DF Series
Oxygen Analyzer

OEM Version
Model *DF-110ℰ*

Instruction Manual

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Rev C
031611

The Delta F Difference

Your Analyzer has been designed, manufactured and will be supported under ISO-9001 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 start-up, please read this manual carefully. There are important cautions and a number of helpful hints that will 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 or e-mail us at service@delta-f.com.

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3 CAUTIONS

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

3.1 Explanation of Graphic Symbols

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.

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

DANGER

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 operate this Oxygen 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.

4 Specifications

4.1 Range

DF-110 Single Range Analyzer

Range (ppm)	DF-110 Model #	Range (%)	DF-110 Model #
0 to 5,000 ppm	111-5000	0 to 25%	111-P25
0 to 1,000 ppm	111-1000	0 to 10%	111-P10
0 to 500 ppm	111-500	0 to 5%	111-P5
0 to 100 ppm	111-100	0 to 1%	111-P1
0 to 50 ppm	111-50		
0 to 10 ppm	111-10		

DF-110 Three Range Analyzer

Ranges (ppm)	DF-110 Model #	Ranges (%)	DF-110 Model #
0 to100/1,000/10,000 ppm	113-10000	0 to 0.25/2.5/25%	113-P25
0 to 50/500/5,000 ppm	113-5000	0 to 0.1/1/10%	113-P10
0 to 10/100/1,000 ppm	113-1000	0 to 0.05/0.5/5%	113-P5
0 to 5/50/500 ppm	113-500		
0 to 1/10/100 ppm	113-100		

4.2 Response Time

Responds instantaneously to O_2 change. Equilibrium time depends on specific conditions. Typically less than 10 seconds to read 90% of a step change.

4.3 Accuracy

At constant conditions, the greater of +/- 3% or 0.5% of measurement range, but not lower than 0.05% of full analyzer range for three range analyzers.

4.4 Sample Gas Compatibility

Standard Sensor

All inert and passive gases including N_2, H_2, CO, freons, light hydrocarbons, etc.

Sensor with Stab-El™

Neutralizes contaminants including acids such as CO_2, H_2S, Cl_2, NO_X, SO_X, etc. (See page 15 for concentration limits).

4.5 Sample Requirements

Gas phase, non-condensing, sample temperature: -17 to 45°C (0 to 113°F).

Flow rate 1.0 to 2.0 scfh at 0.2 to 1.0 psig pressure.

4.6 Ambient Temperature Requirements

Room/cabinet temperature: 0 to 45°C (32 to 113°F)

4.7 Miscellaneous

Store and operate between 0°C and 45°C (32°F and 113°F).

100-120/200-240 VAC, 50-60 Hz, 1.0/0.5 A maximum

Nominal power consumption 20 Watts

5 Analyzer Start-Up Procedure

Your OEM analyzer has been thoroughly tested and calibrated, however, it is necessary to "charge" the sensor with electrolyte prior to turning the analyzer on.

CAUTION

To avoid damage to your analyzer:

- *Do not operate without electrolyte in the sensor*
- *Do not use more than one bottle of ℰ-Lectrolyte Blue*
- *Do not operate without gas flow*
- *Do not operate a trace level analyzer for more than a few minutes while exposed to air.*
- *Do not exceed the gas pressure and flow limits*

The electrolyte is a caustic solution. Review the Material Safety Data Sheet (MSDS) on page 49 before handling the electrolyte solution.

5.1 Charging the Sensor

Locate the Oxygen Sensor

1. Un-screw the lid from the sensor.

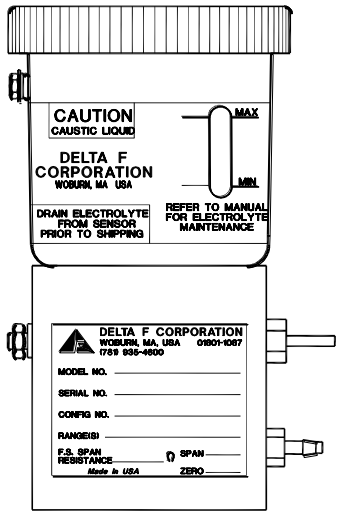

Figure 1: Delta F Oxygen Sensor

Add Electrolyte

1. Add the entire contents of *one bottle* of Delta F type ℰ-Lectrolyte Blue to the sensor.
2. Add enough Delta F Replenishment Solution to raise the level to the "max" line, if needed.
3. Replace the sensor lid.
4. Allow the sensor to sit for 60 minutes before starting gas flow.

CAUTION

To insure proper operation, when adding the electrolyte for the first time, or when changing the electrolyte, allow the sensor to sit for 60 minutes before starting gas flow.

Adjust the sample gas flow rate

1. In positive pressure applications slowly adjust the flow rate as indicated on the flowmeter to 2.0 scfh using an upstream flow control valve or pressure regulator.
2. If a background gas other than nitrogen is being used, the "indicated" flow rate must be set as shown in Table 1.

Background Gas	Flowmeter Setting (scfh)
Argon	1.2
Ethylene	1.0
Nitrogen or Air	1.0
Carbon Monoxide	1.0
Methane	0.8
Hydrogen	0.3
Helium	0.4

Table 1: Flowmeter Settings versus Background Gas

5.2 Powering up the Analyzer

1. Verify the analyzer is set to the desired 110 VAC or 220 VAC selection by checking the voltage indication sticker.
2. For concentrations below 100 ppm, it is useful to let the analyzer "purge" by letting gas flow through it for about five minutes before the power and sensor are turned on.
3. A three range analyzer should be set to the highest range.
4. Be sure the Sensor Off switch is *not* depressed (OFF). See Figure 2

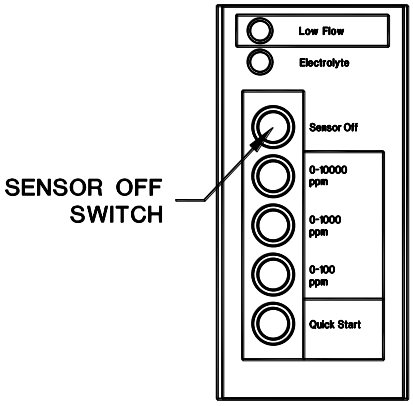

Figure 2: Sensor Off Switch

5. Turn the analyzer on using the power switch. See Figure 3.

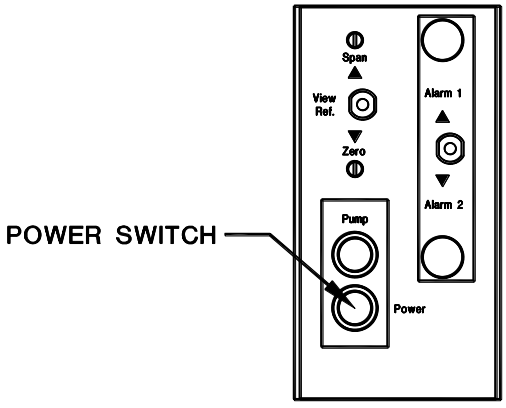

Figure 3: Power Switch

6. Allow several minutes for the analyzer to come "on range"

7. Progressively switch to a lower range as the reading allows.

5.3 Additional Capabilities

Your analyzer may be equipped with additional capabilities. Consult the Standard Features section on page 13 and the Options section on page 15 for information regarding:

- Analog Output Scaling for 0 to 1.0, 2.0 or 5.0 VDC
- 4 to 20 mA Output
- Stab-El™ Acid Gas System
- Pressure Regulators and Flow Control Valves
- Gas Flow Switch
- Sample Pump
- Quick Start

Also, see the Outputs and Remote Connections section on page 27 for information regarding:

- Remote Sensor Operation
- Remote Pump Operation
- Remote Control of On-board Pump

6 Standard Features

The DF Series analyzers use a patented, non-depleting, coulometric sensor to detect oxygen in gas sample streams.

The DF analyzer is generally tolerant of contaminants, as well as pressure and temperature fluctuations. However, the sample gas must be relatively clean, dry, and free of hostile components.

Your analyzer has been custom built to order and calibrated to operate across a specific range of oxygen concentrations using calibration gas traceable to NIST.

