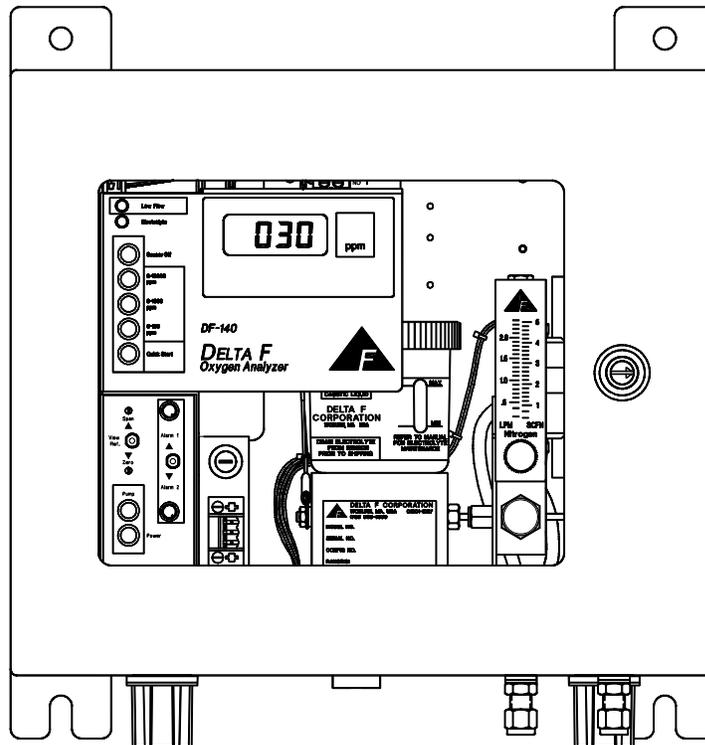


DF Series Oxygen Analyzers

Model DF-140



 **Delta F Corporation**
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Woburn, Massachusetts 01801-1087
Telephone: (781) 935-4600
FAX: (781) 938-0531

User's Manual
P/N 99000028
Rev B
091103

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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Read Me First...

Unpacking

Follow the steps below to unpack your Delta F 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. Open the analyzer door, remove any shipping materials, and verify that nothing has come loose during transit.
3. The analyzer is set at the factory to operate on 115 VAC or 220 VAC. Locate the voltage indicator label next to the power input connector and verify the voltage is set as ordered.
4. 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.

All DF Series analyzers are shipped with the following:

Item	Delta F Part Number
Two bottles of EO-5 Electrolyte	DF-E05
Water Refill Bottle	67002401
Instruction Manual	99000028

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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 gases only. Delta F cannot be responsible for direct or consequential damages that result from using the analyzer with these gases.

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.

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 set-up or 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.

Specifications

Range

DF-140 Single Range Analyzer

Range (ppm)	DF-140 Model #	Range (%)	DF-140 Model #
0 to 5,000 ppm	141-5000	0 to 25%	141-P25
0 to 1,000 ppm	141-1000	0 to 10%	141-P10
0 to 500 ppm	141-500	0 to 5%	141-P5
0 to 100 ppm	141-100	0 to 1%	141-P1
0 to 50 ppm	141-50		
0 to 10 ppm	141-10		

DF-140 Three Range Analyzer

Ranges (ppm)	DF-140 Model #	Ranges (%)	DF-140 Model #
0 to 100/1,000/10,000 ppm	143-10000	0 to 0.25/2.5/25%	143-P25
0 to 50/500/5,000 ppm	143-5000	0 to 0.1/1/10%	143-P10
0 to 10/100/1,000 ppm	143-1000	0 to 0.05/0.5/5%	143-P5
0 to 5/50/500 ppm	143-500		
0 to 1/10/100 ppm	143-100		

Response Time

Responds instantaneously to O₂ change. Equilibrium time depends on specific conditions. Typically less than 20 seconds to read 90% of a step change.

Accuracy

+/- 2% Full Scale at constant temperature (Except 5% full scale on concentrations below 2.5 ppm).

Sample Gas Compatibility

Standard Sensor

All inert and passive gases including N₂, H₂, CO, freons, light hydrocarbons, etc.

Sensor with Stab-El $\hat{\text{O}}$

Neutralizes contaminants including acids such as CO₂, H₂S, Cl₂, NO_x, SO_x, etc. (See page 13 for concentration limits).

