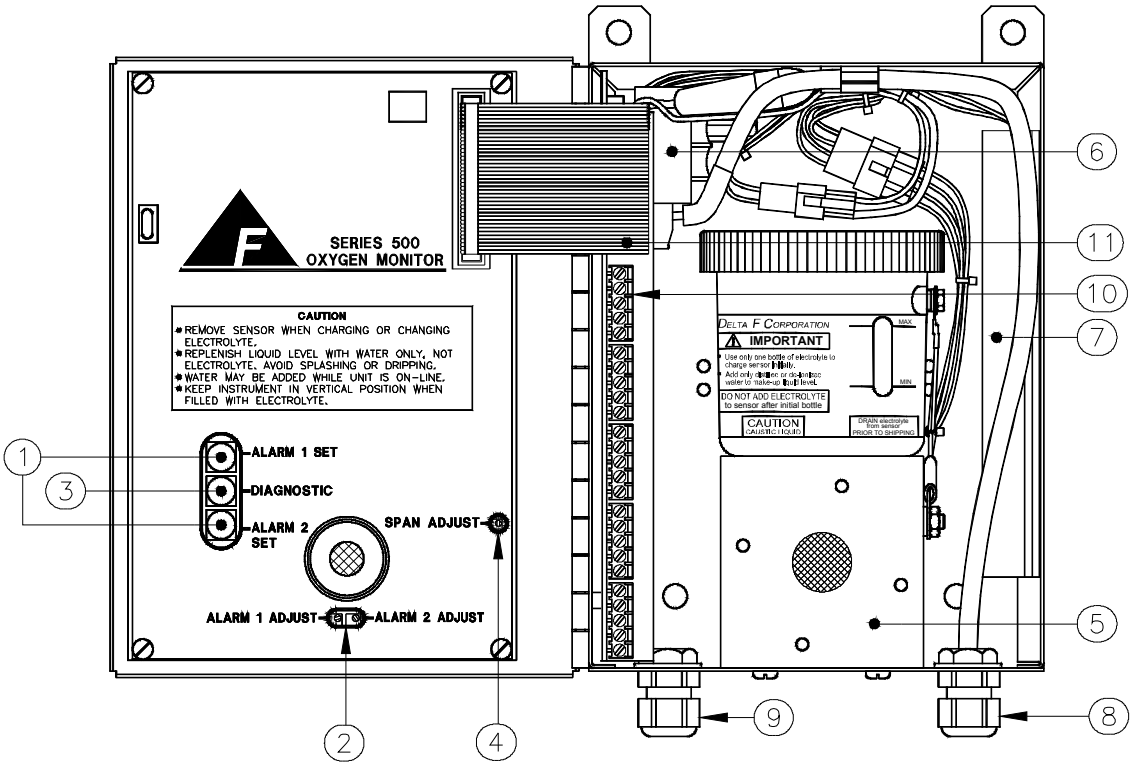

Figure 2: Major Internal Components

1. Alarm setpoint pushbutton	7. Battery pack
2. Alarm setpoint adjustments	8. Power cable entrance
3. Diagnostic pushbutton	9. Signal cable entrance
4. Span adjustment	10. Signal cable connections
5. Oxygen Sensor and tank	11. Ribbon cable
6. Power Supply	

5.4 Mounting

The Series 500 is available in the four mounting configurations:

1) Wall Mounted (standard)
2) Benchtop Portable with Handle (optional)
3) Panel Mounted (optional)
4) Remote Sensor

Remote versions that have a separate, remotely mounted Sensor Assembly are described on page 73. The benchtop portable is not discussed here because it is not mounted.

NOTE

Consideration should be given to the density of gas that could displace ambient atmosphere in a fault condition. If the monitor is in a helium environment, it should be mounted high because a failure would tend to reduce the oxygen concentration at points higher in the monitored area. On the other hand, if in the presence of heavy gases, the monitor should be mounted low.

5.4.1 Wall Mounting

The standard configuration has two tabs for wall mounting, located on the top back corners of the monitor. Refer to Figure 3 for mounting and overall dimensions.

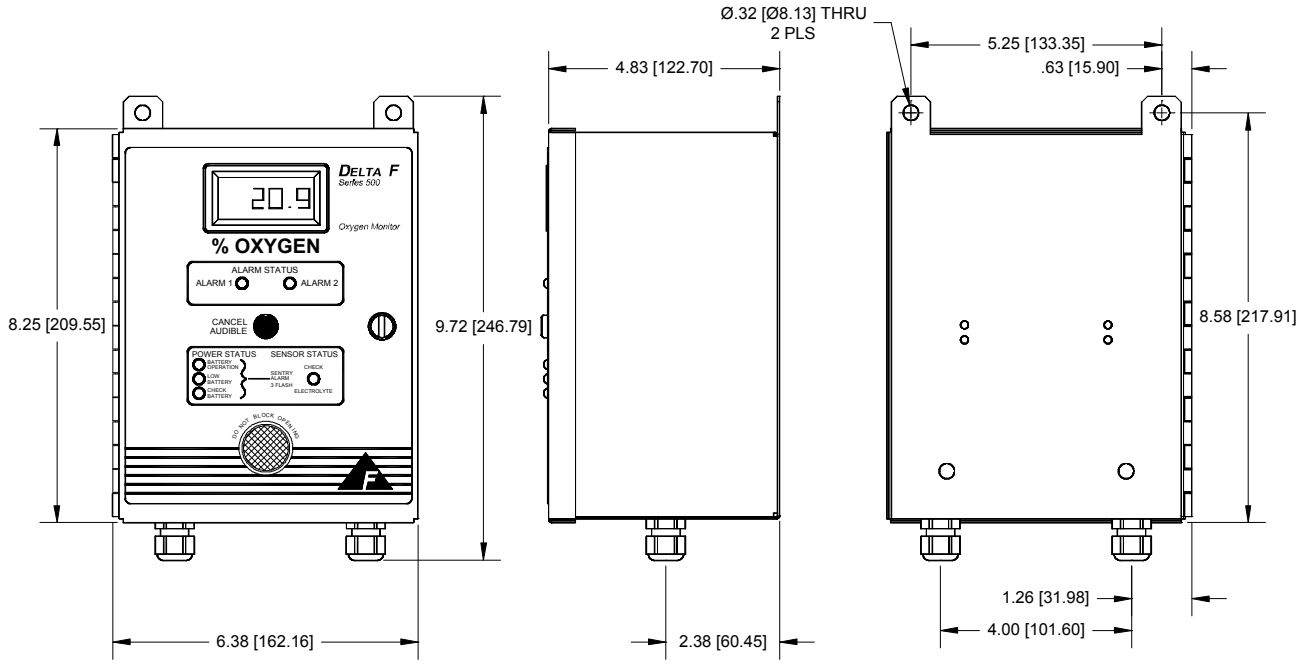

Figure 3: Outline Dimensions

5.4.2 Panel Mounting

The panel mount option includes the panel mount frame, installed on the monitor. Hardware is provided by the customer.

1. Cut out the opening and drill the mounting holes to match the pattern shown in
2. Bring in all power and signal cabling from the rear of the panel.
3. Slide the monitor, with panel frame, into the panel from the front.
5. Align the holes on the panel frame with the holes in the panel and attach with your hardware.

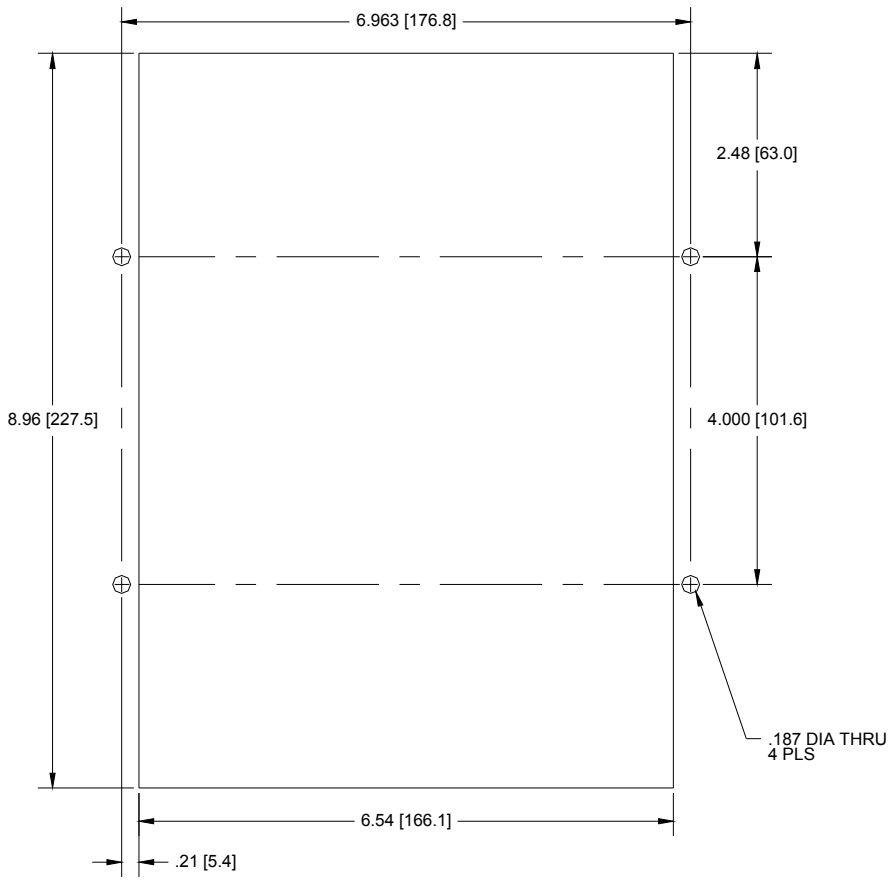

Figure 4: Panel Mount Dimensions

5.5 Adding Electrolyte

The monitor is shipped with two bottles of electrolyte. One bottle of electrolyte is a full charge; the other bottle is for future use.

Adding electrolyte is only done after the Sensor is powered-down and removed from the enclosure as described below.

NOTE

Use only Delta F Electrolyte p/n ℰ-Lectrolyte in the oxygen sensor. Failure to do so will void warranty. Install one bottle only.

If the electrolyte level is low in the oxygen sensor, only Delta F Replenishment Solution should be added to the sensor. ***Do not add electrolyte solution to restore the electrolyte level.*** Do not overfill.

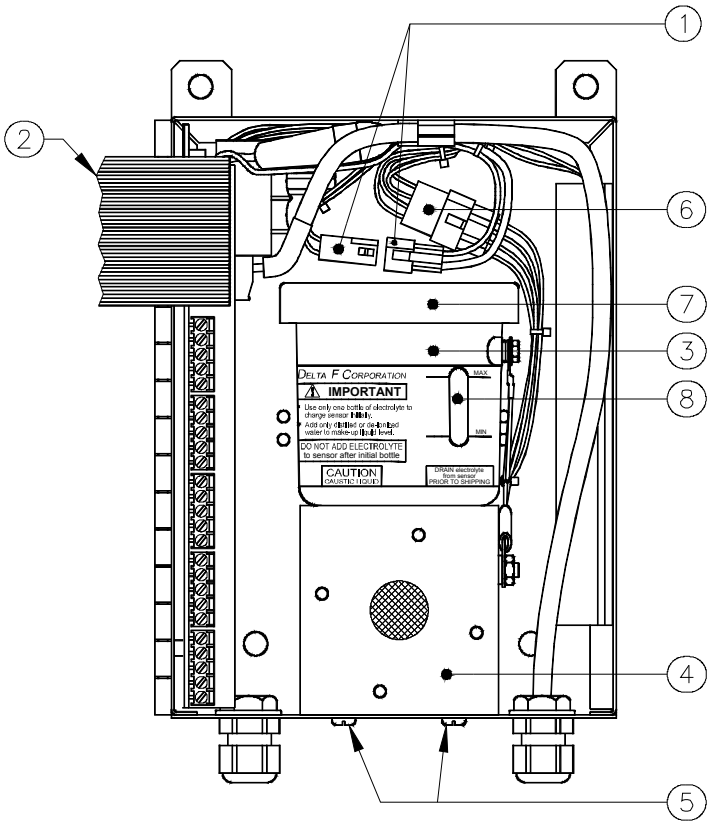

Figure 5: Adding Electrolyte

Fill the electrolyte tank (3), as follows:

- Disconnect power to the monitor. Disconnect the two-pin battery connector (1).
- Disconnect the Sensor from the Power Supply Board by unplugging the four-pin connector (6).
- Remove the four mounting screws (5) at the bottom of the cabinet and take the Sensor (4) out by lifting it forward to clear the instrument housing.
- Unscrew the electrolyte reservoir cover (7).
- Empty one bottle of Delta F ε-Lectrolyte Black into the tank. Replace the screw cover and hand-tighten securely.
- Install the Sensor in the cabinet, securing it with the four screws.
- Reconnect the four-pin connector to the Power Supply Board cable.
- Reconnect the two-pin battery connector and apply power.

5.6 Power Cabling

Verify the appropriate power for your monitor by examining the label on the bottom of the cabinet.

5.6.1 AC Input Voltage

The Series 500 Oxygen Monitor is configured at the factory to operate on 90-120 VAC or 220-250 VAC, as specified on the purchase order. The rechargeable batteries are intended only for short-term use in the event of power failure. See page 58 for additional wiring information.

5.6.2 DC Input Voltage (Optional)

The Series 500 Oxygen Monitor may be configured at the factory to operate on 24 VDC as specified on the purchase order. The rechargeable batteries are intended only for short-term use in the event of power failure. See page 59 for additional wiring information.

5.6.3 Battery Pack

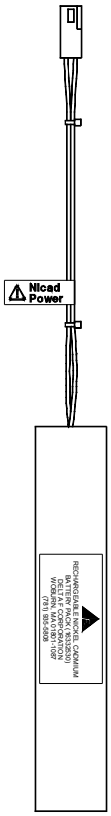

Figure 6: Battery Pack

Series 500 Monitors are shipped with a 7.2 VDC battery pack to provide reserve power.

The battery circuitry is primarily intended to run the unit for several hours in the event of a power failure. A replacement battery pack is available from Delta F. See page 56 for parts ordering information.

The battery pack is attached to the inside of the enclosure with a Velcro strip and can be removed without removing the oxygen sensor.

Batteries are connected to the Power Supply Board by a two-pin connector. The power supply printed circuit board end of the cable includes a 0.5 Amp fast acting fuse. See page 56 for parts ordering information.

Series 500s that are equipped with a pump do not have a battery pack.

NOTE

The battery pack may require charging when the instrument is first operated. If so, the LOW BATTERY and possibly the CHECK BATTERY LED's will be illuminated when the AC power is first applied. The batteries will re-charge automatically.

5.7 Powering Up

CAUTION

Be sure to connect the battery connector before applying AC power. The monitor should not be operated unless the battery is connected.

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When the Series 500 is first powered up, it performs a "cold start" as follows:

- The display will read 00.0% oxygen and all the front panel LED indicators will flash once.
- The audible alarm will sound once.
- The display will change to .2.5.0 to indicate over-range (oxygen reading >25.0%). The oxygen reading will come on scale in 15-30 minutes and will continue to stabilize over the next one to two hours.

The Series 500 goes through this process each time power is applied.

Note that there is no battery backed memory in the Series 500. Upon a cold start, the instrument reinitializes itself based on the stored program. Any input changes, introduced directly or via the RS-232C interface, will revert to default values. (This includes changes to the Baud rate. Reset the Baud rate to the desired value after a reboot.)

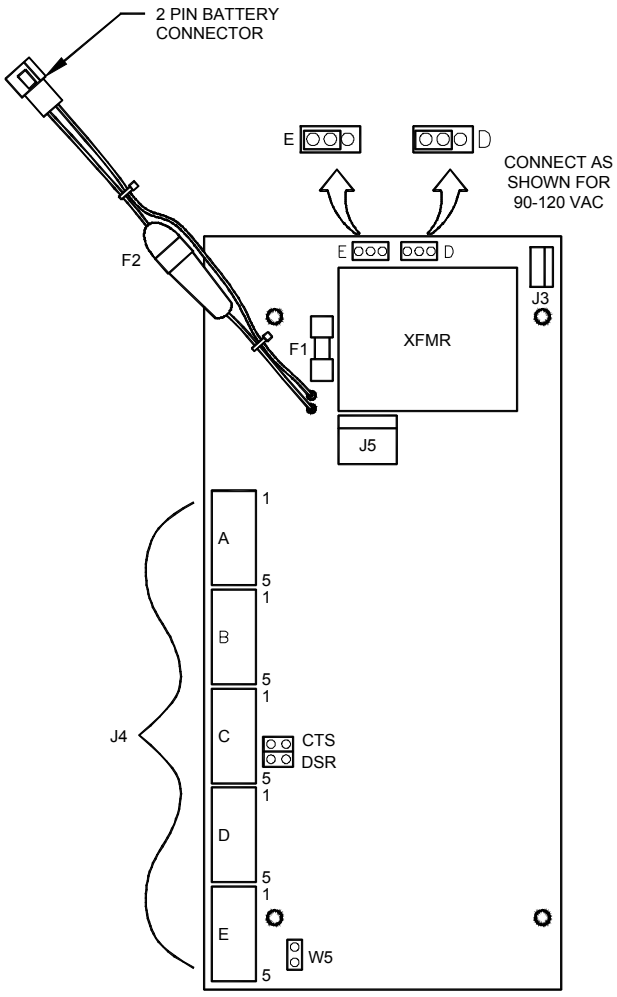


Figure 7: Power Supply Layout

5.8 Overview of Additional Features

This section is intended to familiarize the user with the operation of additional features of the Series 500 Oxygen Monitor. Topics covered are: diagnostic voltage check, oxygen calibration check, alarm setting, and other features. Greater detail will be provided in section 6.0 Operation.