6.1 Stable Calibration

The analyzer will remain calibrated as long as the sensor and its electrolyte are properly maintained. Refer to the Maintenance and Calibration Checks section on page 33 for additional information.

6.2 Electrolyte Condition Indicator

This indicator will light if the electrolyte level falls too low or, in some cases, becomes contaminated. If the electrolyte is low, simply add Delta F type Replenishment Solution to the sensor. ***Do not add more electrolyte after the initial bottle is put in!***

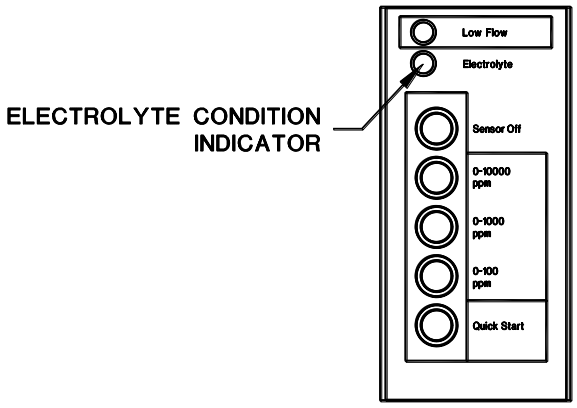

Figure 4: Electrolyte Condition Indicator

6.3 Analog Output

The default setting for the analog signal output is 0 to 10 VDC. Alternate settings available when ordering are 0 to 1 VDC, 0 to 2 VDC or 0 to 5 VDC.

The analog output is proportional to the oxygen reading of the analyzer. The analog output on a three range analyzer will be scaled to the “selected” range.

7 Options

7.1 Stab-El™

The Stab-El™ option can prevent trace levels of acid in the gas from compromising the sensor. The maximum allowable levels of acid component in the sample stream are the following:

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

*Concentrations of CO_2 are in percent. One percent is equivalent to 10,000 ppm.

Table 2: Maximum Acid Gas Concentrations with Stab-El™ (in ppm)

Contact Delta F for recommendations on using the Stab-El™ sensor on acid gases other than those listed above.

If the acid gas components in your gas exceed the limits in Table 2 several approaches can be taken:

- An acid scrubber can be placed up stream of the analyzer to remove the bulk of the acids, and the Stab-El™ option will allow the analyzer to cope with the remaining trace levels.
- The analyzer duty cycle can be adjusted to limit its exposure to acids and to allow the Stab-El™ option to “keep up”.
- A dilution system can be added to limit acid concentration.
- Consult Delta F for further recommendations.

7.2 Alarms

The **DF-110** can be equipped with one or two alarms. Alarm 1 can be factory configured for high O_2, low O_2, and Trouble. Alarm 2 can be configured for high O_2 or low O_2.

In the standard oxygen alarm configuration:

- Alarm 1 activates when oxygen exceeds the set point.
- Alarm 2 activates when oxygen falls below the set point.

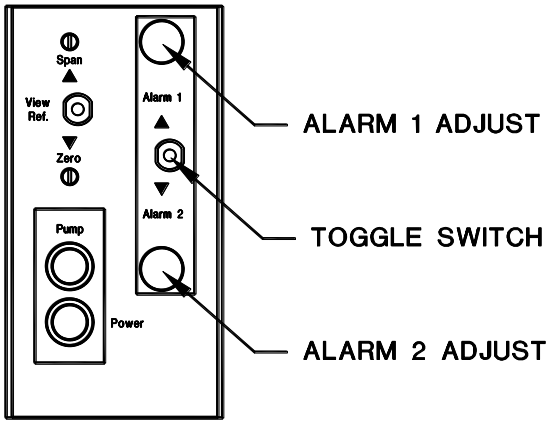

Figure 5: Setting alarms

7.2.1 Adjusting Oxygen Alarm Set Points

1. Push the toggle switch, located between the alarm set point adjustments, in the appropriate direction.
2. Adjust the alarm knob while viewing the alarm value on the display. See note below for analyzers with no local display.
3. Release the toggle switch to resume normal operation.

NOTE FOR ANALYZERS WITH NO LOCAL DISPLAY

On OEM analyzers that are not equipped with a local display, the meter signal is connected to the Display + and Display - pins on the Remote Sensor Connector. This output is high impedance and must be measured with a meter having an input impedance of 10 Meg or greater.

If the analyzer is equipped with one or more optional Oxygen Alarms the signal at Display + and Display - will correspond to the Alarm Set Point when the Alarm View switch is set to the Alarm 1 or Alarm 2 position. The voltage read is the alarm set point scaled exactly the same way as in the oxygen measurement mode, as seen in Table 3.

(Example: See the entry for the three range 0-100.0/1000.0/10000 PPM analyzer. If the analyzer is set to the 0-100.0 PPM range the alarm set point at Display + and Display - will be 0-100.0 PPM scaled over 0 to 1.000 VDC. So if the voltage happened to be 0.100 VDC then the set point would be 10.0 PPM. If the analyzer were operating on the 0-1000.0 range the alarm set point at Display + and Display - will be 0-1000.0 PPM scaled over 0 to 1.000 VDC. So if the voltage happened to be 0.100 VDC then the set point would be 10.0 PPM.)

Analyzer Range	Voltage At Pins Display + & Display -
SINGLE RANGE TRACE ANALYZERS	
0-5000 PPM	0-0.500 V
0-1000 PPM	0-1.000 V
0-500 PPM	0-0.500 V
0-100.0 PPM	0-1.000 V
0-50.0 PPM	0-0.500 V
0-10.00 PPM	0-1.000 V
SINGLE RANGE PERCENT ANALYZERS	
0-25.0%	0-0.250 V
0-10.00%	0-1.000 V
0-5.00%	0-0.500 V
0-1.00%	0-0.100 V
TRIPLE RANGE TRACE ANALYZERS	
0-100.0/1000.0/10000 PPM	0-1.000 V
0-50.00/500.0/5000 PPM	0-0.500 V
0-10.00/100.0/1000 PPM	0-1.000 V
0-5.00/50.0/500 PPM	0-0.500 V
0-1.00/10.0/100 PPM	0-0.100 V
TRIPLE RANGE PERCENT ANALYZERS	
0-.250/2.50/25.0%	0-0.250 V
0-0.100/1.00/10.0%	0-0.100 V
0-.050/.50/5.0%	0-0.050 V

Table 3: Meter Output Voltages

NOTE

- *Alarm triggers are inhibited while adjusting the set points.*
- *The analyzer will continue to operate normally while alarms are adjusted.*

7.2.2 Alarm Relays

In the “No Alarm” condition the **NC** contact is connected to the **C** contact.

In the “Alarm” condition the **NO** contact is connected to the **C** contact.

The alarm relays are configured for “Fail Safe” operation. The relays will go to an Alarm Condition when the analyzer is turned off or when power fails.

Each alarm has a SPST relay rated at 125/250 VAC at 5 amps and 30 VDC at 5 amps.

7.3 Pressure Regulators

The Standard Regulator is rated for 3000 psig inlet pressure.

The Absolute Regulator is rated to 1000 psig inlet pressure.

7.4 Filter

The Gas Sample Particle Filter is mounted upstream of the sensor. The following filter elements can be purchased from Delta F.

Filter	Part Number
Fine grade (BQ) (< 1 micron)	64005012
Standard grade (DQ) (> 1 micron)	64005011

Table 4: Particle Filters

The life of the filter element is dependent upon the nature of the sample gas. Therefore, it is difficult to recommend a filter element replacement frequency.

Delta F recommends to check the filter condition every several weeks initially until the demands of the application can be determined and a filter element replacement frequency can be established.

7.5 Low Flow Indication

The Sample Gas Flow Switch is mounted downstream of the sensor. The contacts will open when the sample flow falls below 0.12 lpm (0.26 scfh).

The Flow Switch connections can be made directly at the flow switch or terminal strip, if equipped. The contacts are rated at 120 VAC or 120 VDC at 0.5 A resistive.