Sample Requirements

Gas phase, non-condensing, 0-50°C (32-122°F).

Flow rate 1.0 to 3.0 scfh at 0.2 to 1.0 psig pressure.

Physical Dimensions

Overall Dimensions: 35.56cm w X 30.48cm h X 29.02cm d

Weight: 13 kg

Overall Dimensions: 14.0''w X 12.0''h X 11.42''d

Weight: 29 lbs

Miscellaneous

Store and operate between 0°C and 45°C (32°F and 112°F).

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

Nominal power consumption 20 Watts

ETLc Approved

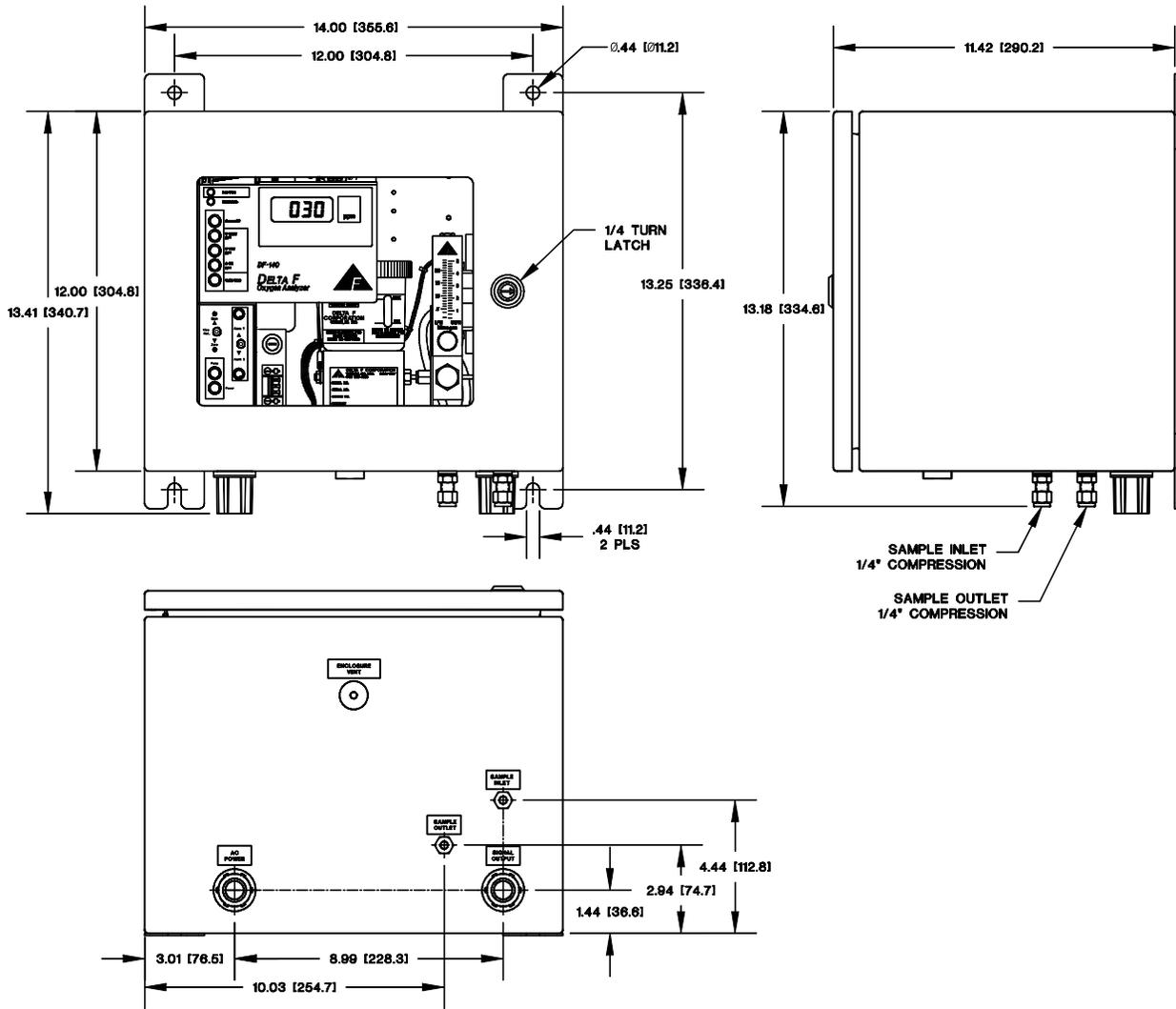


Figure 1: DF-140 Oxygen Analyzer

Analyzer Installation

This oxygen analyzer has been installed in a NEMA 4 certified enclosure and has been thoroughly tested and calibrated, however it is necessary to mount the enclosure, make proper gas and electrical connections and to “charge” the sensor prior to turning the analyzer on.