5.8.1 Diagnostic Check

The Diagnostic Check is used to ensure that the unit is operating properly. It is assumed that the Sensor has been filled with electrolyte and the monitor is on power.

- Open the monitor door. There are three switches on the rear of the front door. Press the one labeled DIAGNOSTICS, while looking at the display. The diagnostic sequence number, "--1", will appear for one second followed by the Sensor voltage.

- Each time the DIAGNOSTICS button is pressed, the monitor will briefly display the next sequence number and then the reading for that sequence. After the last number, the entire sequence repeats.
- Use the DIAGNOSTICS button to cycle through all diagnostic readings. Compare the results with the values in Table 1. If all values are within limits, the monitor is functioning properly.
- While in the diagnostic sequence "--1" through "--6", pressing either Alarm Set button will return the Series 500 to oxygen monitoring. See Section 6.1 for more details about the Diagnostics mode.

SEQUENCE	FUNCTION	NORMAL RANGE
1	Sensor Voltage X 10	13.8 to 14.2
2	Charging Voltage	8.5 to 9.5
3	Positive Reference	9.8 to 10.2
4	Negative Reference	4.8 to 5.2
5	Battery Voltage	6.0 to 9.3
6	Sentry Compensation Factor	90 to 110
7	Baud Rate (RS-232 ONLY)	Factory Default

Table 1: Diagnostic Readings

5.8.2 Oxygen Calibration Check

The monitor is calibrated at the factory, using ambient air (20.9% oxygen). It should not be necessary to recalibrate unless the monitor is operated at an elevation above 1500 feet. If you would like to verify calibration, operate the monitor in an environment containing clean, dry, ambient air. Allow the displayed oxygen value to stabilize. The oxygen reading should be 20.9 ± 0.3%. See page 49 for calibration information.

5.8.3 Alarm Settings

- On the rear of the door there are three push button switches labeled ALARM 1 SET, DIAGNOSTICS, and ALARM 2 SET. Press ALARM 1 SET to enter the alarm setting mode. See Figure 2.
- The front panel ALARM 1 light will begin flashing, and the oxygen display will show the alarm set point. Locate the ALARM 1 set point adjustment potentiometer below and to the right of the push button switches. Use a small screwdriver to adjust the pot to display the desired set point.
- When alarm 1 has been set you can press either the DIAGNOSTICS button to return to oxygen monitoring, or the ALARM 2 SET button to set the Alarm 2 set point. The second alarm value is set the same way as the first. See page 33 for more information on setting alarms.

5.8.4 Battery Backup with Battery Condition Testing

On the front panel there is a LOW BATTERY and a CHECK BATTERY indicator. When operating on the backup batteries, LOW BATTERY indicates that the battery pack is in need of charging. While operating on AC the battery is periodically tested under load to ensure that it is fully charged. If this test fails, the CHECK BATTERY indicator will turn on. The third (diagnostic) alarm relay will also close to signal an alarm condition. If the check battery problem is fixed the alarm will automatically clear in approximately five minutes.

5.8.5 Electrolyte Condition Monitoring

If the electrolyte level drops below minimum, or the conductivity of the electrolyte changes, the front panel ELECTROLYTE CONDITION light will illuminate. The third (diagnostic) alarm relay will also close to signal an alarm condition.

5.8.6 Two Oxygen Alarms

The standard Series 500 is equipped with two, user-settable, LOW alarms. There is a form C (SPDT) relay for each alarm.

5.8.7 Sentry Circuit

When operating on ambient air the monitor continuously calibrates itself. The Sentry Circuit™ monitors the amount of recalibration so that calibration changes greater than +/- 1.0% oxygen will cause an alarm. Consequently, the Sentry Circuit™ ensures a continuously accurate oxygen measurement with the added benefit of calibration drift checking.

5.8.8 0-10 VDC Analog Output

A linear 0-10 VDC (0-25.0% Oxygen) output is provided for driving a chart recorder or data acquisition system.

5.9 Analog & Digital Data Connections

The standard analog output is a 0-10 VDC signal, corresponding to 0-25% oxygen. This signal can drive a load resistance of >10K Ohms, and can be used to connect to a strip chart recorder or other data acquisition system. To convert the analog voltage output to % oxygen, multiply by 2.5. Optionally, a 4-20 mA signal is available (maximum resistance is <750 Ohms). The 4-20 mA circuit has a built-in source of 30 VDC compliance voltage.

In addition, three relays are included as standard equipment. Each relay provides a form C (SPDT) set of contacts. These are used for activating remote alarm systems.

Optional data communications outputs include a 20 mA current loop, and an RS-232C port. The RS-232C port is compatible with the serial port found on many personal computers. RS-232C connection is typically used when one monitor is connected to one communication device (modem or serial port) by a cable less than 50 feet in length.

For distances greater than 50 feet, the 20 mA current loop option should be utilized. The 20 mA current loop option also allows multiple Series 500s to be linked to a central station for multipoint monitoring (see Figure 8). This capability is particularly useful where it is desirable to monitor oxygen levels in several locations, from a single data processor. Please refer to your sales order to determine which data connections have been provided with your Series 500 unit.

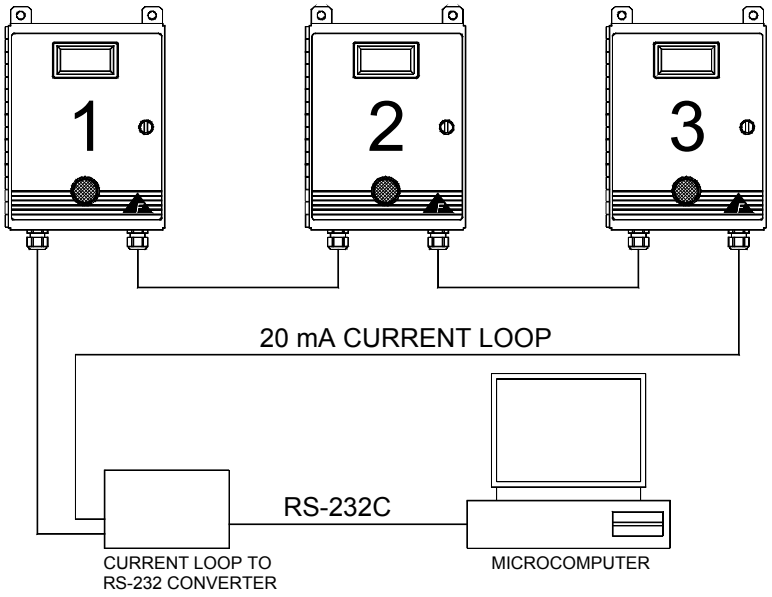


Figure 8: Multiple Unit Installation

5.9.1 Signal Wiring

The signal cable enters through a cable clamp at the bottom of the enclosure (refer to Figure 2, item 9). Signal connections are made to the terminals on the left side in the enclosure (Figure 2, item 10).

5.9.1.1 Analog Voltage Output (Standard)

The analog output voltage is a variable dc signal, with the range from 0-10 volts corresponding to a range from 0-25% oxygen. (To convert this analog voltage output to percentage of oxygen, multiply by 2.5.) Connect the leads as indicated in Figure 9. The signal can drive a load resistance of >10K Ohms.

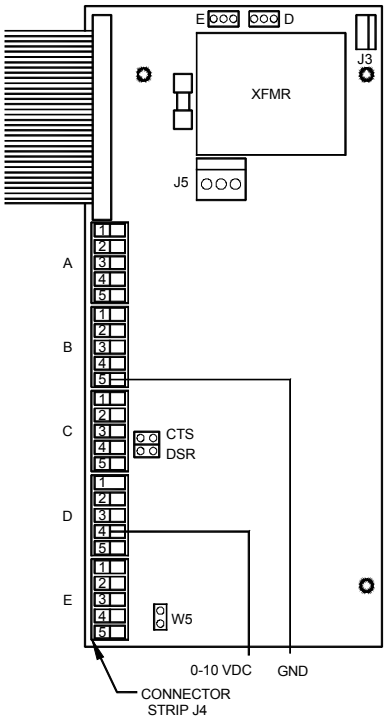


Figure 9: Analog Voltage Output Wiring

5.9.1.2 Alarm Relay Contacts

The standard Series 500 contains three alarm relays. Each relay contact is configured as SPDT (Form C), rated 125 VAC or 110 VDC at 0.3 Amp, or 30 VDC at 1 Amp.

Relay	Pin	Description	Pin	Description	Pin	Description
Alarm 1	A1	Normally Open	A2	Common	A3	Normally Closed
Alarm 2	A4	Normally Open	A5	Common	B1	Normally Closed
Diagnostic	B2	Normally Open	B3	Common	B4	Normally Closed

Table 2: Alarm Relay Connections

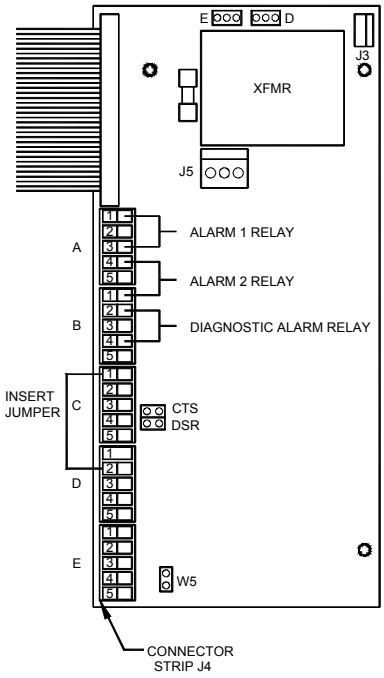


Figure 10: Alarm Relay Wiring

5.9.1.3 4-20mA Current Loop (Optional)

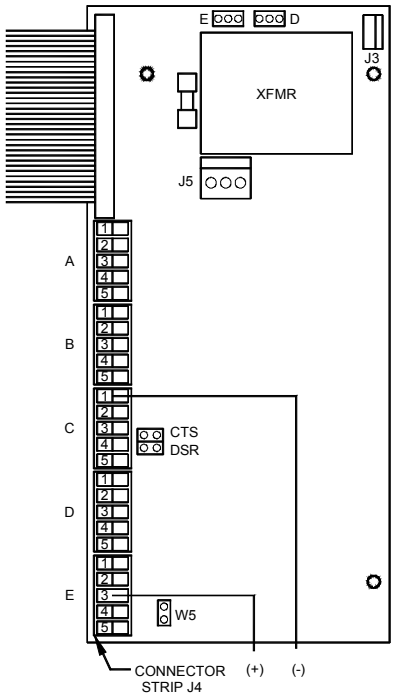


Figure 11: 4-20 mA Connections

Check your sales order to see whether your monitor includes this option. Connect the leads as shown in Figure 11. This output provides a current of 4-20 mADC, corresponding to 0-

25% oxygen. Convert loop current (I) in mADC to percent oxygen by subtracting 4 and multiplying the result by 1.563: % Oxygen = (I - 4) x 1.563

Conversely, percent oxygen can be converted to loop current by: I = 4 + 0.640 x % Oxygen.

Maximum loop resistance must be limited to < 750 Ohms. A loop compliance voltage (30 VDC) is provided by the Series 500.

5.9.1.4 RS-232C Interface (Optional)

Check your sales order to see whether your monitor includes this option. Available connections are shown in Figure 5-11. With this option, the monitor responds to commands from computers that meet the RS-232C signaling standard.

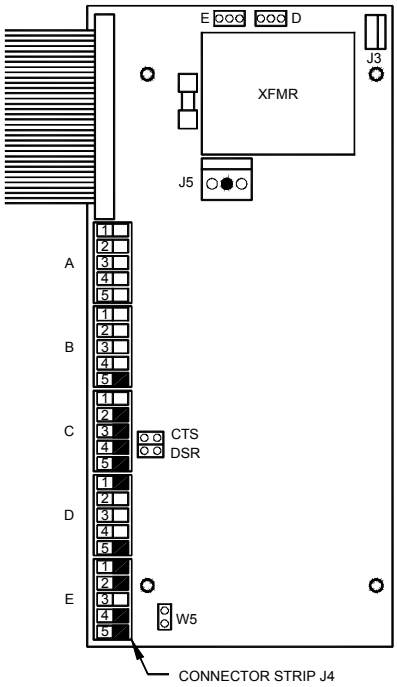
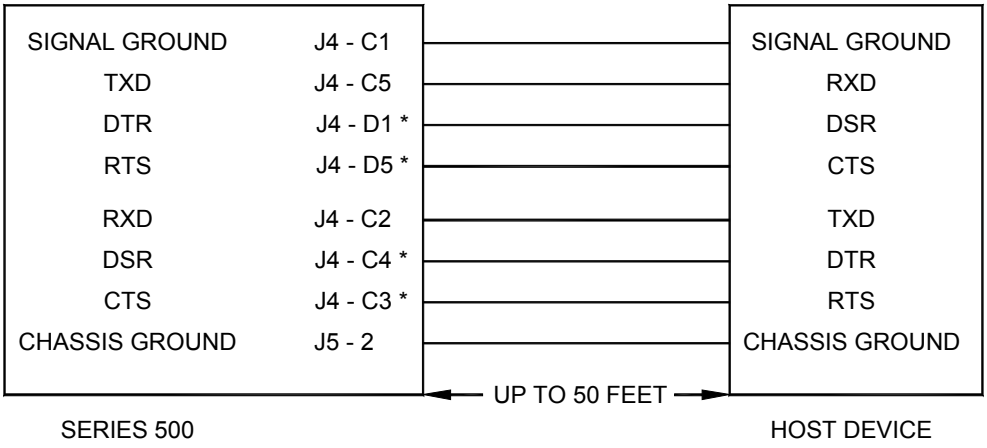


Figure 12: RS-232C Connections

B5	Signal Ground
C2	RxD - Data received by the Series 500 from the device.
C3	CTS - Clear to send
C4	DSR - Data Set Ready
C5	TxD - Data transmitted from the Series 500 to the device
D1	DTR - Data Terminal Ready
D5	RTS - Request To Send
E1	Current Loop Transmit (-).
E2	Current Loop Transmit (+)
E4	Current Loop Receive (-)
E5	Current Loop Receive (+)
J5-2	Chassis Ground

Table 3: RS-232C Connections



*OPTIONAL - IF DSR AND CTS ARE NOT CONNECTED, THEY MUST BE CONNECTED TO +VOLTS AT THE JUMPERS BEHIND J4-C ON THE POWER SUPPLY BOARD.

Figure 13: RS-232C Interconnect

5.9.1.5 Auxiliary Connections

Two additional connection points are also provided as standard equipment:

D2 - Used to disable the Sentry Circuit™ System. Connect terminal D2 to terminal C1 if you want to disable the Sentry Circuit™.

D3 - This terminal is used to indicate when the monitor is operating on battery power. If the AC power source fails, the output changes state (with respect to terminal C1). Standard output is an open collector transistor which turns on when AC power fails. TTL (Transistor-Transistor Logic) is available as an option, which outputs a logic high when AC power fails.

5.9.1.6 RS-232C/Current Loop Wiring

If the RS-232C option has been ordered, operation can be by means of direct RS-232C interconnections or by means of a 20 mA current loop interconnection. Examples of these interconnections are shown on the interconnection diagrams in Figure 14, and Figure 15. Note that for RS-232C, if the CTS and DSR lines are not used, they must be connected to a source of + voltage on the Power Supply Board by installing a jumper at location CTS and DSR. The jumper at location W5 must be installed for 20 mA current loop operation, and must not be installed for RS-232C operation. The 20 mA current loop compliance voltage (28 VDC max.) is customer supplied.