7.6 Flow Control Valve

The upstream Flow Control Valve is mounted adjacent to the Flow Indicator. It may be used to control the gas flow rate in systems where the inlet pressure is less than 5 psi.

7.7 Pump

The On-board Pump allows the analyzer to operate on gas sample streams between 2.0 psig vacuum and 2.0 psig positive pressure.

If the analyzer has a pump, it will also have a downstream Flow Control Valve mounted in the bottom of the flow meter. When using the pump, always use the downstream valve to control the gas flow rate.

If the pump is not in use, (positive pressure application) always control the gas flow with an upstream valve or regulator and leave any down stream valves wide open.

CAUTION

Do not use an upstream valve to control flow if the analyzer is operating on a pump.

7.7.1 Pump Control

The on-board pump is controlled by the Pump On/Off Switch.

If factory configured, an on-board pump can also be controlled via a user supplied, remote switch.

7.8 Analog Output

The default setting for the analog output is 0 to 10 VDC. Alternate settings available when ordering are 0 to 1 VDC, 0 to 2 VDC or 0 to 5 VDC.

The analog output is proportional to the oxygen reading of the analyzer. The output of a three range analyzer will be scaled to the “selected” range.

The minimum load impedance is 10k ohms.

7.9 Isolated 4 to 20 mA Output

The optional 4 to 20 mA output is proportional to the oxygen reading of the analyzer. The output of a three range analyzer will be scaled to the currently "selected" range.

An output of 4mA represents an operating analyzer with zero detected oxygen. Outputs ranging from 4 to 20 mA represent oxygen concentrations from zero to the top of the currently selected range.

The 4 to 20 mA output is electrically isolated from all other analyzer outputs and from chassis (Earth) ground.

The maximum load resistance is 1K ohms. The analyzer provides a loop supply of approximately 28 VDC.

7.10 Gas Scale Correction Factor

The analyzer is factory calibrated to measure oxygen in a background gas of nitrogen. If the background gas has a lower molecular size and weight than nitrogen (as does helium or hydrogen) the concentration of oxygen reported by the analyzer will be greater than the actual concentration. This effect occurs because the oxygen molecules can more easily diffuse through a low molecular weight gas (and reach the measurement electrode) than through nitrogen. The scale factor option allows the analyzer to automatically correct the oxygen reading for this background gas effect. Correspondingly, if the background gas has a higher molecular size and weight than nitrogen the concentration of oxygen reported by the analyzer will be less than the actual concentration. A special heavy gas scale factor option is also available to allow the analyzer to automatically correct the oxygen reading.

The analyzer is factory configured at the time of order for the customer selected scale factor gas option. For gases lighter than nitrogen the available options are Helium or Hydrogen Scale Factor. This option permits the analyzer to be easily changed from measuring oxygen in a 100% nitrogen background gas to measuring oxygen in a 0 to 100% light gas (He or H2 only). There is a front panel adjustment control (labeled **% He in N_2**, or **% H_2 in N_2**) that allows the user to dial in the volume-percentage of the lighter gas portion of the sample gas. If the control is turned to minimum the analyzer will be adjusted to read correctly in Nitrogen. If the control is turned to maximum the analyzer will be adjusted to read correctly in 100% hydrogen or helium (depending upon the configuration ordered). For gases heavier than Nitrogen the specific gas must be specified at time of order, and many heavy gases may be accommodated, with a few limitations. Consult Delta F, prior to ordering, for details. The scale factor adjustment control will be labeled with the factory configured scale factor (example: **% N_2 in Ethylene**). Note that for light gases the dialed in percentage is for the light gas volume, and for the heavier gases the dialed in percentage is for the volume of Nitrogen. So, if the control is turned to the minimum (0% Nitrogen) the analyzer will be adjusted

to read correctly in Ethylene. If the control is turned to the maximum (100% Nitrogen) the analyzer will be adjusted to read correctly in Nitrogen.

When measuring oxygen in a background gas other than Nitrogen, with an analyzer not equipped with the GSF option, see Table 5 for multiplier values which the user can use manually to compensate for various gas diffusivities.

NOTE: If the sample contains an oxygen concentration near the high-end of the instrument (e.g. 80 ppm on a 0-100 ppm unit), and consists of a light gas background, the current generated by the sensor may be too much for the electronics to source and will effectively put the instrument out of range. In such a case, it would be appropriate to use an analyzer of the next highest range (e.g. 0-500 ppm). Consult Delta F for application specific details.

7.10.1 Adjusting the Gas Scale Factor Pot for Light Gases (He or H_2)

1) Open the front door.

2) Locate the View Ref. Toggle switch. See Figure 6.

3) Throw the toggle switch upward to % H_2 in N_2 (or % He in N_2, as appropriate) and observe the front panel display. The number will be preceded by a negative sign to differentiate it from an oxygen reading. Ignore the decimal point as it will be in a different position depending on the selected range.

4) Continue to hold the toggle switch lever in the upward position. The displayed number may be adjusted by using the screwdriver pot located above the % H_2 (or He) in N_2 label. This number ranges from 0 to -1000, corresponding to 0% to 100.0 % of the light gas. If the Scale Factor Pot is set to -000 the instrument will be calibrated for Nitrogen. If the Scale Factor Pot is set to -1000 the instrument will be calibrated for 100% of the light gas. Settings between -000 and -1000 will adjust the calibration to compensate for proportions of the light gas ranging from zero to 100%.

5) Once the toggle switch lever is released allow ten seconds for the analyzer to return to normal operation.

NOTE: During this ten second timeout period if the switch is thrown upward again the display will not show the scale factor value.

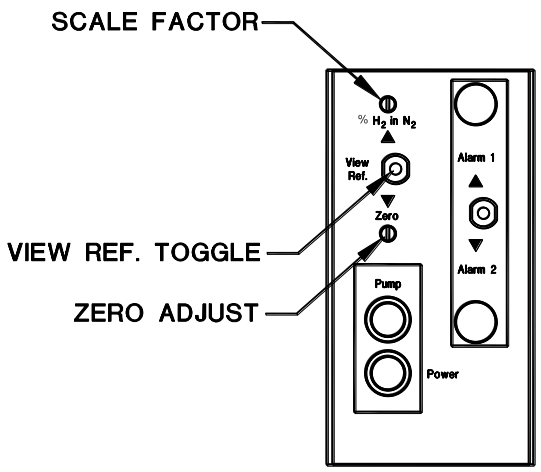

Figure 6: Gas Correction Factor Adjustment

7.10.2 Adjusting the Gas Scale Factor Pot for Gases Heavier Than Nitrogen

1) Open the front door.

2) Locate the View Ref. Toggle switch. See Figure 6.

3) Throw the toggle switch upward (toward the label that lists the scale factor gas) and observe the front panel display. The number will be preceded by a negative sign to differentiate it from an oxygen reading. Ignore the decimal point as it will be in a different position depending on the selected range.

4) Continue to hold the toggle switch lever in the upward position. The displayed number may be adjusted by using the screwdriver pot located above the scale factor gas label. This number ranges from 0 to -1000, corresponding to 0% to 100.0 % of Nitrogen. If the Scale Factor Pot is set to -000 the instrument will be calibrated for the heavy gas. If the Scale Factor Pot is set to -1000 the instrument will be calibrated for 100% of Nitrogen. Settings between -000 and -1000 will adjust the calibration to compensate for proportions of Nitrogen gas ranging from zero to 100%. It is assumed that the heavy gas will be the remaining portion of the gas mix.

5) Once the toggle switch lever is released allow ten seconds for the analyzer to return to normal operation.

NOTE: During this ten second timeout period if the switch is thrown upward again the display will not show the scale factor value.