CAUTION



To avoid damage to your analyzer:

- *Do not operate without electrolyte*
- *Do not use more than one bottle of DF-E05 electrolyte*
- *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 pressure and flow limits*



The electrolyte is a caustic solution. Review the Material Safety Data Sheet (MSDS) on page 56 before handling the electrolyte solution.

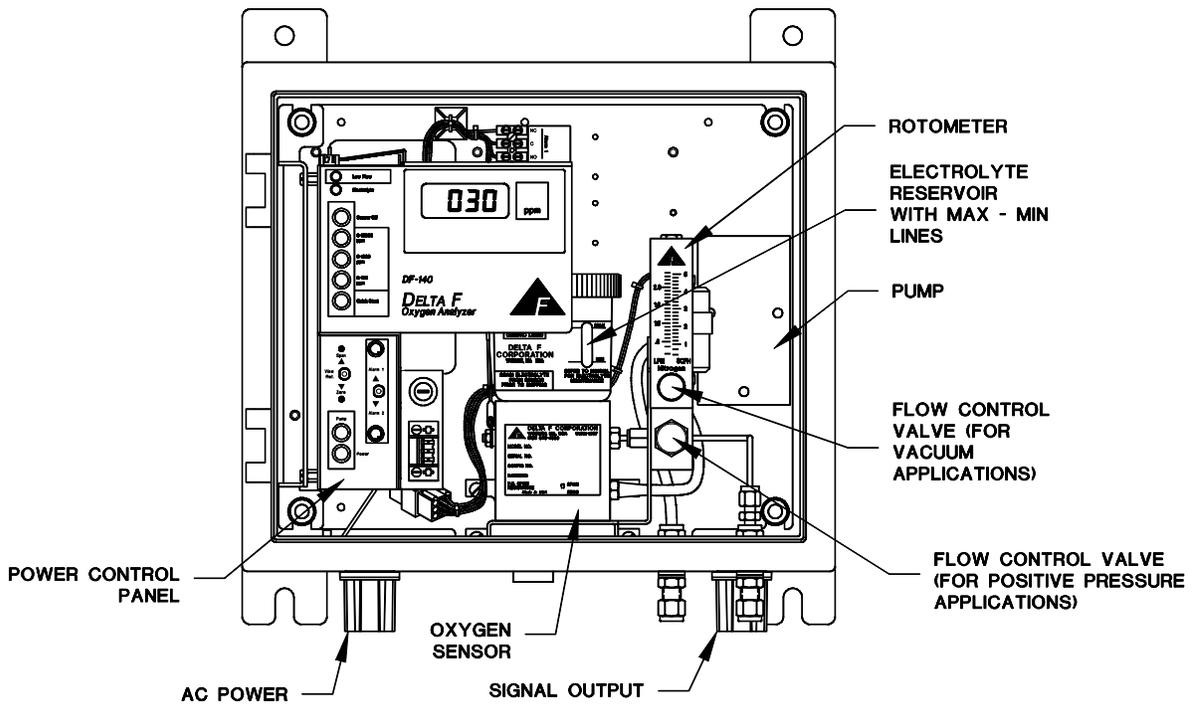


Figure 2: Major Internal Components

Mounting the Enclosure

The enclosure must be mounted according proper local codes with appropriate hardware in an upright position with cable and plumbing connections on the bottom. See Figure 1 for mounting hole locations.

The maximum allowable ambient temperature for the oxygen sensor is 110 degrees F (45 C). The enclosure must not be installed in areas of high heat caused by radiation or convection.

If installed outdoors the enclosure must be shielded from the sun to avoid overheating. In addition, a heater must be installed in the enclosure in areas where the temperature goes below freezing.

Making Power Connections

Supply the AC power, 120 or 220 VAC, according to the label inside the enclosure, through the Type 370 Bullet Hub coupling at the bottom of the enclosure to the three pin power connector mounted beside the power control switch. All wiring must be done according proper local codes.