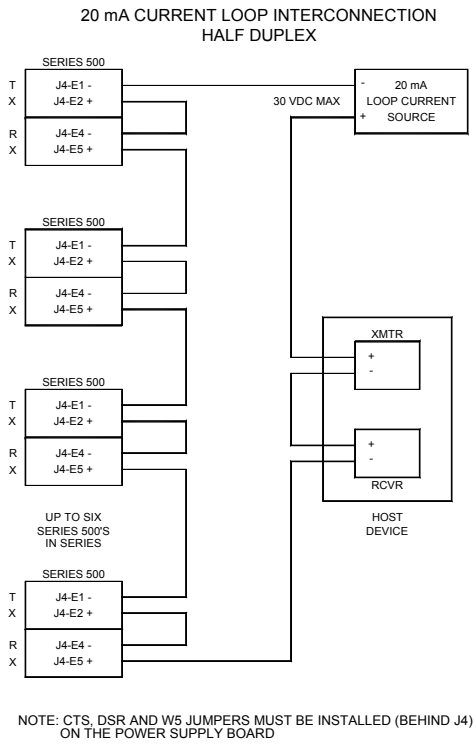


Figure 14: 20 mA Loop (Half Duplex)

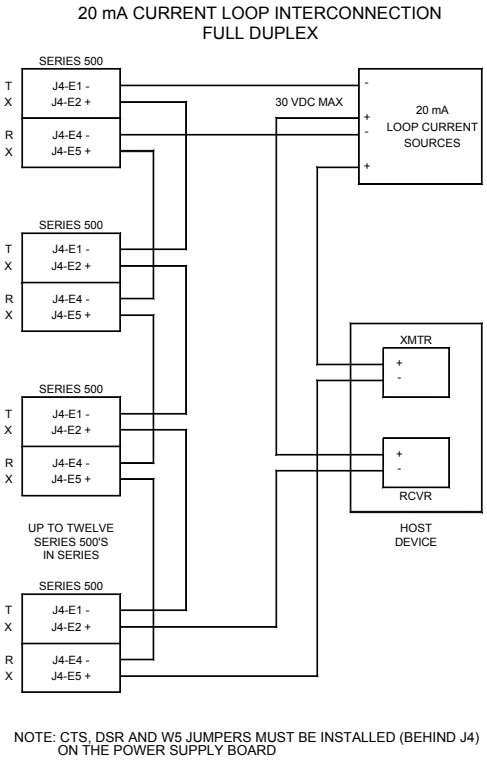


Figure 15: 20 mA Loop (Full Duplex)

6 Operation

6.1 Diagnostic Checks

A series of diagnostic checks are programmed into the Series 500. It is advisable to run through these checks after a cold start, and at any other time when instrument function is in question. This sequence of seven diagnostic checks can be run by pressing the DIAGNOSTICS push button on the inside of the front door (#1 in Figure 16).

To place the monitor in the diagnostic mode, hold the button down until the annunciator issues a short beep. The instrument then displays the first sequence number (- -1) for one second, followed by the value of that function.

Each subsequent time the button is pressed, the next sequence number is displayed, followed by its value. (Refer to Table 4 for the sequence of functions).

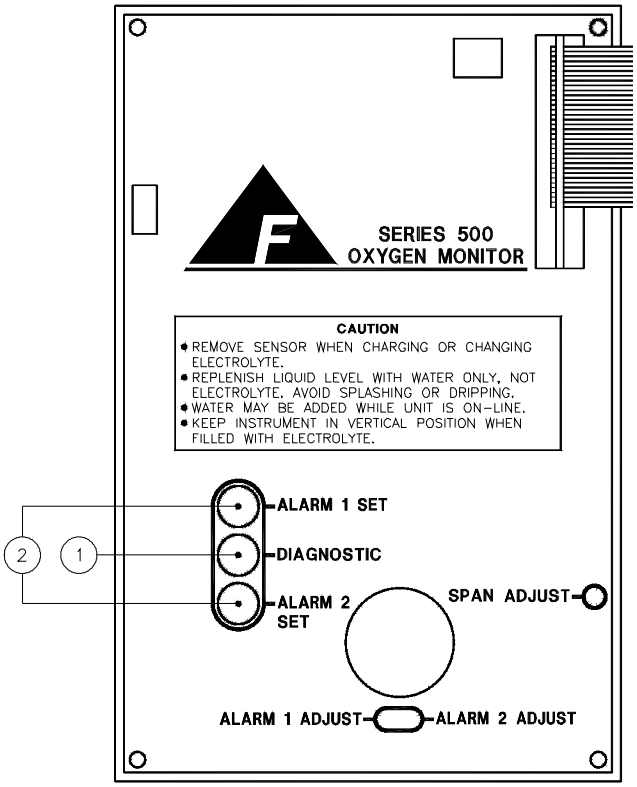


Figure 16: Inside Door

You can exit the diagnostic mode and return to normal operation at any time, by pressing either ALARM SET push button (#2 in Figure 16). Exception: on instruments equipped with the RS-232C option, you must be in one of the first 6 diagnostic sequences to resume normal operation; sequence 7 uses the ALARM SET push buttons for changing the Baud Rate, as explained below.

If the Series 500 is left in the diagnostic mode for approximately 2 minutes, it will automatically revert to normal operation. (This feature is designed to prevent the instrument from inadvertently being left in the diagnostic mode, and thus failing to monitor oxygen level.) Exception: diagnostic sequence 6 is designed specifically as an "idle" position. It is used to take the Series 500 off-line for extended periods of time.

NOTE: The instrument will not revert automatically to normal operation if left in diagnostic sequence 6.

6.1.1 Diagnostic Functions

SEQUENCE	FUNCTION	NORMAL READING	NOTES
1	Sensor voltage	13.8 - 14.2	1
2	Charging voltage	8.5 - 9.5	4
3	Positive reference	9.8 - 10.2	
4	Negative reference	4.8 - 5.2	
5	Battery voltage	6.0 - 9.3	4
6 (also acts as idle position)	Sentry compensation factor	90 - 110	2
7 (units with RS-232C only)	Baud rate selected	See Table 5	3

Table 4: Diagnostic Functions

Notes:

1. Cell voltage is actually a nominal 1.4 volts. (The display reads 14.0 because the decimal point cannot be moved.) During a cold start, cell voltage reading will be low and gradually increase to 14.0. If stabilized voltage reading is not within the above limits, it may be adjusted by pot R2 on the front panel.
2. This position displays the Sentry CircuitTM compensation factor. The Sentry CircuitTM compensates for calibration variances, as long as actual calibration remains within the range of 90 - 110. If the Sentry CircuitTM has not adjusted calibration, the value will be 100. If the compensation factor is close to 90 or to 110, manual calibration of the monitor will soon be required. See sections 6.4 and 7.1.2 for more Sentry CircuitTM information
3. (Units with RS-232C only). This position displays the current selected Baud Rate, as shown in Table 5. When you are in Diagnostic Sequence 7, you can set the Baud rate by pressing either ALARM SET button to increase or decrease the displayed value. Once the desired Baud rate is shown, press the DIAGNOSTICS push button once. This places the instrument back into Diagnostic Sequence 1. To exit the Diagnostic Mode, press either ALARM SET button again.

Reading	Baud Rate
.1.1.0	110
.3.0.0	300
.6.0.0	600
.1.2.0	1200
.2.4.0	2400
.4.8.0	4800
.9.6.0	9600
.1.9.2	19200

Table 5: Baud Rate Settings

4. For units equipped with a pump, there is no battery backup. Therefore, the battery-related voltages that are read in the Diagnostic Mode should be disregarded for Diagnostic Sequences 2 (charging voltage) and 5 (battery voltage).

6.2 Setting Alarms

The Series 500 is available with various factory programmed oxygen alarm options. The specific version of alarms must be selected at time of order. The installed alarm options are determined by the program EPROM (Erasable Programmable Read-Only Memory) which plugs into front panel socket U3. If you wish to change any of the alarm characteristics, a new chip may be ordered from the Delta F Customer Support Services Department (781-935-5808).

The standard oxygen alarms both trip LO, and are user adjustable. In other words, an alarm occurs when the oxygen value falls below the alarm setpoint, and the alarm setpoint may be changed using switches and potentiometers available on the rear of the front panel.

Each alarm may be ordered with the following characteristics: HI or LO trip, factory fixed or user adjustable setpoint.

If the monitor has adjustable setpoints, they may be adjusted as follows:

1. Press push button (1) in Figure 17, ALARM 1 SET.
2. The current alarm setpoint value is displayed on the front panel LCD. The ALARM 1 status light will also be flashing.
3. Turn the ALARM 1 ADJUST potentiometer (2) with a screwdriver to adjust the setpoint, on the front panel display.
4. Repeat the procedure for the second alarm setpoint, using ALARM 2 SET (3) and ALARM 2 ADJUST (4).
5. Press push button (5), DIAGNOSTICS to return to normal operating mode.

In units equipped with the RS-232C interface, you can also adjust alarm setpoints from your remote terminal.

The RS-232C option also provides commands to disable local setting of Alarm setpoints. If these commands have been sent, you will not be able to adjust setpoints manually. (See section 6.5.4.)

The manual alarm setpoint will be superceded by the setpoint adjustment in RS-232C. However, the RS-232C setpoint is not stored in non-volatile memory and the setpoint will revert to the manual value if the Series 500 power is turned off. Also, the RS-232C setpoint can be returned to the manual setpoint value by entering and leaving the manual alarm setting mode (this assumes that manual setting has not been disabled by using RS-232C commands).

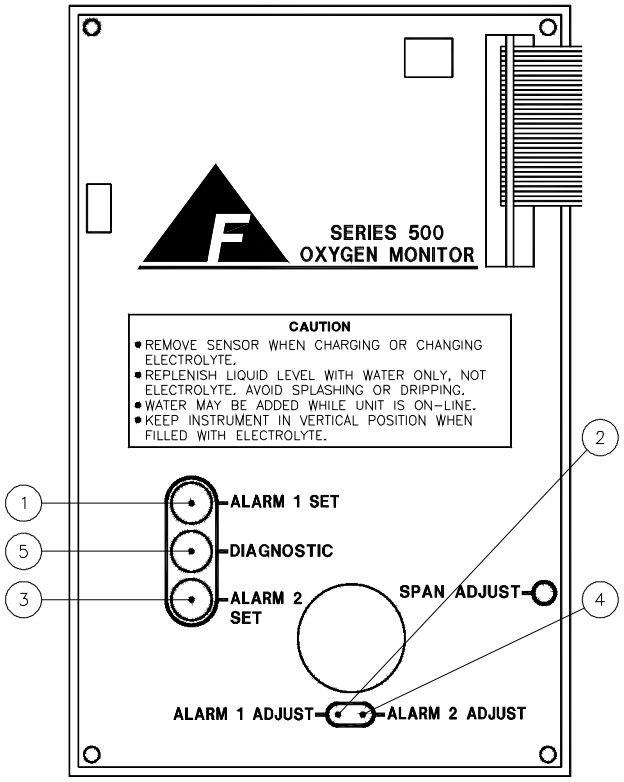


Figure 17: Alarm Setting

6.3 Alarm Conditions

Condition	Indication	Relay Function	Action
Oxygen ALARM 1 or 2 LED lights.	Oxygen level has fallen below alarm setpoint 1 or 2.	Alarm 1 or 2 relay contact changes position.	Take action to correct oxygen level. Audible alarm may be canceled by button on front panel. (Note 1)
BATTERY OPERATION LED lights.	AC power has failed, and the monitor is operating on backup battery power.	Open Collector: switches to ground TTL: switches to logical high (+5 Volts).	Take action to restore AC power. Monitor the LOW BATTERY relay. (Note 6)
LOW BATTERY LED lights. Intermittent audible alarm.	The battery is almost dead; the monitor will cease to operate in approximately 1 hour.	Alarm relay 3 contact changes position.	Power the instrument from an AC source as soon as possible. (Alarm will clear). (Note 6)
CHECK BATTERY LED lights. Intermittent audible alarm.	Batteries will not function to provide back-up power if needed.	Alarm relay 3 contact changes position.	Check batteries and wiring contacts. (Notes 2, 3 & 6)
CHECK ELECTROLYTE LED lights. Intermittent audible alarm.	Electrolyte is low or contaminated.	Alarm relay 3 contact changes position.	Check electrolyte level. If low, add Delta F Replenishment Solution. If not, replace. (Note 4)
BATTERY OPERATION, LOW BATTERY, CHECK BATTERY LEDs flash together. Audible beeps.	Sentry Circuit™ detects need for sensor recalibration.	Alarm relay 3 contact changes position.	Recalibrate/check calibration. (Note 5)

Notes:

Visual and relay contact transfer indicators remain in their alarm condition, and automatically reset when the condition is corrected. Alarm "Indication" description is for standard LO alarm configuration.

1. The CHECK BATTERY function does not operate while the unit is on battery power. A LOW BATTERY indication will be your warning that the unit is close to running out of power.

2. During normal operation, on AC power, the Series 500 periodically disconnects the charging circuit from the Battery Pack, and checks to make sure the batteries will operate properly in event of a power failure. The CHECK BATTERY alarm indicates that the Battery Pack is not working properly. This situation should be corrected immediately, as follows:

a. Verify that the two-pin connector between the Battery Pack and power supply is properly seated. Check all wiring connections and verify that the inline fuse is not blown. Once the problem is resolved the check battery alarm should automatically clear within approximately five minutes. If this does not clear the problem, replace the battery pack (Delta F part number 16332530).

3. The Check Electrolyte Alarm is usually due to low electrolyte. Check the sight glass in the Sensor unit, and if the level is low, add Delta F Replenishment Solution (see section 8.2- Sensor Maintenance).

NOTE

If the electrolyte is low, add Delta F Replenishment Solution. Do not add electrolyte solution! Do not overfill.

4. Refer to section 6.4 - Sentry CircuitTM and section 8.1- Calibration.

5. On Series 500 units which do not include battery back-up (i.e., pump equipped units), the front panel LOW BATTERY, CHECK BATTERY, and BATTERY OPERATION lights do not indicate the battery conditions.

6.4 Sentry Circuit

An in-depth discussion of the Sentry CircuitTM appears on page 44.

6.4.1 Use of the Sentry Circuit

The Sentry CircuitTM is an automatic feature that continuously checks calibration accuracy when the Series 500 is monitoring ambient air (20.9% Oxygen). At one hour intervals the Sentry CircuitTM checks if the display is reading 20.9%, and if not, Sentry CircuitTM automatically recalibrates the instrument to read 0.1% to 0.2% closer to 20.9%. If the displayed oxygen value is greater than 0.2% away (but not greater than +/-1%) from 20.9%, several one hour periods must pass before the monitor actually reads 20.9%. This slow adjustment prevents the monitor from compensating for the rapid oxygen drop that would typically occur in the event of a system upset.

If the displayed oxygen value is more than +/-1% oxygen away from 20.9%, the Sentry CircuitTM will not make an adjustment, because such large changes are usually related to actual shifts in oxygen concentration.

The Sentry CircuitTM adjustment compensates for small (less than +/-1% oxygen) gradual drifts in sensor calibration and changes due to barometric pressure and humidity. The monitor keeps track of automatic calibration adjustments and triggers an Out of Calibration alarm if the monitor calibration changes more than +/-1% oxygen.

An Out of Calibration alarm is signaled by the BATTERY OPERATION, LOW BATTERY, and CHECK BATTERY lights flashing at one second intervals while the annunciator beeps. Also, the Diagnostic Alarm relay switches to the alarm position. The audible annunciation may be silenced by pressing the CANCEL AUDIBLE button on the

front panel. An Out of Calibration alarm indicates that the instrument is in need of manual calibration. See section 8.1for the calibration procedure.

When operating on ambient air the Sentry CircuitTM ensures that the monitor is continuously "in calibration" and ready to accurately read oxygen values over the entire 0-25% range. Even if the monitor is normally used to monitor low oxygen concentrations, the Sentry CircuitTM may be used as an auto-calibration feature by allowing the Series 500 to monitor ambient air whenever a calibration is desired.

6.4.2 Diagnostic Position "- - 6"

It is possible to monitor the amount of calibration adjustment that the Sentry Circuit™ has applied. As discussed in section 6.1.1Diagnostic Functions, sequence 6 displays the Sentry Circuit™ compensation factor. This factor has a nominal value of 100 when the monitor is shipped from the factory. The value may range from 90 to 110 before the Out of Calibration alarm is triggered. It is recommended that the compensation factor be examined at three month intervals. In this way, manual calibration can occur before an alarm happens.

6.4.3 When to Disable the Sentry Circuit

The Sentry Circuit™ assumes that the monitor is continuously sampling 20.9% oxygen, and periodically adjusts its calibration to read 20.9%. If the displayed oxygen value is not within the range of 19.9% to 21.9% the Sentry Circuit™ will stop making adjustments. This prevents auto calibration from being performed when the ambient oxygen level is really changing.

If the actual ambient oxygen value is not 20.9%, but is within the range of 19.9% to 21.9% then the Sentry Circuit™ will keep adjusting to 20.9%, and may inadvertently mask the real oxygen value. To handle these circumstances the Sentry Circuit™ may be disabled by connecting a wire between C1 and D2 on connector J4 (Figure 7).

The Sentry Circuit™ is also disabled during a manual instrument calibration, as described in section 8.1 - Calibration.

6.5 RS-232C/Current Loop Background and Set-Up

The RS-232C/Current Loop option permits serial data communication between the Series 500 and a terminal, computer or modem. Command structure is described in section 6.5.4. If RS-232C/Current Loop has been ordered the monitor is shipped configured for RS-232C. Installation of three jumpers converts the monitor to 0-20 mA current loop operation, as described in section 5.9.1.3, under RS-232C/Current Loop Operation. There are several possible communication configurations:

a. One Series 500 is connected, via RS-232C, to a computer or terminal. Cable length is limited to approximately 50 feet. The instrument may be interrogated by the operator, or a user written computer program, to report oxygen, diagnostic voltages, alarm values, etc. Also, the alarm setpoints may be changed. Instrument alarm messages will be automatically sent by the monitor with no interrogation required.

b. Up to 12 Series 500s may be connected, via 0-20 mA current loop, to a computer or terminal. Typically, a current loop to RS-232 converter is used to convert a terminal or computer to the 0-20 mA protocol. The current loop configuration permits wiring to be hundreds of feet in length. Instruments may be interrogated individually. Alarms will be automatically reported by all instruments on the loop. Each unit may be given a user-chosen name so that alarm messages will be tagged with the identity of the sender.

c. One Series 500 is connected, via RS-232C, to a Hayes compatible modem. When an alarm condition occurs or clears, the Series 500 will instruct the modem to dial a user-programmed telephone number. The Series 500 will respond to modem handshaking to confirm that the call went through, and report the alarm condition after which it will hang-up. At any time the instrument may be called via the modem. In this way, the Series 500 may be interrogated and controlled remotely.