Gas Scale Factor Correction Values					
Background Gas	50-500 ppm	1,000 ppm	5000-10,000 ppm	2.5%-10%	25%
Argon (Ar)	1.03	1.05	1.04	1.05	1.02
Hydrogen (H2)	.61	.42	.51	.42	.74
Helium (He)	.69	.53	.61	.53	.79
Methane (CH4)	.94	.90	.92	.90	.96
Ethane (C2H6)	1.15	1.23	1.19	1.23	1.10
Propylene (C3H6)	1.22	1.33	1.27	1.33	1.14
Propane (C3H8)	1.26	1.38	1.32	1.38	1.17
Butene (C4H8)	1.45	1.68	1.57	1.68	1.30
Butane (C4H10)	1.48	1.72	1.60	1.72	1.32
Butadiene (C4H6)	1.42	1.63	1.52	1.63	1.28
Acetylene (C2H2)	1.05	1.08	1.06	1.08	1.03
Hexane (C6H14)	1.75	2.13	1.94	2.13	1.50
Cyclohexane (C6H12)	1.57	1.86	1.71	1.86	1.38
Vinyl Chloride (CH2CHCl)	1.35	1.53	1.44	1.53	1.24
Vinylidene Chloride (C2H2Cl2)	1.30	1.44	1.37	1.44	1.20
Neon (Ne)	.85	.78	.81	.78	.90
Xenon (Xe)	1.43	1.65	1.54	1.65	1.29
Krypton (Kr)	1.21	1.32	1.26	1.32	1.14
Sulfur Hexaflouride (SF6)	1.84	2.27	2.06	2.27	1.56
Freon 318 (C4F8)	2.54	3.31	2.93	3.31	2.03
Tetraflouromethane (CF4)	1.61	1.91	1.76	1.91	1.40
Carbon Monoxide (CO)	1.01	1.02	1.01	1.02	1.01

Table 5: Gas Scale Factor Correction Values

Disclaimer

The method used to correct the calibration of the Delta F Oxygen Analyzer for measurement in non-nitrogen background gases is derived from a well known theoretical mass transfer equation. This equation accounts for the change in oxygen diffusion rates through different gases.

Although significant empirical work has been done in this field, it is generally accepted that the equation may be only 85-90% accurate. In addition, there is further error introduced when correcting for a "multi" component background gas. This may result in an additional 3-5% error. Correcting the calibration (for all combinations of background gases) using theoretical means has its limitations.

An alternate method when using a non-nitrogen or "multi" component background gas is to obtain a certified oxygen calibration standard which has been prepared in a background gas which models the average process sample. In this case any possible error introduced in using the theoretically derived correction factor is eliminated. Caution must still be used, however, as certified standards may also have inaccuracies associated with them.

Questions regarding the calculation of a background gas correction factor for a specific application should be directed to the Delta F Customer Support Services Department at (781) 935-5808.

NOTE: In light gas (H_2 or He) backgrounds, the diffusion rate of oxygen will be greater than that in nitrogen, resulting in a higher absolute current generated by the sensor. If the sample contains an oxygen concentration near the high-end of the instrument (e.g. 80 ppm on a 0-100 ppm unit), and consists of a light gas background, the current generated by the sensor may be too much for the electronics to source and will effectively put the instrument out of range. In such a case, it would be appropriate to use an analyzer of the next highest range (e.g. 0-500 ppm). Consult Delta F for application specific details.

8 Sample Gas and Plumbing Cautions

Consistent, high performance from your analyzer requires an understanding of gas delivery systems and their proper installation.

There are several issues to be aware of during the installation and operation of any gas analyzer.

8.1 Condensation

Like most gas analyzers, the DF series operation will be compromised if there is condensation in the sensor. If that possibility exists, the gas should be pre-conditioned. Several techniques are available. If the gas is a hydrocarbon, maintain the sample from 20°F to 40°F above its dew point. In some applications, it may be necessary to chill the gas before it enters the analyzer so that the hydrocarbons can be condensed and removed.

8.2 Temperature

Gas temperature should not exceed 50°C (122°F), nor should it fall below 5°C (40°F). Gas temperatures can be controlled by passing the sample through 5 to 10 feet of metal tubing that is within the recommended temperature range.

8.3 Leaks

Significant measurement error can be caused by leaks in the plumbing. A simple **Flow Sensitivity Test** can be performed to identify oxygen leaks.

1. Observe the oxygen readout at two flow levels: 0.5 and 2.0 scfh. In a tight plumbing system, only a slight readout increase should occur as the flow is increased. If a leak does exist, the increased flow, and resulting dilution of the sample will cause a decrease in the oxygen readout, typically as much as 25% to 50%.
2. When flow sensitivity is observed, check the external plumbing for leaks." Carefully check the stem and packing on the sensor inlet flow control valve (if equipped).
3. If a leak is suspected in the gas inlet line and the sensor is equipped with an up-stream valve, fully close the valve (clockwise). Pressurize the inlet gas line from 5 to 10 psig and use a soapy solution such as Snoop™ to identify leaks.

CAUTION

After performing the leak test, open the up-stream valve slowly to slowly lower the pressure to the sensor.

8.4 Process Up-sets (Oxygen Shock)

If a low range sensor is exposed to high concentrations of oxygen such as room air, it will enter an over range condition. The sensor may absorb excessive oxygen and it may take some time before it comes back “on-range”. If the exposure is prolonged, it may take as long as 12 to 24 hours for the residual oxygen to fully purge.

CAUTION

If the sensor remains on while exposed to oxygen concentrations significantly higher that its range for prolonged periods of time, (approximately one hour), permanent damage may occur.

To minimize the effects of oxygen shock and to protect the sensor during over range exposures, turn the sensor off using the Sensor Off switch. See Figure 2.

9 Outputs and Remote Connections

9.1 The I/O Connector

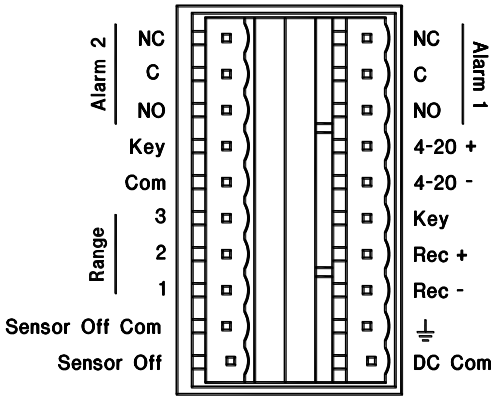

Figure 7: I/O Connector Pin-out

9.1.1 Alarm 1 and 2 (NC-C-NO)

The DF110 analyzer can be equipped with one or two optional alarms.

In the "No Alarm" condition the **NC** contact is connected to the **C** contact.

In the "Alarm" condition the **NO** contact is connected to the **C** contact.

The alarm relays are configured for "Fail Safe" operation. The relays will go to an Alarm Condition when the analyzer is turned off or when power fails.

Typically, the alarms are configured for high and low oxygen set points. If the analyzer is equipped with a Low Flow Alarm (see page 29), it will be wired to Alarm 1.

Each alarm has a SPST relay rated at 125/250 VAC and 30 VDC at 5 amps resistive load.

9.1.2 4 to 20 mA Isolated Output (4-20+, 4-20-)

The 4 to 20 mA output is proportional to the oxygen reading of the analyzer. The output on a three range analyzer, will be scaled to the currently selected range.

An output of 4 mA represents an operating analyzer with zero detected oxygen. Outputs ranging from 4 to 20 mA represent oxygen concentrations from zero to the top of the currently selected range.

The 4 to 20 mA output is electrically isolated from all other analyzer outputs and from chassis (earth) ground.

The maximum load resistance is 1K ohms. The analyzer provides a loop supply of approximately 28 VDC.

Connections to the 4-20mA output should be made through a shielded, twisted pair with the shield tied to the Ground connection (⏚).

9.1.3 Analog Output (Rec + & Rec -))

The default setting for the analog output is 0 to 10 VDC. Alternate settings available when ordering are 0 to 1 VDC, 0 to 2 VDC, or 0 to 5 VDC.

The analog output is proportional to the oxygen reading of the analyzer. On a three range analyzer the output will be scaled to the "selected" range.

The minimum load impedance is 10k ohms.

Connections to the analog output should be made through a shielded, twisted pair with the shield tied to the Ground connection (⏚).

9.1.4 Remote Range Indicator (Range Com - Range 1, 2, 3)

The analog output is proportional to the oxygen reading of the analyzer. On a three range analyzer, the output will be scaled to the currently selected range.