Pin #	110 VAC	220 VAC
1	Phase	Phase
2	Ground	Ground
3	Neutral	Phase

Making Sample Gas Connections

NOTE



For gas pressures between 1.0 and 5.0 psig use a high quality flow control valve between the gas source and the analyzer to set the flow rate.

You may have an optional Flow Control Valve mounted on the sensor bracket. (see “Flow Control Valve” on page 19).

For gas pressures above 5 psig use a high quality pressure regulator to set the flow rate.

Gas Connection

1. Connect the gas line to the 1/4 inch compression fitting marked sample inlet on the bottom of the enclosure. If equipped, install the filter and regulator upstream of the gas inlet. See the section on filter and regulator options starting on page 15. The filter should always be first in line.
2. Open the door and slowly adjust the flow rate to 2.0 scfh as indicated on the flowmeter using the flow control valve or pressure regulator. *On positive pressure installations do not control the flow with valve mounted in the flowmeter (if equipped).*
3. If a background gas other than nitrogen is being used, the “indicated” flow rate must set the as shown in Table 1.

Background Gas	Flowmeter Setting (scfh)
Argon	2.4
Ethylene	2.0
Nitrogen or Air	2.0
Carbon Monoxide	2.0
Methane	1.5
Hydrogen	0.5
Helium	0.7

Table 1: Flowmeter Settings versus Background Gas

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 .

Making Output Signal Connections

The following considerations are important when performing this step:

- The analog output signal is factory-set to 0 to 10 VDC unless otherwise specified.
- The analog output is proportional to the oxygen reading of the instrument. On Three Range Analyzers the output is scaled to the “selected” range.
- The minimum impedance of the load is 10K Ohm.

Charging the Sensor with Electrolyte

1. Open the front door.
2. Turn power off.
3. Un-screw the lid from the sensor.
4. Carefully add the entire contents of *one bottle* of Delta F type DF-E05 Electrolyte to the sensor.
5. Add enough de-ionized or distilled water to raise the liquid level to the “max” line.
6. Replace the lid securely.

Powering Up the Analyzer

1. Verify the analyzer is set to the desired 110 VAC or 220 VAC selection by checking the voltage indication on the label beside the power connector.
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 concentration range.
4. Be sure the Sensor Off switch is not pushed in. See Figure 3
5. Turn the analyzer on using the power switch. See Figure 4
6. Allow several minutes for the analyzer to come “on range”.

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

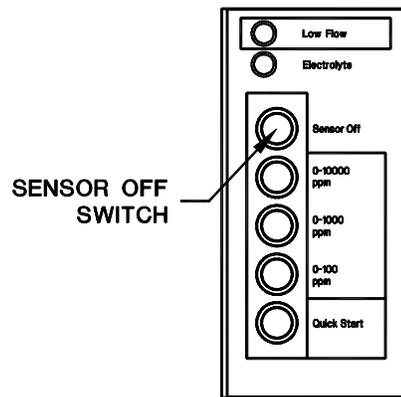


Figure 3: Sensor Off Switch

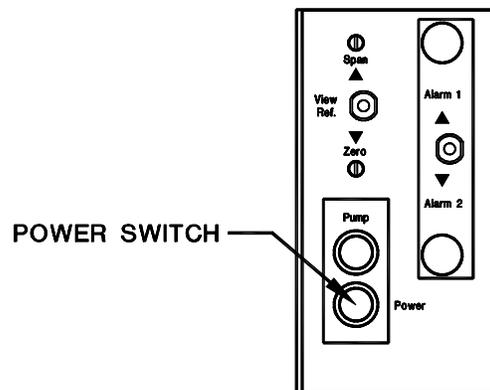


Figure 4: Power Switch

Additional Capabilities

Your analyzer may be equipped with additional capabilities. Consult the Standard Features section on page 10 and the Options section on page 13 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 Valves
- Gas Flow Switch
- Sample Pump
- Quick Start
- Gas Scale Factor

Also, see the Outputs and Remote Connections section on page 33 for information regarding:

- CE Qualified Analyzer Outputs
- Remote Sensor Operation
- Remote Pump Operation
- Remote Control of On-board Pump

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 gases traceable to NIST.

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 39 for additional information.