6.5.1 Terminal Set-Up for RS-232C

Default communication parameters are 7 bits, no parity, one stop bit. The standard baud rate is 1200 baud, although any default baud rate from 1200 to 9600 can be selected at time of order. Set the terminal for half duplex operation (echo on). This will cause the terminal to perform "echo" operation so that the text you type will appear on the terminal screen. The Series 500 transmits a carriage return at the end of each line of information. Set the terminal to translate each carriage return to a carriage return and a line feed. XON/XOFF flow control should NOT BE USED because Series 500s use XON/XOFF to prevent data collisions on multiple-instrument loops. Hardware control, via RTS/CTS or DTR/DSR, may be used, although it is usually not needed, even for terminals operating up to 9600 baud. The terminal may transmit characters at 9600 baud, but the time delay between characters is long, due to typing speed. Consequently, the Series 500 can keep up with received data. Most terminals can also easily display data at 9600 baud without handshaking.

6.5.2 Terminal Set-Up for 0-20 mA Current Loop

Default communication parameters are 7 bits, no parity, one stop bit. The standard baud rate is 1200 baud, although any default baud rate from 1200 to 9600 can be selected at time of order. The Series 500 transmits a carriage return at the end of each line of information. Set the terminal to translate each carriage return to a carriage return and a line feed. XON/XOFF flow control should NOT BE USED because Series 500s use XON/XOFF to prevent data collisions on multiple-instrument loops.

For two-wire operation set the terminal for full duplex, no echo. The fact that transmitting and receiving happens on the same two wires will cause echo to occur automatically.

For four-wire operation set the terminal to full duplex, echo on.

6.5.3 Clearing Communication Problems

It is possible to send spurious characters to the Series 500, if it is powered, when hooking-up wiring. These characters may cause the Series 500 to stop communicating properly. The Series 500 should be disconnected from battery and AC power until all wiring is complete. If the Series 500 ever stops communicating, the first remedy to try is to shut down the monitor and restart it. Remember to reset the Series 500 baud rate if your system is operating at a different rate than the default.

If communication frequently becomes garbled, try operating at a slower baud rate. If this does not improve the performance, it is possible that cabling is picking up interference from nearby sources of electromagnetic energy. It is recommended that shielded cable be used for RS-232C, and a shielded twisted pair be used for 0-20 mA current loop operation. To prevent ground loop problems, the shield should be connected to ground only at one end.

6.5.4 RS-232 Current Loop Commands

For units equipped with the RS-232C/Current Loop interface, commands may be entered from a remote terminal, computer, or modem.

Command syntax should be entered as shown Table 6. Commands may be entered in either upper or lower case.

NOTE

All command syntax must be entered as shown in the examples. Unpredictable results may occur if commands are entered incorrectly.

Keyboard commands are indicated as they should be entered, followed by examples, where applicable. Spaces are indicated by [_]. Where items or numbers are bracketed, brackets should not be entered. Phone numbers should be entered without spaces, hyphens, or parentheses (see notes below).

Before a Series 500 recognizes commands, sent through the RS-232C or current loop interface, it must be "awakened" by receiving its serial number. If several Series 500s are connected together in a loop, only one unit can be communicated with at any time. To select a different unit, its serial number would be sent, which would "awaken" that monitor and place all others in the "sleep" mode.

When entering commands, the Series 500 will allow correction or change to the command line prior to the <ENTER> command line terminator. These corrective characters are DELETE, RUBOUT, and BACKSPACE. In addition, the ESCAPE character will delete the entire command line so you can start over.

The baud rate for all serial communications is determined by selection from the diagnostic mode described in section 6.1.1. The default baud rate is 1200 baud. This is the power-up baud rate. The default baud rate can be selected at time of order, or changed by ordering an EPROM that is configured accordingly. Contact the Customer Support Services Department at 781-935-5808 for details. Note that if both AC and battery power are

removed from the Series 500, or if the batteries are allowed to run down, the baud rate defaults to the power-up value.

COMMAND	EXAMPLE	DESCRIPTION
5-[5-digit serial Number]	5-12345	Enables unit to response to all commands that follow
AA		Returns both current alarm set points
A1		Returns alarm setpoint #1
A2		Returns alarm setpoint #2
A		Returns all reportable data values – See Note 1 below
B		Returns current battery voltage
C		Returns current Sensor voltage
D1 (Note 7)		Disables manual adjustment of alarm setpoint #1 at unit
D2 (Note 7)		Disables manual adjustment of alarm setpoint #2 at unit
E1 (Note 2 & 7)		Enables manual adjustment of alarm setpoint #1 at unit
E2 (Note 2 & 7)		Enables manual adjustment of alarm setpoint #2 at unit
H		Returns help menu containing all available commands
M		Returns current Sentry compensation factor
O		Returns current oxygen reading
P (Note 3)		Returns current telephone number
P_P_[phone number] (Note 4)	P P 19993561234	Enters new telephone number (pulse dialing)
P_T_[phone number] (Note 4)	P T 19993561234	Enters new telephone number (tone dialing)
R		Returns current positive and negative reference voltages
S1_[desired value] (Note 5&7)	S1 18.6	Sets alarm setpoint #1 from remote terminal
S1_[desired value] (Note 5&7)	S2 19.2	Sets alarm setpoint #2 from remote terminal
T_[19 character message] (Note 6)	T BOILER ROOM	Identifies one of several units in a loop. The unit will reply with this name.
V		Returns EPROM firmware version

Table 6: RS-232C Command Protocol

Notes:

1. - Current oxygen reading in %
   - Alarm #1 setpoint in %
   - Alarm #2 setpoint in %
   - Sensor voltage in VDC
   - Battery voltage in VDC
   - Battery charge voltage in VDC
   - Positive reference voltage in VDC
   - Negative reference voltage in VDC
   - Current Phone number (if it has been set)
2. Will undo a previous "D" command. Both alarm setpoints are enabled when power is first turned on at a "cold start".
3. If no previous phone number has been entered, the message '*** No Phone Number Received ***' will be displayed. The phone number will be in the format:

   ATD T 19993561234

   Where ATD are the first 3 letters of Hayes Smartmodem command and T denotes tone dialing (P would denote pulse dialing).
4. Only to be used when the instrument is installed in a dial-up modem configuration.
5. Four characters (including the decimal point and leading zeros) which are less than 25.0, must be entered; for instance, 12.0 and 09.5 are acceptable; 8.0 or 25.6 will cause a command error message.
6. Used to describe a location in the facility. Use a maximum of 19 characters, or a command error message will be sent.
7. D1, D2, E1, E2, S1, and S2 commands are not available if factory fixed alarm setpoints are installed.

6.5.5 RS-232C/Current Loop Alarm Messages

Monitors equipped with the RS-232C/Current Loop interface send alarm messages to the host in the formats described in Table 7.

All messages begin with: S/N 5-[5-digit serial number] [19 character user-defined location code]

ALARM CONDITION	MESSAGE
Oxygen Alarms 1 & 2	S/N 5-12345 Boiler Room Alarm [1or 2] SET: --SET PT: [current] CUR. VAL: [current O2 reading]
Electrolyte Condition	S/N 5-12345 Boiler Room Electrolyte Condition -- CHECK
Low Battery	S/N 5-12345 Boiler Room Low Battery Condition – CHECK
Battery Check	S/N 5-12345 Boiler Room Battery Check -- FAILED
Calibration Check (Sentry Circuit)	S/N 5-12345 Boiler Room <<<WARNING>>> UNIT CALBRATION SHOULD BE PERFORMED AS SOON AS POSSIBLE

Table 7: Alarm Message Examples

When an alarm condition is detected, the monitor will wait to ensure the communication circuit is idle, then send one of the above messages. The terminal "bell" command will also be sent, to help get the user's attention. The message will be sent only once for each time the alarm condition occurs. It should be noted that no time or date information is sent with the alarm messages. If required, the time and date must be supplied by the host equipment.

When an alarm condition is corrected, the Series 500 will detect that it has cleared, and it will send an alarm clear message.

7 Technical Description

7.1 Theory of Operation

7.1.1 Sensor

The Delta F Coulometric Sensor uses an ambient temperature oxygen reaction that is non-depleting. The cell produces a current flow that is determined by the number of oxygen molecules that are reduced at the cathode. The sensor reaction is driven by 1.4 Volts applied across the sensing electrodes. The resulting electron flow is measured as a current that is precisely proportional to the oxygen concentration in the sample gas.

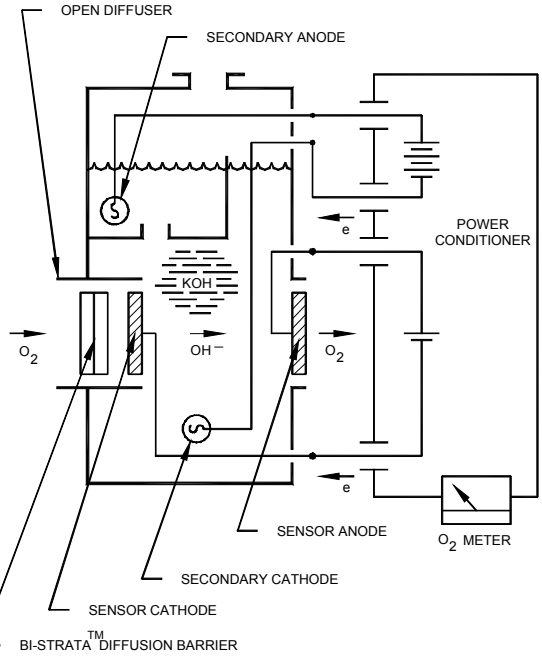


Figure 18: Schematic of Delta F Oxygen Sensor

The cathode reaction uses 4 electrons from the 1.4 volt circuit, 2 water molecules from the electrolyte, and 1 oxygen molecule from the sample gas to generate 4 hydroxyl ions which migrate across the reaction chamber to the anode:

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

The anode reaction consumes the 4 hydroxyl ions and delivers 4 electrons to the circuit, 2 water molecules back to the electrolyte, and vents one oxygen molecule.

$$4O\,H^- \rightarrow O_2 + 2H_2O + 4e^-$$

There is no net change to the electrolyte and no depletion of the sensor or electrodes.

As a result, the Delta F oxygen sensor does not require periodic replacement or frequent re-calibration.

7.1.2 Sentry Circuit

Section 6.4.1 describes the primary Sentry Circuit™ function. An additional function performed by the Sentry Circuit™ is keeping track of how much correction has been applied to the oxygen reading.

If the sensor calibration has changed more than +/- 1.0% oxygen from the last manual calibration (when reading 20.9%), the monitor is declared "Out of Calibration". An Out of Calibration condition results in the three Power Status LED's blinking at one second intervals while the beeper sounds. Additionally, the Diagnostic relay will switch to the alarm position.

If the monitor is equipped with RS-232C an alarm message will be transmitted. An Out of Calibration condition signals the need for a manual calibration as described on page 49.

Actually, there is an internal correction factor by which the raw oxygen value (uncorrected) is scaled to get the displayed oxygen value. The internal value is called the Compensation Factor. It is nominally 100, and may range from 90-110 before the monitor is Out of Calibration. Mathematically, the correction factor is used as follows:

DISPLAYED VALUE = [(Compensation Factor + 100) X Uncorrected Oxygen Value] / 200

The amount of calibration shift may be monitored by viewing the Compensation Factor in Diagnostic Mode Sequence 6.

The Compensation Factor is not stored in non-volatile memory. Consequently, if the instrument is powered down and restarted, or soft rebooted, the factor is reset to 100, and the previous manual calibration returns, i.e. the front panel will read the actual oxygen value, without benefit of Sentry Circuit™ correction. This feature is useful when it is necessary to perform a manual recalibration.

To perform a manual calibration, the monitor is rebooted by pressing and holding the CANCEL AUDIBLE button and then pressing any of the three ALARM 1 SET, DIAGNOSTICS, or ALARM 2 SET buttons. The Sentry Circuit™ must also be disabled by placing a jumper between J4-C1 and J4-D2 (see Figure 12). Next, the monitor is allowed to stabilize and the Span pot is adjusted for a front panel reading of 20.9%. Finally, the Sentry Circuit™ is enabled by removing the jumper -- and Sentry Circuit™ adjustment may, once again take place over a +/- 1.0% range.

7.2 Electronics

7.2.1 Front Interior View

Figure 19 below shows the relationship between the various electronic assemblies of the Series 500 Oxygen Monitor:

Inside the Instrument Enclosure are the Power Supply Board (1), the Battery Pack (2) and the Front Panel Board (3).

External AC power enters the enclosure through the right cable clamp (4). Power is connected to the Power Supply Board at J5.

All data connections enter the enclosure through the left cable clamp (5) and terminate on the Power Supply Board terminal strip J4 (6), which is composed of five sections labeled A through E. Each section has five terminals.

The Battery Pack wires are routed to the Power Supply Board via a two-pin in-line connector. Similarly, the 4-conductor Sensor wiring is routed to the Power Supply Board via a four-pin in-line connector which terminates at J3.

The Front Panel Board is connected to the Power Supply Board by a 40-conductor flexible ribbon cable (7).

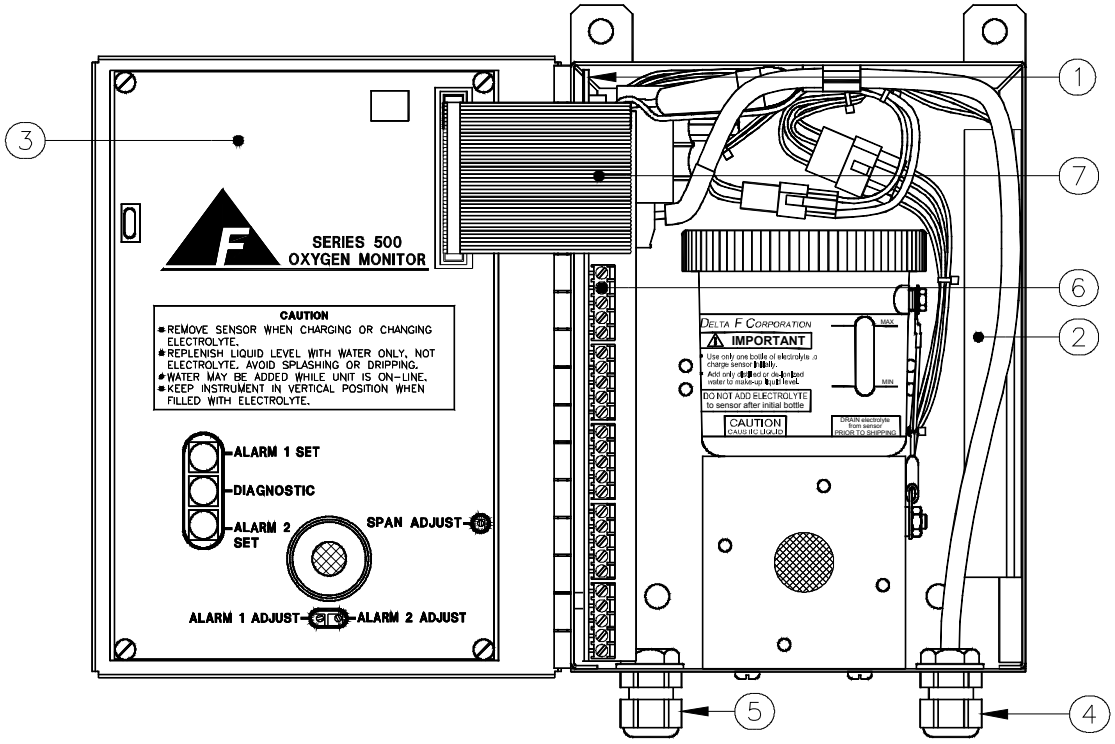


Figure 19 Interior View

7.2.2 Microprocessor Operations

To analyze oxygen concentration in the Sensor, a Sensor driver circuit applies a stable -1.40 volts dc to the - terminal of the Sensor. The + terminal, which receives the current from the electrochemical reaction inside the Sensor, is connected to an amplifier which serves as a current-to-voltage converter. The analog output of this converter is directly proportional to the concentration of oxygen in the sample gas.

Under 8085 microprocessor control, an 8-channel multiplexer accepts inputs from the Sensor amplifier, two alarm set points, the + and - reference voltages, the charging voltage, the battery voltage and the Sensor driver voltage. The microprocessor selects one input at

a time to be converted in the 3.5 digit Analog to Digital Converter (ADC). The ADC output is then used by the microprocessor to present specified data to the front panel display when instructed by the diagnostic routine.