If the analyzer has three ranges and the analog output is being sent to a recorder or other remote device, it will be necessary to also send a Range Indicator so the remote reading can be properly scaled.

The Remote Range Indication is a contact closure between Range Com and the selected range, with the lowest range being contact one and the highest range being contact three.

The contacts are rated 24 VDC, .5 amps.

9.1.5 Sensor Off (Sensor Off Com, Sensor Off)

To avoid oxygen saturation of the sensor during over-range exposures, the sensor can be turned on and off using the Sensor Off switch. The position of the Sensor Off switch is indicated by an SPST contact across the "Sensor Off" contacts. Sensor On is indicated by a "closure" and Sensor Off is indicated by "open".

The contact is rated 24 VDC, .5 A.

9.1.6 DC Common (DC Com)

Do Not Use.

9.1.7 Ground (⏚)

This is frame ground. All signals such as alarms, range indication, sensor off, analog and 4-20 mA outputs should be shielded and the shield should be tied to this terminal. To prevent ground loops, only connect the shield at this end.

9.1.8 Trouble Alarm

The trouble alarm (if installed) is a combination of two alarms wired to a single output. It is made up of the Electrolyte Condition and Low Flow Alarms. If either of these alarms are tripped the Trouble Alarm will indicate on the Alarm 1 contacts. Both of these alarms must be cleared before the Trouble Alarm will clear. See Alarm 1, Electrolyte Alarm and Low Flow Alarm for more information.

9.2 The Remote Sensor Connector

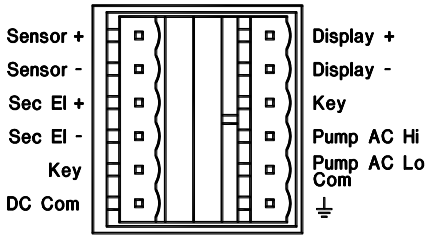

Figure 8: Remote Sensor Connector Pin-out

9.2.1 Remote Sensor (Sensor +, Sensor -)

When connecting the sensor to the analyzer circuit board, it should be wired through a shielded, twisted pair cable of sufficient size for the required run (see Table 6). The shield should be terminated at the Ground connection (⏚) on the analyzer and the polarity must be maintained.

Remote Sensor Cable Wire Size	
Distance in Feet	**Minimum Wire Size**
0 – 150	#20 AWG
150 – 250	#18 AWG
250 – 350	#16 AWG
350 – 1000	#14 AWG

Table 6: Sensor and Flow Switch Cable Specifications

9.2.2 Secondary Electrodes (Sec El +, Sec El -)

When connecting the sensor to the analyzer circuit board, the secondary electrodes connections on the sensor should be wired through a shielded, twisted pair cable. The shield should be terminated at the Ground connection (⏚) on the analyzer. The polarity must be maintained.

9.2.3 Display Outputs (Display +, Display -)

OEM analyzers that are not equipped with a local meter have the meter signal connected to the pins labeled Display + and Display -. This output is high impedance and must be measured with a meter having an input impedance of 10 Meg or greater.

During oxygen measurement the display signal is oxygen information scaled over the selected operating range of the analyzer. (For Example: On a three range analyzer, when operating on the 0-100.0 range the output will be 0-100.0 PPM scaled over 0-1.000 VDC. When operating on the 0-1000 PPM range the output will be 0-1000 PPM scaled over 0-1.000 VDC.) See Table 3: Meter Output Voltages on page17.

9.3 Pump Control

9.3.1 Analyzer Control of an External Pump

If factory configured, an external pump (usually mounted on the sensor bracket) can be powered through the Pump AC Hi and Pump AC Lo connections on the Remote Sensor connector. The pump power is controlled by the Pump On/Off switch on the front panel.

The pump connector will have 110 VAC present even if the analyzer is running on 220 VAC. The pump connector is intended to power the Delta F 5 watt pump only.

The pump wires should be in a shielded cable (separate from the sensor signal) with the shield attached to the frame ground. The pump cable should be of sufficient size for the required run (see table below) and should not share the same conduit as the sensor cable.

Pump Cable (separate from sensor cable)	
Distance in Feet	**Minimum Wire Size**
0 – 500	#22 AWG
500 – 1000	#20 AWG

Table 7: Pump Cable Specification

9.3.2 Remote Control of an External Pump

If factory configured, an external pump (usually mounted on the sensor bracket) can be controlled via a remote, user provided switch connected in series with the Pump AC Hi and Pump AC Lo connections. The pump switch located on the front panel is in series with any external remote switch and must be turned on to allow remote control of the pump.

DANGER

The pump connections will have 110 VAC present.

NOTE

The pump switch must be pushed in to enable remote pump control.

Any user-provided remote switch and wiring should be rated for 5 watts and 110 VAC.

10 Maintenance and Calibration Checks

10.1 Sensor Maintenance

Delta F analyzers require no routine maintenance other than the occasional addition of Delta F type Replenishment Solution to the sensor.

Exposure to dry gas samples will gradually extract water from the sensor. Under these conditions, the frequency of additions will be slightly higher. Typically, a very dry gas can extract 10 to 20 ml of solution per month.

It is good practice to check the sensor level every 1 to 2 months initially to determine the rate at which the electrolyte level in the sensor is dropping based on your application. Quarterly additions of solution are not unusual.

CAUTION

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

10.1.1 Adding Replenishment Solution

1. Remove the lid from the sensor tank.
2. Gently add Replenishment Solution to raise the electrolyte level to the "max" mark. *Do not over fill.* ***Do not add electrolyte***.
3. Re-install the lid.

10.2 Calibration

All Delta F analyzers are calibrated with certified gas standards at the factory prior to shipment. No additional calibration is required.

Depending on the application, the calibration should be *checked* approximately every six months using a gas of known concentration and high quality plumbing components.

NOTE

Unless otherwise requested, the analyzer is factory calibrated on nitrogen. Analyzer readings will be inaccurate if used with a background gas other than the one for which it is calibrated. If the analyzer was calibrated on a gas other than nitrogen, the gas will be noted on the calibration log inside the front door and on a label below the display .

10.2.1 Adjusting Calibration

If an adjustment to the calibration is required, the following procedures should be completed.

A. Log the present calibration reference values

NOTE: The factory calibration reference values are recorded on the sensor.

1. Locate the View Ref. toggle switch. See Figure 9
2. Throw the toggle switch to Span, and record the Span Calibration Reference Value as shown on the display. (For analyzers with no local display see the note below.) The number will be preceded by a negative sign to differentiate it from an oxygen reading. Ignore the decimal point as it will be in a different position depending on the selected range.
3. Similarly record the Zero Calibration Reference Value.
4. Release the toggle switch.
5. Allow 10 seconds for the analyzer to return to normal operation.

NOTE

The action of throwing the View Ref toggle switch to the Span position freezes the present O2 value at the analog outputs. For 10 seconds after the toggle switch is released the analog outputs and oxygen display are held at the last valid O2 value. Throwing the View Ref toggle switch again during the 10 second delay will display a meaningless number.

B. Adjust Span/Zero Calibration

1. Apply a calibrated span or zero gas to the analyzer.
2. Allow ample time for the analyzer to equilibrate.
3. If necessary, slowly turn the appropriate Span or Zero adjustment to obtain an oxygen reading that agrees with the Span or Zero calibration gas.
4. Record the reference values as described above.
5. Allow 10 seconds for the analyzer to return to normal operation.

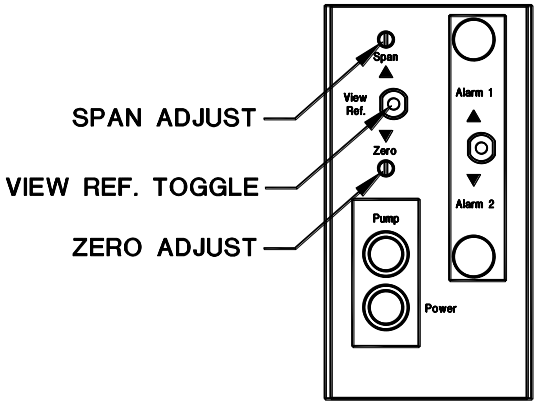

Figure 9: Calibration Controls

NOTE

The drift of the zero-baseline is small compared to the accuracy of the instrument. As a result, for most applications, it is unnecessary to adjust the zero set point of the analyzer.