Electrolyte Condition Indicator

The indicator marked Electrolyte will light if the electrolyte level falls too low or, in some cases, becomes contaminated. If the electrolyte is low, simply add distilled or de-ionized water to the sensor to replace what has evaporated. *Do not add more electrolyte after the initial bottle is installed!*

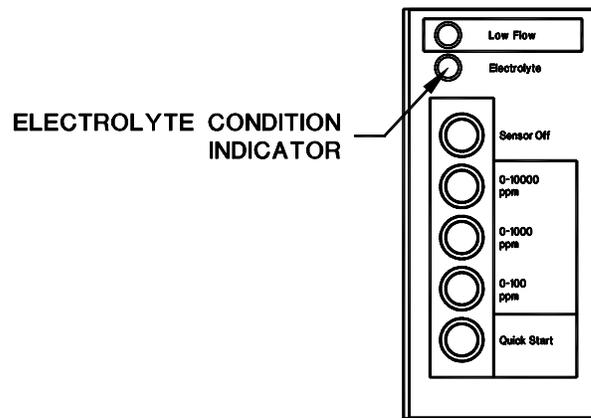


Figure 5: Electrolyte Condition Indicator

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.

See the sticker on the inside of the enclosure for the current setting of the analog output voltage.

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

Options

Stab-EI[®]

The Stab-EI[™] 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 ₂ S	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 CO₂ are in percent. One percent is equivalent to 10,000 ppm.

Table 2: Maximum Acid Gas Concentrations with Stab-EI[™] (in ppm)

Contact Delta F for recommendations on using the Stab-EI[™] 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-EI[™] 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-EI[™] option to “keep up”.
- A dilution system can be added to limit acid concentration.
- Consult Delta F for further recommendations.

Alarms

The **DF-140** can be equipped with one or two alarms. Alarm 1 can be configured for high O₂, low O₂, or Low Flow. Alarm 2 can be configured for high O₂ or low O₂.

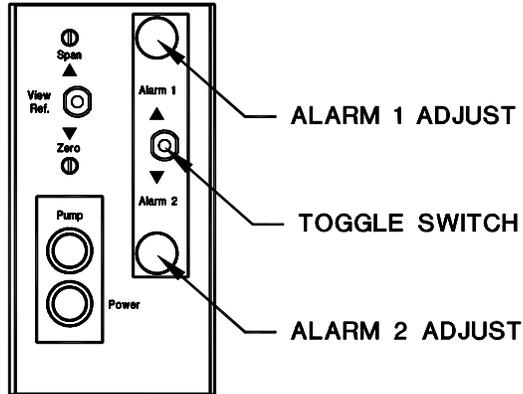


Figure 6: Setting alarms

Adjusting Oxygen Alarm Set Points

1. Open the front door.
2. Push the toggle switch, located between the alarm set point adjustments, in the appropriate direction.
3. Adjust the alarm knob while viewing the alarm value on the display.
4. Release the toggle switch.

NOTE



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

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.

If the analyzer is equipped with a Low Flow Alarm (see page 18), it will be wired to Alarm 1.

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.

Non-CE Qualified Analyzers

Each alarm has a SPDT relay rated at 125/250 VAC at 5 Amps or 30 VDC at 5 Amps resistive load.

CE Qualified Analyzers

Each alarm has an SPDT relay rated at 30 VDC at 5 Amps. Exceeding this rating may cause damage to the analyzer. Not to be used for switching AC voltage.

Pressure Regulators

The regulator is mounted on or near the side of the enclosure with the separate, supplied bracket as shown in Figure 7. The outlet of the regulator is connected to the ¼ inch gas inlet fitting on the bottom of the enclosure.

If a filter is included in the installation, it should be mounted upstream of the regulator as in Figure 9.

The Standard Regulator is rated for 3000 psig inlet pressure.

The Absolute Regulator is rated to 1000 psig inlet pressure.

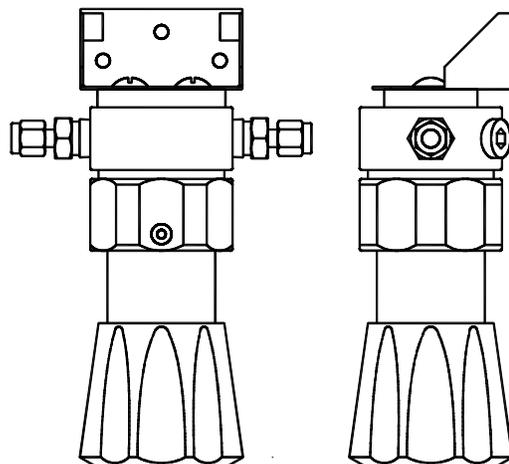


Figure 7: Regulator Installation

Filter

The Gas Sample Particle Filter is mounted on or near the side of the enclosure with the separate, supplied bracket as shown in Figure 8. The outlet of the filter housing is connected to the ¼ inch gas inlet fitting on the bottom of the enclosure.