Typically, only the percent of oxygen concentration is displayed on the front panel; however, under control of the Series 500 diagnostic program, any of the analog inputs to the multiplexer can be selected and displayed. With the RS-232C option, any of the voltage inputs to the multiplexer can be remotely read on demand. The 8-bit Digital-to-Analog Converter (DAC) produces an analog output voltage directly proportional to the oxygen concentration.

7.2.3 RS-232C Option

A Universal Synchronous/Asynchronous Receiver Transmitter (USART) is installed to provide a communication port to the Series 500 microprocessor. The USART enables the microprocessor to receive and transmit via an RS-232C interface, as well as via a 20 mA current loop interface. Under alarm conditions, the USART makes it possible to transmit an alarm message automatically. Additionally, a HAYES Smartmodem 1200 option, or compatible modem, actually telephones a remote location to report alarm messages. It is also possible to dial a modem-equipped Series 500 to obtain its complete operating status.

With the RS-232C option, optically coupled isolators are mounted on the Power Supply Board to support the 0-20 mA current loop interface. Jumpers on the Power Supply are configured to choose between RS-232C operation, or 0-20 mA. The RS-232C data lines, or isolated current loop data signals, are routed to the Front Panel Board via a 40-conductor cable.

7.2.4 Power Supply Board

The Power Supply Board (Figure 20) is central to the operation of the Series 500, because it distributes the power and interconnects the various Series 500 functions.

In the AC powered version, the line voltage is applied to the AC range selector and to the transformer (XFMR). The transformer drops the line voltage, for conversion to dc by a bridge rectifier, to produce a voltage of 15-16 VDC (+V UNREG). The input transformer, that provides isolation for the Series 500 circuitry from the AC power line, can support inputs of 90-120 VAC or 220-250 VAC, by manually changing jumpers on the Power Supply Board. The dc power from the XFMR and bridge rectifier powers the Series 500 and operates the battery charge circuitry.

In the 24 VDC version of the Series 500 the 24 VDC at 0.5 A is converted to 16.5 VDC by a switching-regulator daughter board that is installed in place of the AC transformer. The daughter board circuitry replaces the "AC Range Selector," and "XFMR And Bridge Rectifier" blocks seen in Figure 20.

Battery power is supplied by six nickel-cadmium rechargeable batteries with an output voltage of between 6 and 9.5 VDC. Both the output of the XFMR/bridge rectifier and the battery pack are diode-auctioneered to provide dc system power. (Auctioneering means that the highest output will assume the load, so in case of AC power failure, the battery pack will automatically assume the load.)

During AC operation, +V UNREG is directly used to supply +15 VDC. However, when operating on batteries the nominal 7.2 V battery voltage is fed to a controlled up-converter to provide doubling to +15 VDC.

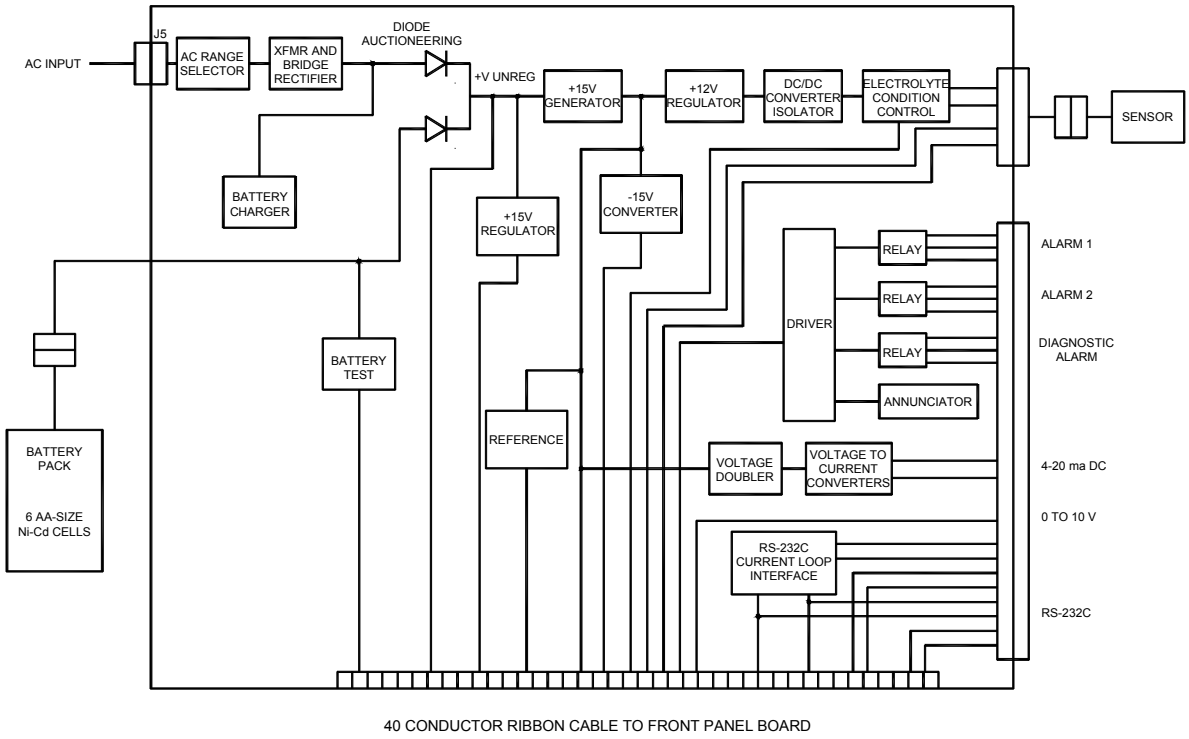


Figure 20: Power Supply Block Diagram

A charge-pump IC takes the +15 VDC and converts it to -15 VDC. This +/-15 VDC supply is then used to power the analog circuitry on the Front Panel Board. The +V UNREG dc input is also regulated down to +5 volts for use by the microprocessor and logic circuitry on the Front Panel Board.

The circuitry to energize the Electrolyte Condition System is also on the Power Supply Board. This isolated circuitry detects a low electrolyte level or contaminated electrolyte in the Sensor.

Additional features of the Power Supply Board that are under microprocessor control are the alarm relays that signal alarm conditions; the annunciator that provides an audible indication of an alarm condition; and the battery test function that enables the microprocessor to determine the quality of the battery system.

7.2.5 4-20 mA Output Option

With the 4 to 20 mADC output option, a voltage doubler and voltage-to-current converter are added to the Power Supply Board. This feature converts the standard 0 to +10 VDC output signal to an equivalent 4 to 20 mADC signal for use by certain process and recording equipment. The use of a current instead of voltage eliminates the voltage drop problem associated with sending voltage (such as the 0-10 VDC output) over a long distance.

The voltage doubler provides 30 VDC loop compliance voltage, thus eliminating the need for an external supply.

7.2.6 Front Panel Board

The microprocessor in the Front Panel Board, located on the back of the front door, controls the operation of the instrument. Figure 21 below, is a block diagram of the Front Panel Board.

The operating program is stored in an EPROM (Erasable, Programmable Read-Only Memory) that is non-volatile -- that is, it does not lose data stored in memory when all power is turned off. When powered up, the microprocessor retrieves instructions from the EPROM, executes the instructions and monitors and controls all instrument functions based on response to these instructions.

The microprocessor "talks" to other system parts via a bus structure. A RAM (Random Access Memory), I/O (Input/Output) device, display driver, output DAC, and an optional USART are also attached to the microprocessor bus. Any of the four push buttons on the front panel board of the Series 500 can be used to interrupt normal microprocessor operations to obtain priority attention.

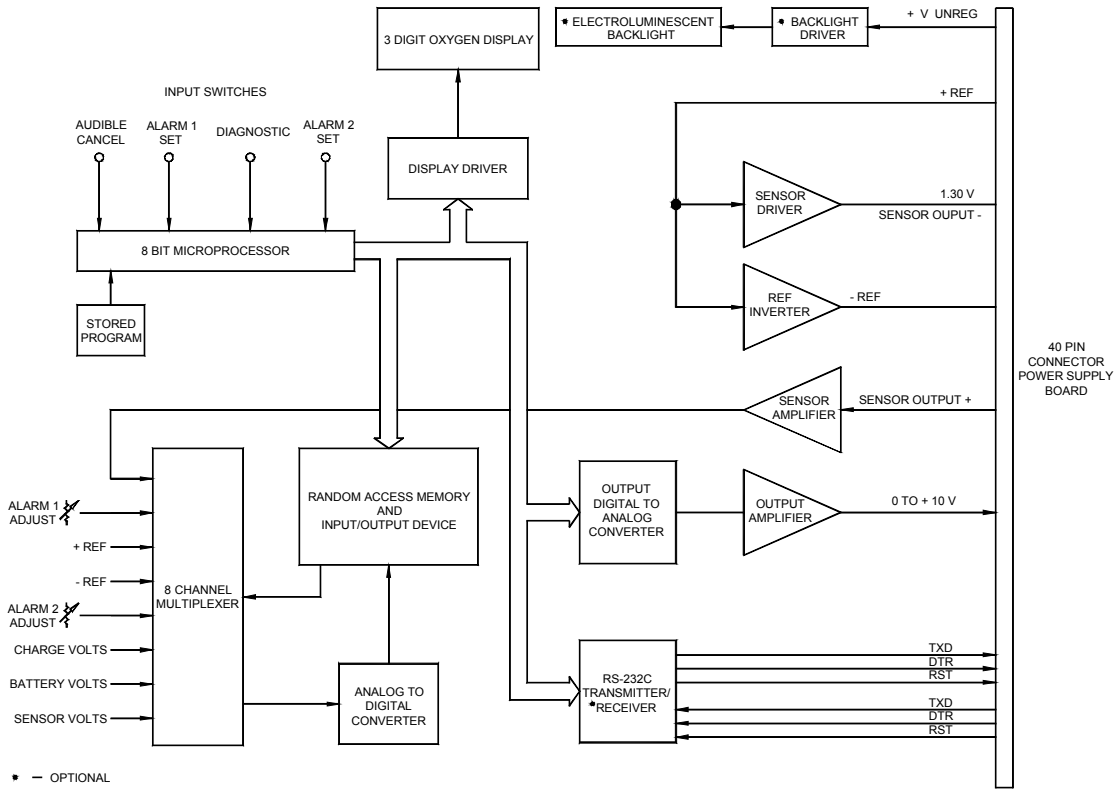


Figure 21: Front Panel Board Block Diagram

8 Maintenance

8.1 Calibration

All Delta F Series 500 Oxygen Monitors are calibrated at the factory prior to shipment. Because of its non-depleting Sensor electrodes, the Series 500 does not require special precautions to protect the Sensor from exposure to oxygen during shipment or storage.

No initial calibration of the Series 500 Oxygen Monitor is required upon receipt from the factory, unless the operating location is >1500 feet above sea level. It is a good idea, however, to verify the calibration of your Series 500 at start-up using breathing or ambient air that has an oxygen concentration of 20.9%. Since the Series 500 has a full-scale range of 0-25%, breathing air is an ideal calibration medium. If there is any question about the composition of the ambient air, it is recommended that initial calibration be performed next to an open door or window, where fresh air is available.

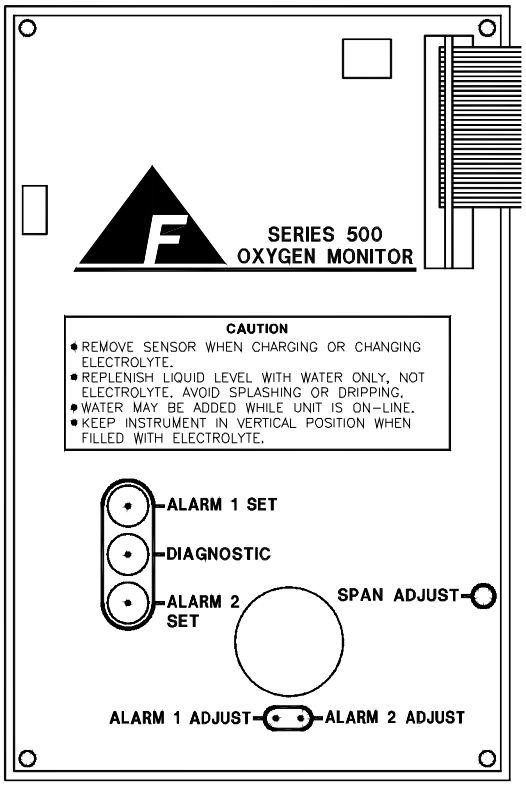


Figure 22: Front Panel Board

To perform a calibration check, if the Series 500 has just been started up, allow six hours of warm-up prior to calibration. Operate the monitor on ambient air for at least 30 minutes. The Sentry CircuitTM compensation factor must be reset to 100 to remove the effects of automatic

calibration. Press and hold the front panel CANCEL AUDIBLE button and then press any other push button. (ALARM 1 SET, DIAGNOSTICS, or ALARM 2 SET) to cause the instrument to restart its program (reboot) and reset the compensation factor. If the front panel display is not reading 20.9%, a manual calibration adjustment is required. The Sentry CircuitTM must be disabled by installing a jumper wire between J4-C1 and J4-D2, see Figure 12.

Allow the displayed value to stabilize and adjust the SPAN potentiometer for a reading of 20.9%. The SPAN potentiometer is accessed from the inside of the Front Panel Board mounted on the door (see Figure 22). To increase the oxygen value, turn the potentiometer clockwise.

NOTE

Accurate calibration of the monitor is directly related to the quality of the calibration standard. As a result, it is imperative that the calibration gas is fresh breathing air.

NOTE, increased humidity in ambient air can easily decrease the oxygen value to as little as 19.9%..

A useful feature of the Delta F Sensor is its' inherent linearity which requires only a single calibration gas, eliminating the need to use certified gas cylinders. Since the Series 500 is a safety monitor it is advisable to recheck the calibration after every 2 to 3 months of continuous use.

The zero setting of the electronics should be checked once every 9 to 12 months. Disconnect the Sensor cable plug at the in-line connector between the Sensor and the Power Supply Board, Figure 5-3. The digital panel meter should read 0.00. If it does not, remove the four screws fastening the black plastic cover to the pc board on the rear of the door. Adjust the zero potentiometer (R52) until it reads 0.00. Then, monitor the analog output voltage between J4-D4 and J4-B5. Adjust R47 until the analog output voltage reads 0.00. Next, reconnect the Sensor at the in-line connector between the Sensor and the Power Supply Board. The instrument is now ready to operate.

8.1.1 Using the Optional Calibration Cup

An optional Calibration Cup as shown in Figure 23 is available for the Series 500. The Calibration Cup allows the user to check Series 500 operation at oxygen levels other than ambient or breathing air (20.9%). Routine instrument calibration should still be done at the highest oxygen level possible, which is usually ambient air.

Attach the Calibration Cup directly to the open diffuser inlet at the Sensor. The Sensor has four 6-32 threaded holes around the open diffuser for the 6-32 captive screws in the Calibration Cup. Orientation of the Calibration Cup is not important. Tighten the four screws.

After mounting the Calibration Cup, attach 1/4" tubing to a source of calibration gas and to the fitting on the Calibration Cup. The flow of the gas should be set at 1-2 scfh. The gas must be allowed to escape through the vent holes in the Calibration Cup.

NOTE

The vent holds in the calibration cup must never be blocked. Under no circumstances should the pressure applied to the sensor exceed 1 psig or sensor damage may result.

After calibration, remove the Calibration Cup from the Sensor and note that the oxygen reading returns to the current value of the ambient air (approx. 20.9%).

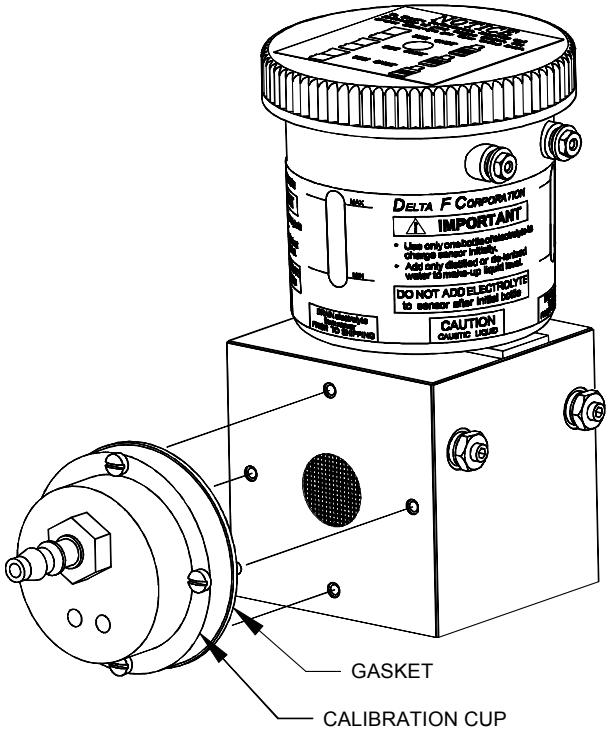


Figure 23: Calibration Cup

8.1.2 Calibration at High Altitude

If the monitor is operated at elevations above 1500 feet, it should be calibrated at the elevation at which it will be operated.