NOTE FOR ANALYZERS WITH NO LOCAL DISPLAY

On OEM analyzers that are not equipped with a local display, the meter signal is connected to pins Display + and Display - on the Remote Sensor Connector. This output is high impedance and must be measured with a meter having an input impedance of 10 Meg or greater.

When the View Reference switch is in the Zero position the Display + and Display - output will be between 0 and -1.000 VDC corresponding to the actual position of the Zero Pot. (Example: If the Zero Pot is set to minimum the output will be 0.00 VDC. If the Zero Pot is set to maximum [fully clockwise] the output will be -1.000 VDC). Likewise, when the View Reference switch is in the Span position the output will be between 0 and -1.000 VDC corresponding to the actual position of the Span Pot. The analyzer is shipped with a Span Pot setting of -0.750 VDC

10.2.2 Adjusting the Span Calibration Pot (with the GSF Option installed)

For analyzers that have Scale Factor installed, the Span calibration potentiometer is located to the right of the Sensor Off switch.

When performing a Calibration Adjustment (as described above) the Span pot does not have a Span Calibration Reference value, as a result there is no need to throw the View Ref toggle switch. Simply adjust the span pot as described above to make the display equal the Span gas value.

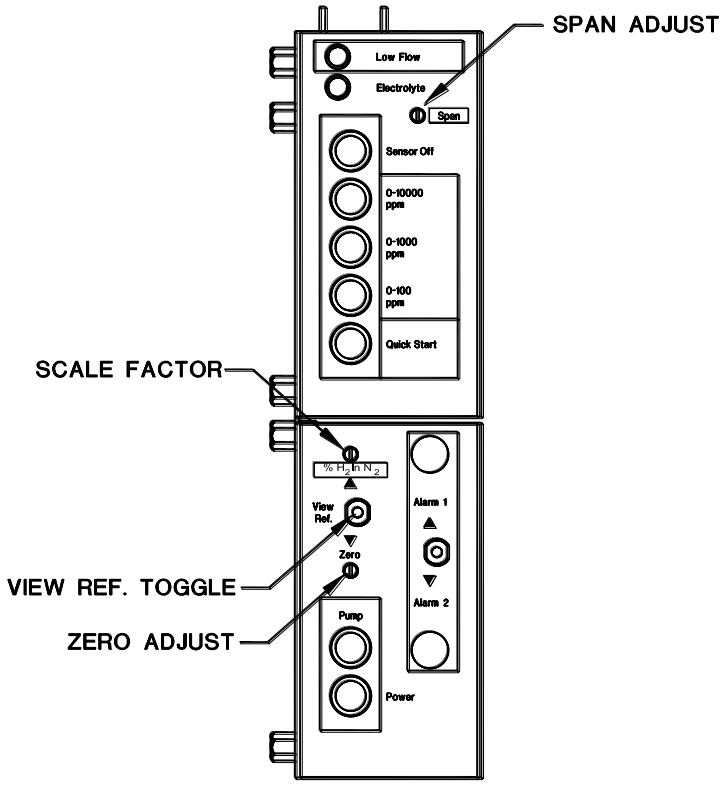

Figure 10: Span Adjust with GSF installed

11 Theory of Operation

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 1.3 volts applied across the electrodes. The resulting electron flow is measured as a current that is precisely proportional to the oxygen concentration in the sample gas.

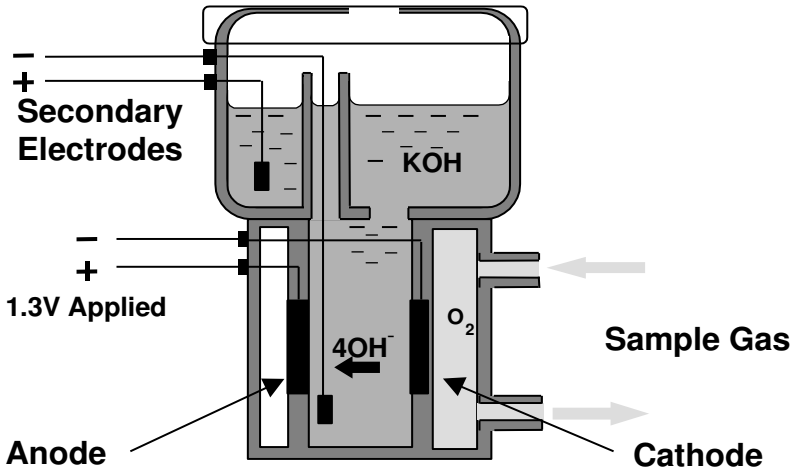

Figure 11: Sensor Layout

The cathode reaction uses 4 electrons from the 1.3 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.

12 Troubleshooting

12.1 Troubleshooting Guide

The trouble shooting guide will help resolve many of the common problems that can occur.

NOTE

If it is necessary to return the analyzer to the factory for repair, refer to the Shipping the Analyzer section on page 45.

12.1.1 Problem Observations

Observation	Possible Remedy (See Key Below)
1. Analyzer reads low	G A B D E H I J K
2. Analyzer reads high	A B C D E I J K
3. Analyzer output noisy	A E I K
4. Analyzer reads high with pump on	C K
5. Analyzer reads 0.00 or less at all times	D K
6. Slow speed of response	G C D E K
7. Electrolyte residue visible on the sensor	K
8. Electrolyte Condition indicator ON	E K

Table 8: Problem Observations

12.1.2 Remedy Keys

	Remedy Description
A	Check the analyzer calibration using a gas of known oxygen concentration. See page **Error! Bookmark not defined.**.
B	Check to see that the Zero Calibration Value agrees with the factory value marked on the sensor. See page **Error! Bookmark not defined.**
C	Check the sample delivery plumbing for leaks using the procedure described in the Sample Gas and Plumbing Requirements section of this manual. See page **Error! Bookmark not defined.**
D	Verify that the correct voltages are being supplied to the sensor. These voltages should be checked with the cable disconnected from the sensor. **Primary Electrodes** wht/yel (-) to wht/blk/red (+) = 1.30 +/- 0.065 VDC **Secondary Electrodes** wht/blue (-) wht/red (+) = 6.50 +/- 1.00 VDC Voltage levels between any other combination of wires should be less than 0.1 VDC.
E	Change the electrolyte using the procedure described in the Analyzer Start-up Procedure section of this manual on page **Error! Bookmark not defined.**. Rinse the sensor with de-ionized or distilled water prior to refilling and use only Delta F $\mathcal{E}$-Lectrolyte Blue brand of electrolyte. Allow the sensor to sit for 60 minutes before starting gas flow and then allow several hours of operation on gas to equilibrate.
G	Remove and check the filter element. Replace if necessary.
H	Check for contaminated plumbing. This is most easily done by examining the flow meter or the plastic outlet tubing, if so equipped, for evidence of oil, powder, or other material that might have made its way into the analyzer.
I	Remove all devices from the analyzer outputs including alarm connections, recorders, etc. Check the operation of the analyzer with those devices removed.
J	Make sure that the sample gas is consistent with the calibration of the analyzer as noted on the Calibration Log on the inside of the door. For example, if the analyzer is calibrated for nitrogen, a helium sample gas will not be measured accurately.
K	Be sure Sensor Off switch is not pushed in.
L	Call the Delta F Service line at 781/935-5808 for assistance.

Table 9: Remedy Keys

12.2 Troubleshooting Considerations

12.2.1 Gas Pressure Effects

Gas tubing should be kept as short as possible to minimize pressure drop and overall system response time. Larger diameter tubing will help avoid pressure drop but will lengthen the response time. In general 1/8 inch tubing should be limited to 15 foot runs. Longer runs should use 1/4 inch tubing.

12.2.2 Positive Pressure Operation

Gas pressure should be set to establish a flow of 1.0 to 2.0 scfh.