8.2 Sensor Maintenance

Once prepared for operation, the Series 500 requires no routine maintenance in most applications. The Sensor may require periodic maintenance when dry gases (gases with low dewpoints) are monitored for an extended time. Exposure to dry gas gradually extracts moisture from the Sensor, making it necessary to occasionally add Delta F Replenishment Solution.

The Sensor Assembly consists of two connected chambers. The lower section contains the sensing electrodes which require total immersion in electrolyte. The upper chamber is the

reservoir for extra electrolyte. The Sensor operates satisfactorily as long as the level of electrolyte is above the minimum mark on the reservoir label.

The reservoir holds at least 100 ml. of liquid. (The Sensor cavity holds an additional 15-20 ml.) Since air at the Sensor inlet extracts no more than 5 ml. of liquid per month, the elexctrolyte level needs replenishment only once every 8 to 10 months. (Operation on sample gases with lower dewpoints increases the need to add Replenishment Solution.)

NOTE

If the electrolyte is low, add only Delta F Replenishment Solution. Do not add electrolyte solution! Do not overfill. Cap RSA bottle tightly after use.

The Series 500 is equipped with an Electrolyte Condition light which signals when Delta F Replenishment Solution should be added to the Sensor. To add Replenishment Solution, remove the Sensor cover. Add Replenishment Solution, using the squeeze bottle supplied with the Series 500. Fill to the upper level shown on the reservoir label. Replace the cover. Replenishment Solution can be added while the instrument is operating. Be careful not to spill or squirt on the electronics, or on the outside of the Sensor.

If the Electrolyte Condition warning light appears while there is an adequate electrolyte solution in the Sensor, the electrolyte may be contaminated from exposure to gas components incompatible with the electrolyte. The electrolyte should be drained, the Sensor rinsed and refilled with fresh electrolyte.

To drain the electrolyte (which is a solution of KOH), remove the Sensor from the cabinet as instructed in section 5.4 - Adding Electrolyte. Invert the Sensor over a suitable receptacle to drain the electrolyte. Flush the Sensor two or three times with water. Refill the Sensor with electrolyte. Install the Sensor. If the Electrolyte Condition LED is still lit after placing the Series 500 back into operation, call the factory, 781-935-5808.

8.3 Electronic Maintenance

There are three electronic sections that make up the Series 500 Monitor: the Battery Pack, the Power Supply Board, and the Front Panel Electronics Board.

8.3.1 Battery Pack

Under normal operation, the Series 500 periodically checks the condition of its battery backup system by disconnecting the charging circuit from the Battery Pack and applying a load comparable to that needed to operate by battery in the event of a power failure. This feature can detect conditions such as a broken wire or an open or high impedance battery, as well as a battery contact failure. Since battery backup is crucial to the integrity of the Series 500, the CHECK BATTERY alarm should be addressed immediately, and will not clear until the cause of the alarm is corrected.

To clear a CHECK BATTERY alarm, open the Series 500 door. Make sure the Battery Pack is plugged into the Power Supply Board at the two-pin in-line connector. Check that the battery

wires are not broken. Unscrew the fuseholder and inspect the fuse to see if it is blown. If the problem persists, it may be necessary to replace the battery pack (Delta F Part Number 16332530).

8.3.2 Power Supply Board

To remove the Power Supply Board, the Oxygen Sensor must be removed first. Be sure to disconnect all sources of power to the Series 500 before attempting to remove the Power Supply Board. Once the Sensor has been removed, disconnect the 40-conductor cable (Power Supply Board to the Front Panel Board) at the Front Panel Board and the power cord connector at J5. Remove the two screws that fasten the splash shield to the Power Supply Board at the front edge and lift off the splash shield. Next, remove the two standoffs that are on the front edge of the power supply. Then remove the two standoffs that hold down the Power Supply Board at the rear edge. Note that the standoffs are of different length. Keep track of which standoff is used in each location. There is another splash shield between the pc board and the cabinet.

Re-assembly is the reverse of this procedure. Seat the Power Supply Board, and the splash shield that sits under the board, over the threaded locations on the enclosure. Reinstall the four standoffs. Reinstall the splash shield that sits over the component side of the board and fasten it in place with the two screws. Plug in the power connector at J5, and plug the 40-conductor ribbon cable back into the Front Panel Board.

8.3.3 Front Panel Board

Before removing the Front Panel Board, remove all sources of power from the Series 500. Disconnect the 40-conductor cable connector at the Front Panel Board. Remove the four screws that fasten the plastic cover to the four standoffs. Then, remove the four standoffs that hold the electronics board to the door. Remove the Front Panel Electronics Board. When handling the Front Panel Board, be careful to avoid bending components that protrude from both sides of the board, especially the LED's.

When re-assembling the Front Panel Board, position it over the Series 500 door from the rear side, ensuring that the Cancel Audible switch and the LEDs pass through the door openings properly. Start the four standoffs into their captive fasteners on the rear of the door. Tighten the standoffs after the electronics board is positioned so that the Cancel Audible push button is free to operate through the hole in the door without binding on the edge of the opening.

8.4 Shipping

To ship the Series 500 to the factory or to another location, follow these instructions to prevent damage to the instrument during shipping.

If the Series 500 Monitor is to be returned to Delta F, it will be necessary to obtain a Return Authorization Number by contacting the Delta F Customer Support Services Department at 781-935-5808, Fax 781-932-0053, or e-mail at service@delta-f.com.

1. Disconnect AC power from the Series 500 and disconnect the Battery Pack from the Power Supply Board at the two-pin in-line connector

between the Battery Pack and the Power Supply Board. Also disconnect any external data connections to the terminal strip J4. Mark each for easy reconnection.

2. Disconnect the Sensor at the four-pin in-line connector between the Sensor and the Power Supply Board.
3. Remove the four screws holding the Sensor to the enclosure bottom.
4. Remove the Sensor.
5. Unscrew the cover at the top of the Sensor.
6. Drain the electrolyte into a suitable receptacle.
7. Add distilled or deionized water to the Sensor to rinse. Drain the water into the receptacle. Repeat this step.
8. Securely hand-tighten the cover.
9. Re-install the Sensor by fastening it to the bottom of the enclosure with the four screws.

For shipping, use the original shipping container, or equivalent. Be sure that all internal components such as the Sensor and printed circuit boards are adequately secured. Pack bubble packing or similar material inside the enclosure to protect the instrument.

8.5 Storage Temperature

If the Series 500 is to be stored for extended periods of time, be sure that the temperature of storage location does not exceed 122EF (50EC). Storage in direct sunlight can cause temperatures to exceed the recommended limits even though ambient temperatures may not.

8.6 Troubleshooting

The following troubleshooting guide lists possible problems that might arise with your Series 500 and suggestions to help you locate the source of trouble. For assistance contact the Delta F Customer Support Services Department at 781-935-5808, Fax 781-932-0053, or e-mail at service@delta-f.com.

Problem	The Possible Cause
With power applied, there are no lights or sounds when turning on the Series 500.	After verifying the power source, check that AC power is plugged in at J5 on the Power Supply Board. If OK, check Fuse F1, after disconnecting the AC power and removing the splash shield (Section 8.3.2 Power Supply Board).
After AC power is on, and the instrument turns on, the LOW BATTERY and/or CHECK BATTERY LEDs are lit.	Make sure the Battery Pack is plugged into the two-pin in-line connector to the Power Supply Board. Also, check the in-line fuse to ensure that it is not blown, Figure 2. Be sure the unit has run for 30 to 60 minutes if the battery is completely discharged. If these remedies don't solve the problem, the battery pack should be replaced (part number 16332530).
Both AC and Battery Pack connections are okay, but no Front Panel lights or sounds are operable.	Check that the 40-conductor cable from the Power Supply Board to the Front Panel Board is plugged in at the Front Panel Board.
The instrument seems to be operating properly, but the display is reading 0.00 steadily.	Check that the four-pin connector from the Sensor to the Power Supply Board is plugged in. Check the electrolyte level in the sensor.
BATTERY OPERATION, LOW BATTERY, CHECK BATTERY LEDs flash together. Audible beeps.	This is the Sentry Circuit™ alarm that indicates sensor calibration has changed by more than 1%. Perform a manual calibration (page 49).
The instrument display is reading .2.5.0.	This is the over-range indication. Allow the instrument 15-60 minutes to come on scale, after power is first applied.

Table 8: Troubleshooting Guide

8.7 Replaceable Parts List

QTY PER UNIT	DESCRIPTION	RECOMMENDED SPARE QTY	DELTA F PART NUMBER
1	Electrolyte	2	Ɛ-lectrolyte Black
1	Battery Pack	1	16332530
1	Front Panel Board	1	10404820
1	Power Supply Board	1	10404890
1	Oxygen Sensor**	0	SP500
1	Fuse 0.25A SloBlo (110VAC)*	2	45002301
1	Fuse 0.125A SloBlo (220VAC)*	2	45002241
1	Fuse 0.5A Fast Acting (24 VDC)*		
1	Fuse, Battery Pack, .5A	1	45002705
1	Power Cord (110 VAC)	0	59017237
1	Power Cord (220 VAC)	0	59036140
1	Cable Ass'y/Sensor Harness	0	13210470
1	Handle	0	65000004
2	Handle Screws	0	80103250
4	Feet	0	83005018
1	Calibration Cup	0	15206060
1	Panel Mount Kit	0	15305440

Table 9: Replaceable Parts List

NOTE:

* The fuse required for a particular application is determined by the AC power input voltage.

** When ordering a replacement sensor, please provide monitor model and serial number.

To order parts contact the Delta F Customer Support Services Department at 781-935-5808, Fax 781-932-0053, or e-mail at service@delta-f.com.

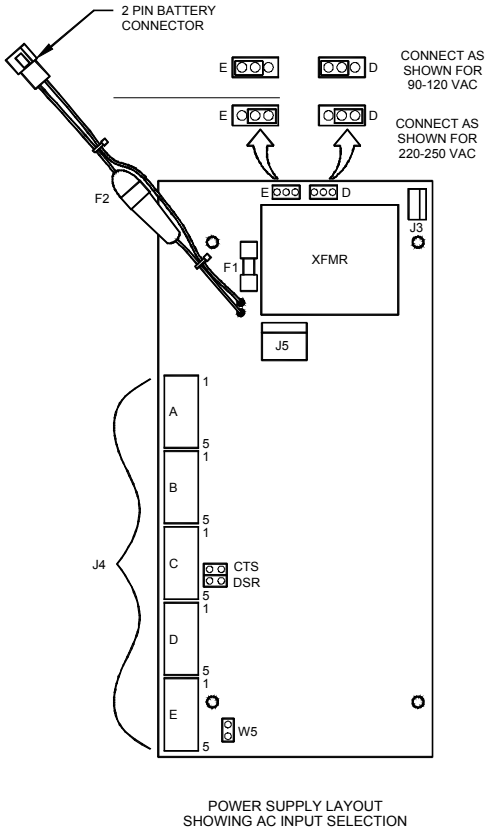
9 Wiring

The Series 500 Oxygen Monitor is designed to operate on either 90-120 VAC 50/60 Hz (Standard) or 220-250 VAC 50/60 Hz (Optional). The NiCAD rechargeable batteries are charged from AC power and serve as a short-term alternative power source.

Changing the AC Input Voltage:

The Series 500 is factory-configured to operate on the AC power voltage specified on the original sales order and as indicated on the label inside. However, to change the AC input voltage (from 90-120 VAC to 220-250 VAC or vice versa) disconnect all power, remove the Oxygen Sensor and Power Supply Board, then move jumpers on the Power Supply Board as shown in Figure 24.

There are two fuses on the Power Supply Board of the Series 500. A 0.5 Amp fuse (F2) protects the battery from any short circuits. Another fuse (F1) protects the AC input supply from shorts or failures in the instrument. The rating of F1 is determined by the AC input voltage. See sticker inside cabinet for operating voltage.



POWER SUPPLY LAYOUT
SHOWING AC INPUT SELECTION

Figure 24: Power Supply Board

Before changing either fuse, first disconnect the instrument from any AC power source (disconnect at J5, Figure 24) then, disconnect the two-pin in-line battery connector to the Power Supply Board.

NOTE

If the AC input voltage is changed, then the fuse must be changed to the appropriate value as well.

9.1 Power Wiring Connections

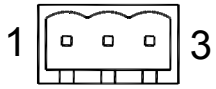


Figure 25: Power Input Connector – J5

9.1.1 AC Power Cord to Power Supply Board

The Series 500 Oxygen Monitor is equipped with a 3-conductor power cord, and three prong plug, attached to the AC power connector. This cord can be used for 90-120 VAC in North America. Units ordered for operation on 220-250 VAC power have a power cord that is unterminated. It will be necessary to purchase the appropriate plug for your location and connect it to the power cord. Wire as follows:

1. Disconnect the power cord from AC power.
2. With the front panel door open, remove the power connector J5 from the Power Supply Board to the left of the Oxygen Sensor (See Figure 24).
3. Attach the 3 wires from the power cord to the power connector. Note that pin 1 is on the left side of connector J5. See Figure 25.

Terminal	Signal	120 VAC Colors	220 VAC Colors
J5-1	AC Line	Black	Brown
J5-2	Chassis Ground	Green	Green/Yellow
J5-3	AC Neutral	White	Blue

Table 10: AC Power Cord Wiring

CAUTION

Disconnect the power cord from AC power before performing maintenance on the monitor.

9.1.2 DC Power Cord to Power Supply Board

The Series 500 Oxygen Monitor may be optionally configured at the time of order to operate on 24 VDC. Note field modification from AC to DC power and vice versa is not possible.

1. With the front panel door open, remove the power connector J5 from the Power Supply Board to the left of the Oxygen Sensor (See Figure 24).
2. Wire the connector as shown in Table 11 using appropriately sized wire. Note that pin 1 is on the left side of connector J5. See Figure 25.

Terminal	
J5-1	+ 24 VDC
J5-2	Chassis Ground
J5-3	24 VDC Common

Table 11: DC Power Cord Wiring

9.1.3 Power Supply Board to Oxygen Sensor

Four wires attached at J3, Figure 26, connecting the Power Supply Board to the Sensor. A four-pin in-line connector is provided to connect to the sensor cable. The connector pinout is as follows:

Sensor Connector Pin	Signal	Wire Color
J3-1	Sensor (+)	White/Black/Red
J3-2	Sensor (-)	White/Yellow
J3-3	Secondary Electrode (-)	White/Blue
J3-4	Secondary Electrode (+)	White/Red

Table 12: Sensor Cable Wiring

To disconnect the Sensor, unplug the in-line cable connector as shown in Figure 26.

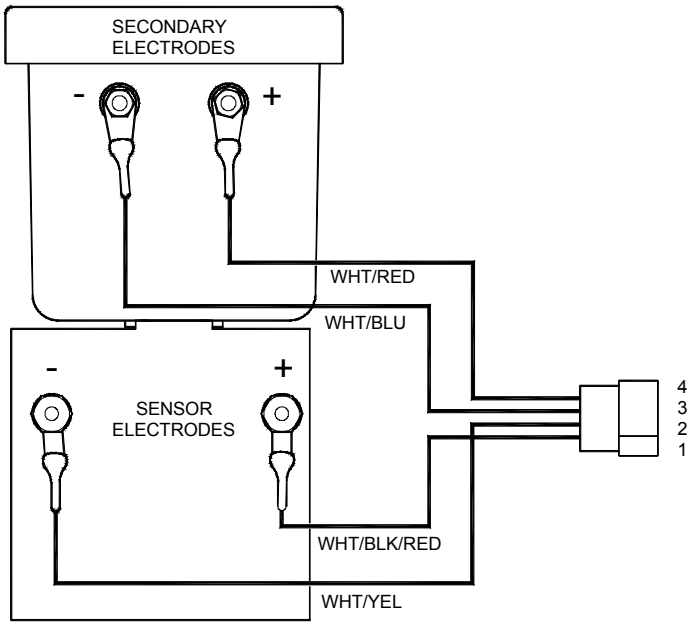


Figure 26: Oxygen Sensor Cable Wiring

10 Safety

10.1 General Warnings

Users of the Series 500 should be familiar with the theory and techniques for operating oxygen monitoring equipment.

This section of the manual is not intended to instruct in general safety procedures, but only in safety related specifically to the Delta F Series 500 Oxygen Monitor.

To reduce the risk of fire or electric shock, do not expose this equipment to rain or water spray.

This instrument operates on potentially dangerous AC voltages. Disconnect all sources of AC power before opening the door for service.

10.2 Electrolyte Solution MSDS

MATERIAL SAFETY DATA SHEET

1. IDENTIFICATION OF THE SUBSTANCE

Trade Name	Electrolyte Solution, *ε-lectrolyte Gold*, *ε-lectrolyte Blue, ε-lectrolyte Black*, DF-E05, DF-E06, DF-E07, DF-E09
Manufacturer	Delta F Corp., 4 Constitution Way, Woburn, MA 01801-1087, USA, Tel + 1-781-935-4600
Emergency Contact	USA: 1-800-424-9300 International: 1-813-979-0626 (collect)
Supplier and contact in UK (for use in the UK only)	

2. COMPOSITION

CAS #	Component	EC Code/class	Concentration	Risk Phrase	Risk Description
7732-18-5	Water	231-791-2			
1310-58-3	Potassium Hydroxide in aqueous solution	215-181-3 C	0.77N: 4.3%w/w	R35	Causes severe burns

3. HAZARDS IDENTIFICATION

Main Hazard Corrosive. Causes severe burns on contact with skin, eyes and mucous membrane

CERCLA Ratings (scale 0-3)	Health = 3	Fire = 0	Reactivity = 1	Persistence = 0
NFPA Ratings (scale 0-4)	Health = 3	Fire = 0	Reactivity = 1	

Potential Health Effects:

Eye Contact	Causes severe eye burns. May cause irreversible eye injury. Contact may cause ulceration of the conjunctiva and cornea. Eye damage may be delayed.
Skin Contact	Causes skin burns. May cause deep, penetrating ulcers of the skin.
Ingestion	May cause circulatory system failure. May cause perforation of the digestive tract. Causes severe digestive tract burns with abdominal pain, vomiting, and possible death.
Inhalation	Inhalation under normal use would not be expected as this product is supplied as an aqueous solution and no hazardous vapors are emitted. Effects of inhalation are irritation that may lead to chemical pneumonitis and pulmonary edema. Causes severe irritation of upper respiratory tract with coughing, burns, breathing difficulty, and possible coma.
Chronic	Prolonged or repeated skin contact may cause dermatitis. Prolonged or repeated eye contact may cause conjunctivitis.

4. FIRST-AID MEASURES

Skin Contact	In case of skin contact, remove contaminated clothing and shoes immediately. Wash affected area with soap or mild detergent and large amounts of water for at least 15 minutes. Obtain medical attention immediately.
Eye Contact	If the substance has entered the eyes, wash out with plenty of water for at least 15 - 20 minutes, occasionally lifting the upper and lower lids. Obtain medical attention immediately.
Ingestion	If the chemical has been confined to the mouth, give large quantities of water as a mouthwash. Ensure the mouthwash has not been swallowed. If the chemical has been swallowed, do NOT induce vomiting. Give 470 - 950ml (2 - 4 cups) of water or milk. Never give anything by mouth to an unconscious person. Obtain medical attention immediately.
Inhalation	Inhalation under normal use would not be expected as this product is supplied as an aqueous solution and no hazardous vapors are emitted; however, if inhalation should somehow occur, remove from exposure to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Seek medical aid immediately.

5. FIRE FIGHTING MEASURES

Special Exposure Hazard	Not applicable
Extinguishing Media	Not Combustible. Select extinguishing media appropriate to the surrounding fire conditions.
Protective Equipment	Wear appropriate protective clothing to prevent contact with skin and eyes. Wear a self-contained breathing apparatus (SCBA) to prevent contact with thermal decomposition products.

6. ACCIDENTAL RELEASE MEASURES

Personal Protection	Use proper personal protective equipment as indicated in Section 8.
Leaks and Spills	Absorb spill with inert material (e.g., dry sand or earth), then place into a chemical waste container. Neutralize spill with a weak acid such as vinegar or acetic acid.
Clean-up Procedures	Wash the spillage site with large amounts of water.

7. HANDLING AND STORAGE

Handling Precautions	Complete eye and face protection, protective clothing, and appropriate gloves must be used. Do not get in eyes, on skin, or on clothing. Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Do not ingest or inhale.
Storage Precautions	Store in a tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances. Keep away from strong acids.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Personal Protection

Eyes	Wear appropriate protective chemical safety goggles and face shield as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.
Skin	Wear appropriate gloves to prevent skin exposure.
Clothing	Wear appropriate protective clothing to prevent skin exposure.
Respirators	Not Applicable. Inhalation under normal use would not be expected as this product is supplied as an aqueous solution and no hazardous vapors are emitted.
Airborne Exposure	This material is supplied as an aqueous solution and will not be present in the atmosphere in normal use.
Exposure Limits	Potassium Hydroxide UK EH40, OEL (8hr TWA) 2mg/m^3 NIOSH, (8hr TWA) 2mg/m^3 ACGIH, Ceiling 2mg/m^3 OSHA, not listed

9. Physical & Chemical Properties

Molecular Formula	KOH Mixture
Physical State	.77N aqueous solution. Colorless, odorless
pH	Alkaline
Solubility	Completely soluble in water
Boiling Point	104.5^{0}C
Melting Point	-3.5^{0}C
Flash Point	Not applicable
Flammability	Not flammable
Explosion Limits	Not applicable
Specific Gravity	1.15
Vapor Pressure	16.1 mm Hg @ 20^{0}C

10. Stability & Reactivity

Chemical Stability	Stable
Conditions/Materials to Avoid	Incompatible materials, acids and metals
Incompatibilities with other Materials	Reacts with chlorine dioxide, nitrobenzene, nitromethane, nitrogen trichloride, peroxidized tetrahydrofuran, 2,4,6-trinitrotoluene, bromoform+ crown ethers, acids alcohols, sugars, germanium cyclopentadiene, maleic dicarbide. Corrosive to metals such as aluminum, tin, and zinc to cause formation of flammable hydrogen gas.
Hazardous Decomposition Products	Oxides of potassium
Hazardous Polymerization	Has not been reported

11. Toxological Information

RTECS#	CAS# 7732-18-5	ZC0110000
	CAS# 1310-58-3	TT2100000
LD50/ LC50	CAS# 7732-18-5	Oral, ret:LD50 = >90 ml/kg

	CAS# 1310-58-3	Draize test, rabbit, skin: 50 mg/24H Severe Oral, rat: LD50 = 273 mg/kg
Carcinogen Status	CAS# 7732-18-5	Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA
	CAS# 1310-58-3	Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA

Potassium Hydroxide Solution is a severe eye, mucus membrane, and skin irritant.

12. Ecological Information

Mobility	Completely soluble in water
Degradability	Will degrade by reaction with carbon dioxide from the atmosphere to produce a non-hazardous product.
Accumulation	No
Ecotoxicity	Information not available. No long-term effects expected due to degradation. The preparation is already in dilute solution and adverse aquatic effects are not expected due to further dilution. The preparation is corrosive, and direct contact with fauna will cause burns.

13. Disposal Considerations

Waste Disposal	Dispose of in a manner consistent with federal, state, and local regulations.

14. Transportation Information

	Shipping Name	Hazard Class	UN Number	Packaging Group
US DOT	Potassium Hydroxide Solution	8	UN1814	II
IATA	Potassium Hydroxide Solution	8	UN1814	II
ADR/RID	Potassium Hydroxide Solution	8	UN1814	II
IMDG Code	Potassium Hydroxide Solution	8	UN1814	II
Canadian TDG	Potassium Hydroxide Solution	8(9.2)	UN1814	Not Available

15. Regulatory Information

US FEDERAL

TSCA	CAS# 7732-18-5	**Listed on TSCA Inventory**
	CAS# 1310-58-3	**Listed on TSCA Inventory**
Health & Safety Reporting List		None of the chemicals on Health & Safety Reporting List
Chemical Test Rules		None of the chemicals are under Chemical Test Rule

Section 12b		None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule		None of the chemicals have a SNUR under TSCA
CERCLA Hazardous Substances and corresponding RQ's	CAS# 1310-58-3	1000 lb final RQ; 454kg final RQ
SARA Section 302 Extremely Hazardous Substances		None of the chemicals have a TQP
SARA Codes	CAS# 1310-58-3	Immediate, Reactive
Section 313		No chemicals are reportable under Section 313
Clean Air Act		Does not contain any hazardous air pollutants Does not contain any Class 1 Ozone depletors Does not contain any Class 2 Ozone depletors
Clean Water Act	CAS# 1310-58-3	Listed as a Hazardous Substance under the CWA
		None of the chemicals are listed as Priority Pollutants under the CWA
		None of the chemicals are listed as Toxic Pollutants under the CWA
OSHA		None of the chemicals are considered highly hazardous by OSHA
STATE	CAS# 7732-18-5	Not present on state lists from CA, PA, MN, MA, or NJ.
	CAS# 1310-58-3	Can be found on the following state right to know lists; CA, NJ, PA, MN, MA.
California Prop 65		California No Significant Risk Level: None of the chemicals are listed.

European/International Regulations
European Labeling in Accordance with EC Directives

Classification	Corrosive	
Hazard Symbol	C	
EC Number	215-181-3	
Risk Phrases	R35	Causes severe burns.
	R22	Harmful if swallowed
Safety Phrases	S1/2	Keep locked up and out of reach of children.
	S26	In case of contact with the eyes, rinse immediately with plenty of water and seek medical advice.
	S36	Wear suitable protective clothing.
	S37/39	Wear suitable gloves and eye/face protection.
	S45	In case of accident or if you feel unwell, seek medical advice immediately (show label where possible).

WGK (Water Danger/Protection)	CAS# 7732-18-5	No information available
	CAS# 1310-58-3	1
Canada – DSL/ NDSL	CAS# 7732-18-5	Listed on Canada's DSL List
	CAS# 1310-58-3	Listed on Canada's DSL List
Canada - WHMIS	Classification E, D1B	Classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by those regulations.
Canadian Ingredient Disclosure List	CAS# 1310-58-3	Listed on the Canadian Ingredient Disclosure List

16. Other Information

MSDS Creation Date: 09/30/94 MSDS Revised: May 1, 2007

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information. Liability is expressly disclaimed for loss or injury arising out of use of this information or the use of any materials designated. Users should make their own investigation to determine the suitability of the information for their particular purpose.

10.3 Replenishment Solution MSDS

MATERIAL SAFETY DATA SHEET

1. IDENTIFICATION OF THE SUBSTANCE

Trade Name	Replenishment Solution, RS-A
Manufacturer	Delta F Corp., 4 Constitution Way, Woburn, MA 01801-1087, USA, Tel + 1-781-935-4600
Emergency Contact	USA: 1-800-424-9300 International: 1-813-979-0626 (collect)
Supplier and contact in UK (for use in the UK only)	

2. COMPOSITION

CAS #	Component	EC Code/class	Concentration	Risk Phrase	Risk Description
7732-18-5	Water (contains trace salts)	215-181-3 C	100%		

3. HAZARDS IDENTIFICATION

Main Hazard None

CERCLA Ratings (scale 0-3)	Health = 0	Fire = 0	Reactivity = 1	Persistence = 0
NFPA Ratings (scale 0-4)	Health = 0	Fire = 0	Reactivity = 1	

Potential Health Effects:

Eye Contact	Not applicable.
Skin Contact	Not applicable.
Ingestion	Not applicable.
Inhalation	Not applicable.
Chronic	Not applicable.

4. FIRST-AID MEASURES

Skin Contact	Not applicable.
Eye Contact	Not applicable.
Ingestion	Not applicable.
Inhalation	Not applicable.

5. FIRE FIGHTING MEASURES

Special Exposure Hazard Not applicable

Extinguishing Media	Not combustible. Select extinguishing media appropriate to the surrounding fire conditions.
Protective Equipment	In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

6. ACCIDENTAL RELEASE MEASURES

Non-hazardous material. Clean up of spills requires no special equipment or procedures.

7. HANDLING AND STORAGE

Keep container tightly closed. Suitable for any general chemical storage area. Protect from freezing. May react vigorously with some specific materials. Avoid contact with all materials until investigation shows substance is compatible.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Personal Protection

Eyes	None required.
Skin	None required.
Clothing	Not applicable.
Respirators	Not Applicable.
Airborne Exposure	Not applicable.
Exposure Limits	Not applicable.

9. Physical & Chemical Properties

Molecular Formula	H2O containing trace salts
Physical State	Colorless, odorless liquid
pH	6.0-8.0
Solubility	Complete (100%)
Boiling Point	100^0C
Melting Point	0^0C
Flash Point	Not applicable
Flammability	Not flammable
Explosion Limits	Not applicable
Specific Gravity	1.00
Vapor Pressure	17.5 mm Hg @ 20^0C

10. Stability & Reactivity

Chemical Stability	Stable

Conditions/Materials to Avoid	Strong reducing agents, acid chlorides, phosphorus trichloride, phosphorus pentachloride, phosphorus oxychloride.
Hazardous Decomposition Products	Not applicable.
Hazardous Polymerization	Has not been reported

11. Toxological Information

Toxicity (water)	CAS# 7732-18-5: Oral, rat: LD50 >90 mL/kg
Carcinogen Status	Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA

12. Ecological Information

Mobility	Completely soluble in water
Degradability	Not applicable.
Accumulation	Not applicable.
Ecotoxicity	Applicable.

13. Disposal Considerations

Waste Disposal	Whatever cannot be saved can be flushed to sewer. If material becomes contaminated during use, dispose of accordingly. Dispose of container and unused contents in accordance with federal, state, and local requirements.

14. Transportation Information

Not regulated.

15. Regulatory Information

16. Other Information

NFPA Ratings: Health: 0 Flammability: 0 Reactivity: 0

MSDS Creation Date: 09/30/94 MSDS Revised: December 7, 2006

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information. Liability is expressly disclaimed for loss or injury arising out of use of this information or the use of any materials designated. Users should make their own investigation to determine the suitability of the information for their particular purpose.

11 Warranty

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

Delta F's three (3) year Sensor Warranty offers extended protection such that, if any Sensor of a Delta F Series 500 Oxygen Monitor fails under normal use within three (3) years of purchase, such Sensor may be returned to the Seller (at the owners expense) and, if such Sensor is determined by the Seller to be defective by material or workmanship, the Seller shall provide the Buyer a replacement Sensor at no charge. Delta F also provides an optional 5 (five) year Sensor Warranty (Contact your local Delta F agent for details).

In no event shall the 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 the 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 the Seller and the directions received for properly identifying items returned under warranty are followed; and (iv) with return, notice authorizes the Seller to examine and disassemble returned products to the extent the 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 the Seller does not assume any other obligation or liability in connection with the sale or use of said products.

DISCLAIMER OF WARRANTY

Delta F Corporation makes no representation or warranties, either express or implied, by or with respect to anything in this manual, including, but not limited to implied warranties of merchantability or fitness for a particular purpose. In no event will Delta F Corporation be liable for any damages, whether direct or indirect, special, consequential or incidental, arising from the use of this manual. Some states do not allow the exclusion of incidental or consequential damages, so this exclusion may not apply.

12 Appendix – Remote Sensor Configurations

NOTE

This section supplements and may supersede information contained in previous sections of this manual.

12.1 Designations

The Remote Sensor is available in four versions summarized in Table 13 below. Refer to the descriptions to determine the configuration that is to be installed.

Designation	Description
R	Open Diffuser Sensor (no inlet/outlet gas fittings)
RB	Extractive Sample Sensor (includes inlet/outlet fittings)
RBFC	Extractive Sample Sensor and Rotameter with Integral Flow Control Valve
RBP	Extractive Sample Sensor, with Rotameter, Flow Control Valve and AC pump

Table 13: Remote Sensor Configurations

12.2 Mounting

The sensor must be mounted in a location that does not experience temperature fluctuations. If the sensor has an open diffuser, the diffuser must be shielded from drafts and directed ambient flow, such as the air stream from a cooling fan or ventilation system.

Monitors that are supplied with pumps have vibration isolators mounted between the oscillating pump and the mounting bracket. The vibration isolators effectively dampen, but do not eliminate, the oscillations from the pump. Installations that contain equipment that is sensitive to vibration may be affected.

12.2.1 Mounting the sensor bracket

Figure 27 - Figure 30 illustrate the various Remote Sensor Assembly configurations. All the Sensor Bracket Assemblies are wall-mounted with four 1/4 inch screws. The hole pattern is shown in Figure 31.