If the analyzer is not vented directly to atmosphere, downstream conditions may effect the sensor. Keep downstream plumbing lengths and restrictions to a minimum.

NOTE

All positive pressure flow control must be accomplished upstream of the sensor.

12.2.3 Negative Pressure Operation

If the gas stream is between 2.0 psig vacuum (12.7 psia) and 2.0 psig, a pump is recommended. If the analyzer is equipped with a pump, it will also have a flow control valve in the flowmeter.

NOTE

All negative pressure flow control must be accomplished downstream of the sensor.

NOTE

If there is a valve or regulator up stream of the analyzer, it should be kept fully open and flow rate adjustments should be done with the downstream flow control valve in the flowmeter.

12.2.4 Temperature Effects on Sensor Performance

The output of the sensor, given a constant oxygen concentration, will vary slightly with sensor temperature. Temperature effects are most pronounced at concentrations near zero in the lower range analyzers. Percent range sensors will exhibit almost no temperature sensitivity.

The effects of temperature are expressed in Table 10.

Range	Temp Range (70ºF nominal)	% of Reading/°F (2% - 100% of range)	Typical Drift (lower 2% of range)
0-50 ppm	45ºF – 95ºF	±0.32	±65 ppb
0-100 ppm	45ºF – 95ºF	±0.32	±125 ppb
0-500 ppm	45ºF – 95ºF	±0.32	±250 ppb
0-1000 ppm	45ºF – 95ºF	±0.32	±500 ppb
0-5000 ppm	45ºF – 95ºF	±0.24	±2.5 ppm
0-10,000 ppm	45ºF – 95ºF	±0.20	±5 ppm
0-5%	45ºF – 95ºF	±0.12	±0.003%
0-10%	45ºF – 95ºF	±0.04	±0.005%
0-25%	45ºF – 95ºF	±0.01	±0.013%

Table 10: Typical Output Drift with Specific Analyzer Range

NOTE

Unless otherwise requested, the analyzer is factory calibrated on nitrogen. Analyzer readings will be inaccurate if used with a background gas other than the for which it is calibrated. If the analyzer was calibrated on a gas other than nitrogen, the gas will be labeled on the front panel to the left of the numeric display.

12.2.5 Replaceable Parts

When ordering spare parts, always include the analyzer model and serial number.

Description	P/N
Connector – I/O (10 pin)	50980743
Connector – Remote Sensor (6 pin)	50980742
Display 3.5 digit	54218506
Display 4.5 digit	54218508
Electrolyte	$\mathcal{E}$-Lectrolyte Blue
Filter Element – Coarse	64005011
Filter Element – Fine	64005012
Flow Meter (0-5 scfh)	11220841
Flow Meter (0-2 scfh)	11240361
Flow Meter w/Valve (0-5 scfh)	11220842
Flow Meter w/Valve (0-2 scfh)	11240362
Fuse 100 mA (Used in 4-20 mA option)	45002504
Fuse .5A (Used for 110 VAC operation)	45002361
Fuse .25A (Used for 220 VAC operation)	45002301
Manual, Operating	99000025
Manual, Installation	99000026
PCB - Alarm	10423440
PCB - Main	10423430
Power Cord 110v	59017300
Pump	63000303
Replenishment Solution	RSA
Ribbon Cable – Display to Main PCB	13326060
Ribbon Cable – Switch Bank to Main PCB	13326070
Sensor	Call Delta F

Table 11: Spare Parts

12.2.6 Fuse Replacement

DANGER

The instrument power switch must be in the OFF position and the power cord unplugged before removing the fuse holder cap.

Failure to do so may expose the operator to hazardous voltages.

All fuses within the analyzer are user replaceable. The main power fuse is located on the rear panel above the AC power connector. Use the proper fuse for the operating voltage of the analyzer. The operating voltage for which the analyzer is set is marked beside the AC power connector. All power input fuses are 5X20 mm, 250 VAC, IEC Sheet III, Type T devices. For 110 VAC operation the fuse is a .5 A time delay device and for 220 VAC operation the fuse is a .25 A time delay device. Refer to the spare parts list in Table 11 for fuse part numbers.

If the analyzer is equipped with a 4-20 mA option, it is installed on a daughter board attached to the main circuit board. There is a 5X20 mm, 250 VAC, 100 mA fast acting fuse on the 4-20 mA board.

13 Shipping the Analyzer

If it becomes necessary to ship the analyzer to the factory be sure to call Delta F at (781) 935-5808 to obtain a Return Material Authorization number.

Be sure to mark the Return Material Authorization number on the outside of the shipping carton and on the packing list.

CAUTION

Do not ship the analyzer with liquid in the sensor. Serious damage can result and the warranty will be voided.

NOTE

The analyzer should be carefully packed in its original packing materials if possible.

13.1 Draining the Sensor

1. Turn power off.
2. Disconnect the electrical cable that runs to the sensor.
3. Disconnect the gas inlet and outlet fittings being sure to use a “back-up” wrench when appropriate.
4. Un-screw four screws below sensor.
5. Un-screw the lid from the sensor.
6. Tip the sensor, carefully capture the liquid, and dispose of it appropriately.
7. Rinse sensor with distilled or de-ionized water.
8. Screw the lid snugly onto the sensor.

NOTE, if equipped, the drain on the side of the sensor may be used to remove the electrolyte from the sensor.

14 Safety and Operating Notices

14.1 Safety Notices

DANGER

Line voltage exists in the Oxygen Analyzer Enclosure. If the enclosure is removed, DO NOT touch any of the electrical components when the analyzer is connected to AC power.

CAUTION

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

14.2 Operating Notices

NOTE

The sensor is shipped dry and must be charged with electrolyte before it is operated. Use only Delta F type ℰ-Lectrolyte Blue*. Failure to do so will void the warranty.*

NOTE

If the electrolyte level is low, only Delta F type Replenishment Solution needs to be added to the sensor. Do not add electrolyte solution to restore the electrolyte level. Do not overfill.

NOTE

The sensor must be drained and flushed prior to shipment.

NOTE

Do not operate the analyzer at oxygen concentrations that are over-range for extended periods of time. Sensors may be damaged if exposed to high levels of oxygen, for example air, for long periods of time (>15 minutes) while on power. If an exposure is unavoidable, turn off power to the instrument.

14.3 General Warnings

- Do not expose this equipment to rain or water spray unless it is housed in a rated NEMA 4 enclosure.
- Do not operate this analyzer above 45°C (113°F).
- Do not expose this analyzer to temperatures above 50°C (122°F).
- Verify that the analyzer line voltage is set correctly.
- Over-pressurizing the analyzer can result in permanent damage to the sensor.
- Do not operate an analyzer unless a sample gas is flowing through the sensor.

14.4 MATERIAL SAFETY DATA SHEET - Electrolyte

1. IDENTIFICATION OF THE SUBSTANCE

Trade Name	Electrolyte Solution, *Ɛ-lectrolyte Gold*, *Ɛ-lectrolyte Blue, Ɛ-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.

14.5 MATERIAL SAFETY DATA SHEET – Replenishment Solution

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

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14.6 Seguridad

PELIGRO

Existen líneas de voltage en la Caja Analizadora de Oxígeno. Si la cubierta ha sido levantada, NO TOQUE ninguno de los componientes eléctricos mientras que el analizador esté todavía conectado a la corriente eléctrica AC.

PRECAUCIÓN

El electrólito es una solución caústica. Repase la hoja de datos de seguridad de materiales (MSDS) en esta sección antes de bregar con las soluciones electrólitas.

PRECAUCIÓN

El sensor se envía seco y antes de operar tiene que ser cargado con electrólitos. Usen solamente E-lectrolyte Blue. Si no cumple con esto, anulará su garantía.

PRECAUCIÓN

Si el nivel de electrólitos está bajo, solo se tiene que añadir al sensor agua destilada o desionizada. No le añade la solución de electrólitos para restablecer el nivel de dichos electrólitos. No sobre llene.

PRECAUCIÓN

El sensor tiene que ser purgado y baldeado antes del embarque.