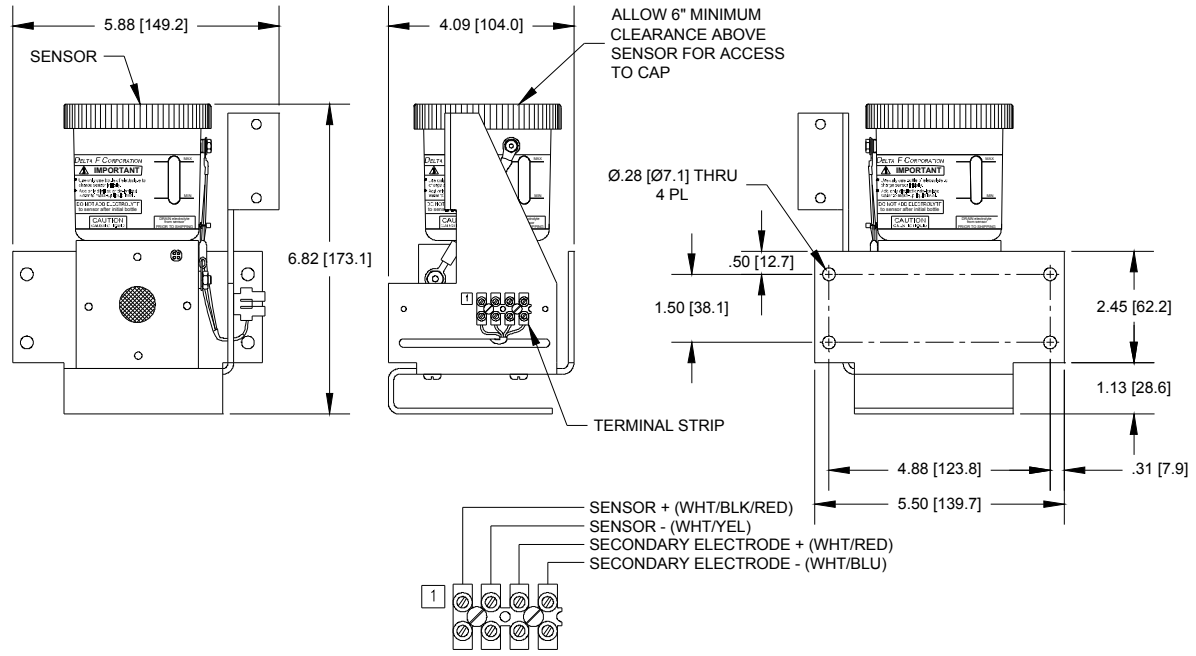


Figure 27: Model R with open diffuser sensor

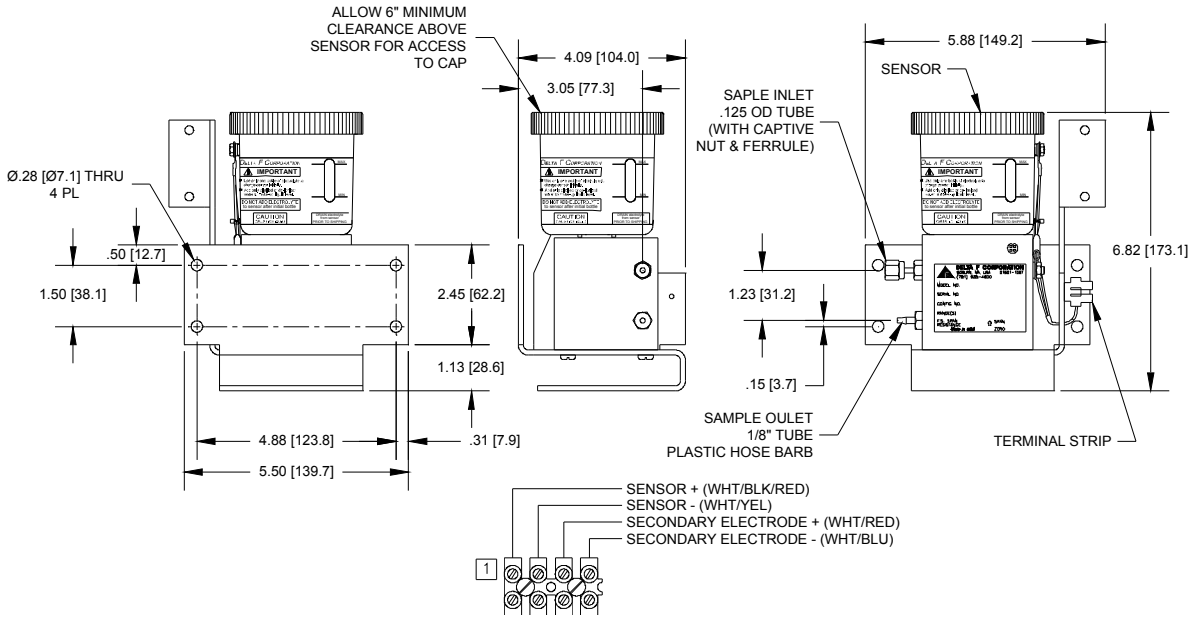


Figure 28: Model RB with extractive sensor

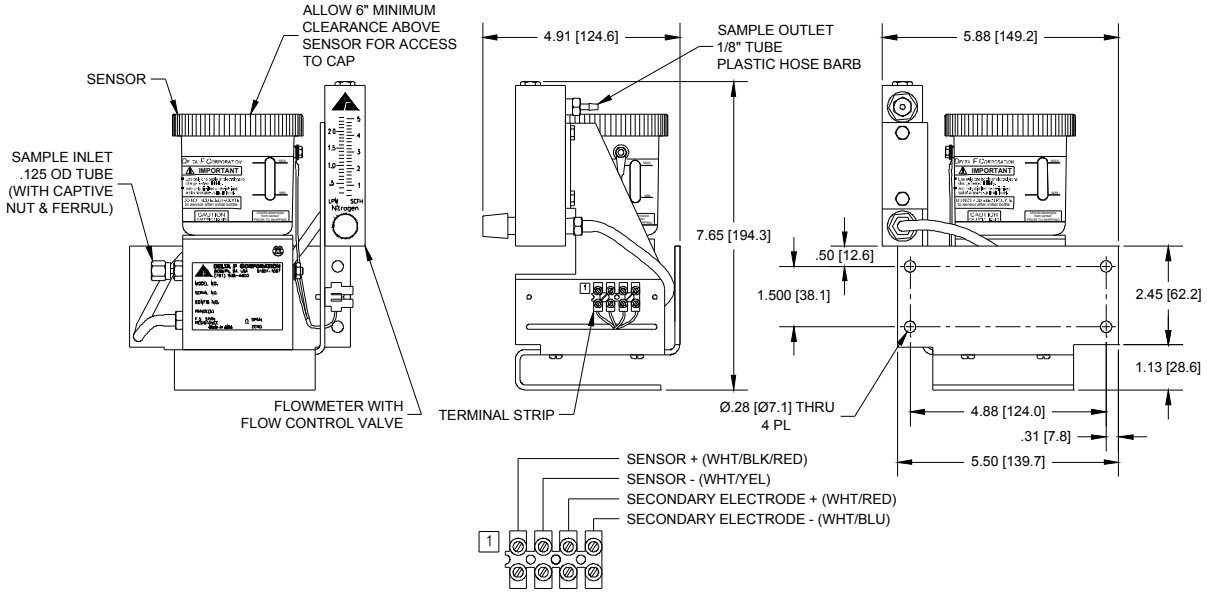


Figure 29: Model RBFC with extractive sensor and flowmeter with flow control valve

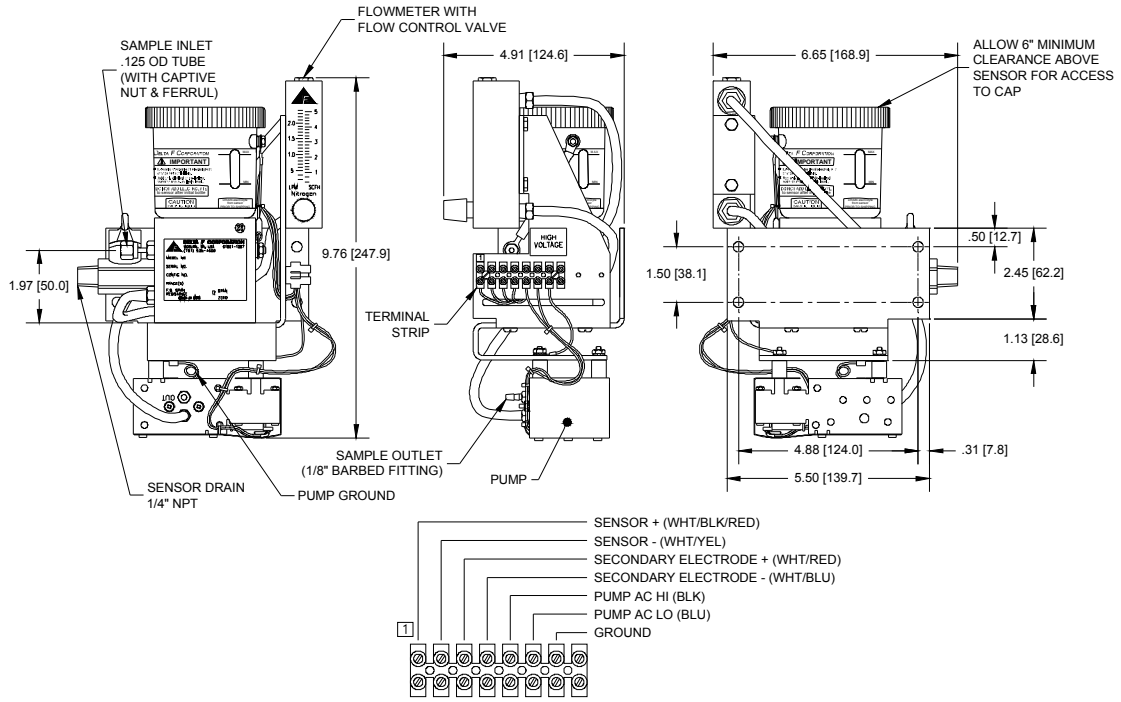


Figure 30: Model RBP with extractive sensor, flowmeter, valve and pump

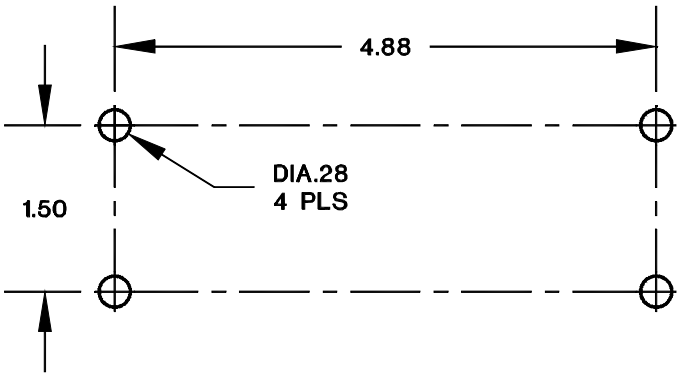


Figure 31: Remote Sensor Bracket Mounting Holes

12.3 Plumbing Configurations

For all except the R version, stainless steel tubing is recommended for the gas sample inlet plumbing. The Sensors used on the RB, RBFC and RBP versions come equipped with 1/8 inch compression fittings on the inlet and outlet of the Sensor. The top fitting, which is the inlet, has a ferrule and nut attached. The Sensor outlet (bottom) plumbing depends upon the version.

12.3.1 R Version

The R version uses an open diffuser in the Sensor. Therefore, R versions do not require any additional plumbing. See Figure 27

12.3.2 RB Version

The RB version has a 1/8 inch tube fitting at the Sensor outlet. Plastic tubing, such as clear PVC can be used on the outlet line. See Figure 28.

12.3.3 RBFC Version

The RBFC version is supplied with a 0-5 scfh rotameter, equipped with an integral flow control valve, plumbed into the Sensor outlet. Typically, the outlet sample line is located at the rotameter outlet (the upper connection) which is fitted with a 1/8 inch tube connection. This plumbing configuration is used where sample supply pressure is less than 1.0 psig and/or the return line may be subject to vacuum conditions.

With the rotameter/valve assembly plumbed downstream of the sensor, pressure at the sensor remains close to atmospheric pressure (assuming inlet pressure losses are close to zero). Clear PVC can be used to plumb the outlet line.

For applications with process supply pressures of <5 psig, the instrument may be ordered with a rotameter/valve assembly plumbed upstream of the sensor. In these cases, the valve is used to reduce sample pressure to a value close to atmospheric pressure. In this configuration, the line connecting the outlet of the rotameter to the inlet of the sensor will be supplied as stainless steel. The Sensor outlet line must not have excessive pressure drop, e.g. > 15"H_2O. The flow rate should be set to 2.0 +/- 0.5 scfh. See Figure 29.

12.3.4 RBP Version

The RBP version is equipped with an extractive sample Sensor with an electrolyte drain valve, a rotameter with integral flow control valve, and a 115 VAC pump, all mounted on a remote bracket, Figure 12-4. The sample pump is installed on the underside of the bracket. This 115 VAC pump is not equipped with an ON/OFF switch, so it operates whenever the Series 500 is powered. A drain valve is provided in this version (which has a pump) to facilitate changing electrolyte.

The pump is on the downstream (outlet) side of the sensor. Gas sample inlet connections are made at the Sensor. Gas sample outlet connections are made at the pump outlet. The pump is equipped with a barbed fitting for 1/8 inch flexible tubing. See Figure 30.

The sample inlet pressure must not exceed 1 psig. Damage to the sensor may result. Any upstream flow control valve(s) must be open prior to powering the pump on.

12.3.4.1 RBP Battery Backup Exclusion

Only the RBP version DOES NOT INCLUDE BATTERY BACK-UP. The front panel LOW BATTERY, CHECK BATTERY, and BATTERY OPERATION lights do not function as described in section 6.3 - Alarm Conditions in this manual. Additionally, the battery-related voltages that are read in the Diagnostic Mode (see manual section 6.1.1-Diagnostic Functions) should be disregarded for Diagnostic Sequences 2 (charging voltage) and 5 (battery voltage).

12.3.4.2 Calibration Procedure for RBP Version

The pump-equipped RBP version of the Series 500 Oxygen Monitor has plumbing lines in place of the open diffuser. This version is calibrated by disconnecting the inlet port (upper gas connection at the sensor) to expose the port to ambient air.

The pump must be operating to draw a sample of ambient air through the sensor. Use the valve on the rotameter to adjust the flow rate to 2 scfh. Under normal atmospheric conditions, at sea level, the monitor will read 20.9% oxygen.

If it is desired to calibrate using a gas with an oxygen content different from air, a bottle of the desired compressed gas, regulated to less than 1.0 psig, can be connected to the 1/8" inlet compression fitting. The pump does not need to be operating. A flow rate of 2 scfh can be set with the rotameter valve after the specified pressure is attained.

It is critical that the inlet pressure and flow be set as specified. Over pressure may cause damage to the sensor.

12.4 Wiring to Remote Sensor

All interconnections between the Sensor, Series 500 enclosure, and output devices must be made before powering-up the monitor.

The terminal strips on the Series 500 cabinet and remote sensor bracket will carry AC voltage if the monitor is equipped with a pump. A removable protective cover has been installed over the terminals to prevent accidental contact. Replace the cover after wiring is complete.

12.4.1 Cable Requirements for Remote Sensor Installations

A remote sensor may be located up to 1000 feet from the Series 500 enclosure. The sensor assembly, with optional pump, is connected to the enclosure through one or two shielded multiconductor cables. The first shielded cable is used for the four sensor signals. The second shielded cable supplies 115 VAC and earth ground to the optional pump. Shielding on both cables is connected to earth ground at the Series 500 cabinet end, only, to prevent

ground loops. The pump cable is shielded to prevent capacitive coupling of AC into the sensor cable.

There is a terminal block inside the Series 500 enclosure, and a terminal block on the remote sensor assembly. One of the remote sensor terminal block positions is used for connecting the earth ground wire from the optional pump cable. Earth ground connection is not required if the remote sensor assembly is not equipped with a pump.

Cable wire sizes should be as follows:

PUMP CABLE	
DISTANCE IN FEET	**MINIMUM WIRE GAUGE**
0 – 500	#22 AWG
500 - 1000	#20 AWG

Table 14: Pump Cable Wire Size

SENSOR CABLE	
DISTANCE IN FEET	**MINIMUM WIRE GAUGE**
0 – 150	#20 AWG
150 - 250	#18 AWG
250 - 350	#16 AWG
350 - 1000	#14 AWG

Table 15: Sensor Cable Wire Size

NOTE

The monitor is calibrated at the factory with a short cable. A 1000 foot cable will cause the calibration to change up to several percent of full scale. If the highest accuracy is required, a span calibration should be performed after the components are installed.

ELECTRONICS ENCLOSURE	SIGNAL	REMOTE SENSOR BRACKET
1	Sensor (+)	1
2	Sensor (-)	2
3	Secondary Electrode (+)	3
4	Secondary Electrode (-)	4
5	Pump AC Hi	5
6	Pump AC Low	6
7	Ground	NONE - See Note 1

Table 16: Interconnect Cable Pin Out

NOTE 1: Cable shields are also connected to pin 7 of the electronics enclosure. In order to prevent ground loops, the cable shield is NOT connected to the remote sensor bracket.

12.5 Pressure and Flow

The RB version is designed to operate with a pressurized sample gas stream, or with a sample return under a slight vacuum. A flow control valve may be installed upstream of the sensor and used to reduce pressure if pressure is <5.0 psig at the source. A regulator may be required to reduce the pressure to a safe operating level if higher than 5.0 psig. Further, if the sample return line is connected up to a vacuum source to establish the sample flow, the vacuum level at the sensor must not drop below 50 inches of water column vacuum (-2.0 psig). It is recommended that a flow control valve be installed between the vacuum source and the sensor to control flow.

If the RBFC version is equipped with the rotameter/valve assembly installed upstream of the sensor, the flow control valve may be used to reduce upstream pressure if source is <5.0 psig.

The RBP version has a pump which is sized to draw the required flow through the Sensor with a 1.0 to 2.0 psig system pressure drop.

The flow rate should be set to 2.0 +/- 0.5 scfh.

12.6 Electrolyte Filling and Draining

For the RBP monitor configuration, a PVC drain valve has been added to the Sensor. This valve is located on the lower left side of the Sensor. Prior to filling the Sensor, make sure that the handle on the valve is in the vertical position. Refer to section 5.4 - Adding Electrolyte for Sensor filling instructions.

To drain the Sensor, attach the supplied fitting and tubing to the threaded end of the valve. Use light wrench pressure on the plastic nut to insure a leak-tight seal. Place the tube end

in a suitable receptacle for proper disposal of electrolyte. Remove the Sensor cover and rotate the valve handle to the horizontal position

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