PRECAUCIÓN

No use el analizador cuando, por periodos de largo tiempo, las concentraciones de oxígen estén demasiado altas. Se pueden dañar los sensores, si se exponen por largo tiempe (>15 min) a niveles altos de oxígeno, por ejemplo aire, mientras que esté encendido.

Si no se puede evitar que uno este expuesto a esto, apague la corriente eléctrica del instrumento..

14.7 Avisos Generales

- No exponga este instrumento a la lluvia ni a alguna rociada de agua, almenos que esté encerrado en una caja clasificada como NEMA 4.
- No use este analizador en temperaturas más altas de 45°C (113°F).
- No exponga el analizador a temperaturas de mas de 50°C (122°F).
- Verifique que la línea de voltage del analizado esté correcto.
- Exceso de presión al analizador puede resulto en daños permanentes al sensor.
- No use el analizador almenos que una muestra de gas esté pasando por el sensor.

14.8 Sicherheitshinweis

VORSICHT/GEFAHR

In der Hülle des Sauerstoff-Analysators besteht Stromspannung. BERÜHREN SIE beim Entfernen der Hülle KEINE elektrischen Bestandteile, wenn der Analysator an Wechselstrom angeschlossen ist.

VORSICHT

Das Elektrolyt ist eine kaustische Lösung. Gehen Sie die Liste der Material-Sicherheitsdaten in diesem Abschnitt durch, bevor Sie mit der Elektrolyt-Lösung umgehen.

VORSICHT

Der Sensor wird trocken versandt und muß mit Elektrolyt geladen werden, bevor er angewandt wird. Verwenden Sie nur Electrolyt E-lectrolyte Blue. Falls Sie dies nicht tun, wird die Garantie ungültig.

VORSICHT

Falls der Elektrolytstand niedrig ist, muß dem Sensor nur destilliertes oder entionisiertes Wasser zugeführt werden. Fügen Sie keine Elektrolyt-Lösung hinzu, um den Elektrolyt-Stand wieder herzustellen. Füllen Sie nicht zu weit auf.

VORSICHT

Der Sensor muß vor dem Versand entleert und ausgespült werden.

VORSICHT

Setzen Sie den Analysator nicht bei Sauerstoffkonzentrationen ein, die zu hoch für längere Zeiträume sind. Die Sensoren können beschädigt werden, wenn sie hohen Sauerstoffniveaus, bzw. Luft, für längere Zeiträume (> 15 Minuten) ausgesetzt werden, während sie eingeschaltet sind.

Schalten Sie den Strom an dem Gerät ab, wenn dieses Ausgesetztsein unvermeidlich ist.

14.9 Allgemeine Warnhinweise

- Setzen Sie diese Geräte keinem Regen oder Wassersprühung aus, sofern dieses sich nicht in einer NEMA-4-geprüften Hülle befindet.
- Bedienen Sie diesen Analysator nicht bei über 45 Grad Celsuis (113 Grad Fahrenheit).
- Setzen Sie diesen Analysator keinen Temperaturen über 50 Grad Celsuis (122 Grad Fahrenheit) aus.
- Überprüfen Sie, ob die Stromspannung des Analysators korrekt eingestellt ist.
- Es kann zu dauerhafter Beschädigung des Sensors führen, wenn dieser unter zu starkem Druck gehalten wird.
- Benutzen Sie den Analysator nicht, sofern nicht ein Probegas durch den Sensor fließt.

14.10 Mesures de sécurité

DANGER

*La ligne de voltage se trouve dans l'enclos de l'Analyseur d'Oxygène. Si l'enclos est d*éplacé*, NE TOUCHEZ aucun des éléments électriques quand l'analyseur est relié au courant alternatif.*

PRECAUTION

L'électrolyte est une solution caustique. Revisez les instsructions dans le feuillet d'informations regard au matériel de sécurité "Material Safety Data Sheet (MSDS)" avant de manipuler la solution électrolyte.

PRECAUTION

Le senseur est expedié à sec et devra être chargé avec l'électrolyte avant d'être employé. Utilisez uniquement l'electrolyte E-lectrolyte Blue. L'inobservance de cet avis annullera la garantie.

PRECAUTION

Si le niveau de l'électrolyte est bas, il suffira d'ajouter au senseur de l'eau distillée ou non-ionisée. N'ajoutez pas de solution electrolyte pour retablir le niveau de l'electrolyte.

Ne remplissez pas au dessus du niveau requis.

PRECAUTION

Le senseur devra être vidé et rincé sous pression avant d'être expedié.

PRECAUTION

N'actionnez pas l'analyseur à des concentrations d'oxygène au dessus des limites pendant des periodes prolongées. Les senseurs pourraient être endommagés s'ils sont exposés à des haut niveau d'oxygène, c'est a dire, de l'air, pendant de longues périodes (>15 minutes) lorsque reliés au courant.

Si l'exposition est inévitable, coupez le courant qui les relie à l'instrument.

14.11 Precautions à prendre en general

- Ne pas exposer l'appareillage à l'eau de pluie ou d'arrosage, à moins qu'il ne soit enfermé dans un enclos classifié: NEMA 4".
- Ne pas opérer cet analyseur à une temperature au dessus de 45°C (113°F).
- Ne pas exposer cet Analyseur à une temperature au dessus de 50°C (122°F).
- Vérifier que la ligne de voltage est reglé correctement.
- Surpression de l'analyseur au dessus du niveau requis pourrait endommager le senseur.
- Ne pas opérer l'analyseur à moins qu'un gaz prélevé circule dans le senseur.

14.12 Misure di sicurezza

PERICOLO

La ligna di voltaggio è acclusa nell'imballagio dell'Analizzatore dell'Ossigeno. Se l'imballagio è disfatto NON SI DEVE toccare gli elementi elettrici quando l'analizzatore viene collegato alla corrente alternata.

ATTENZIONE

L'elettrolito è una soluzione caustica. Rileggere il foglio di informazioni reguardo ai materiali di sicurezza "(MSDS)" prima di maneggiare la soluzione electrolica.

ATTENZIONE

Il sensore è spedito a secco, dunque dovrebbe essere caricato col'elettrolito prima di azzionarlo. Usare solo il ELECTROLYTE E-lectrolyte Blue per l'Analizzatore del'Ossigeno "A-Plus". L'inosservanza di questa precauzione risulterà nell'annullamento della garanzia.

ATTENZIONE

Se il livello del'elettrolito si abbassa, si dovrebbe aggiungere nel sensore solamente acqua distillata o deionizzata. Non si deve aggiungere l'elettrolito per ristabilire il livello del'elettrolito.

Si devrà riempire senza traboccare.

ATTENZIONE

Il sensore dovrebbe essere scaricato e lavato con getti d'acqua prima della spedizione.

ATTENZIONE

Non si deve far funzionare l'analizzatore con concentrazioni di ossigeno al di là del limite, per tempi prolungati. I sensori potrebbero essere dannegiati quando esposti ad alti livelli di ossigeno, cioè, aria, per lunghe durate di tempo. (più di 15 minuti) quanto collegati alla corrente electrica.

Se l'esposizione è inevitabile, si dovrebbe disinserire lo strumento dalla corrente.

14.13 Precauzioni da prendere in generale:

- Non si deve esporre l'apparecchiatura all pioggia o ai getti d'acqua, a meno che essa sia involta in una chiusura stimata al livello" "NEMA 4".
- Non si deve operare l'analizzatore ad una temperature al di là di 45°C (113°F).
- Non si deve esporre l'analizzatore ad una temperature al di là di 50°C (122°F).
- Verificare che l'analizzataoare sia allegata a una corrente con un voltaggio adatto.
- Sovrapressione dell'analizzatore potrebbe risultare in un dannegio permanente del sensore.
- Non si deve azzionare un'analizzatore a meno che un gas conforme a campione circola nel sensore.

15 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 five (5) year Sensor Warranty offers extended protection such that, if any Sensor of a Delta F Oxygen Analyzer fails under normal use, within four (4) years after the expiration of the analyzer's initial one-year full warranty, such sensor may be returned to the Seller and, if such sensor is determined by the Seller to be defective, the Seller shall provide the Buyer a repaired or replacement sensor.

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.

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