The following filter elements can be purchased from Delta F.

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

Table 3: 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.

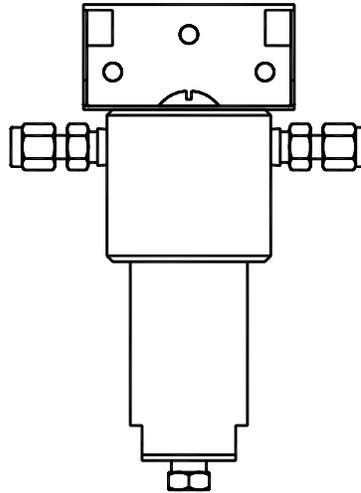


Figure 8: Filter Installation

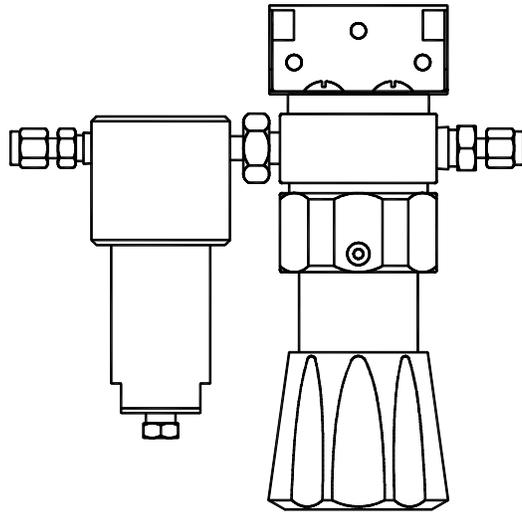


Figure 9: Combination Filter/Regulator Installation

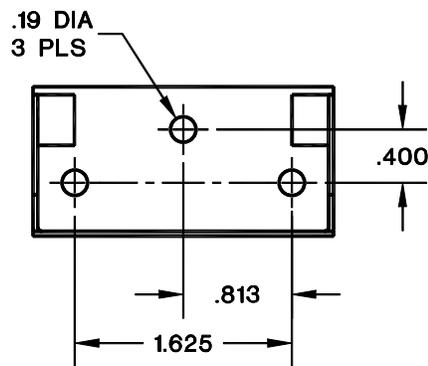


Figure 10: Filter/Regulator Mounting Bracket Dimensions

Low Flow Indication

The Sample Gas Flow Switch, if equipped, is mounted downstream of the sensor. The contacts will open when the sample flow falls below 0.12 lpm (0.26 scfh). For background gases other than Nitrogen, see Table 4 for trip points.

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 .5 A resistive.

Low Flow Alarm

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). For background gases other than Nitrogen, see Table 4 for trip points. The Low Flow Alarm contacts are on the I/O connector labeled Alarm 1 (See page 34). Also the front panel LED marked Low Flow will turn on when the flow is sufficiently low to trip the Flow Switch. (See Figure 11)

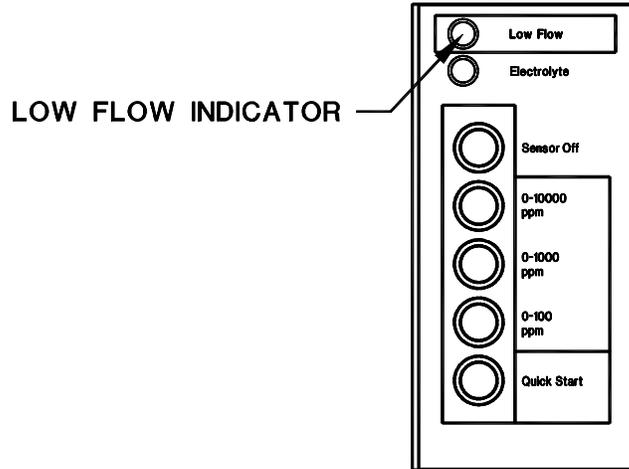


Figure 11: Low Flow Alarm

Background Gas	Trip Point (scfh)
Air	0.25
Ammonia	0.33
Argon	0.22
Butane	0.18
Carbon Monoxide	0.26
Ethane	0.25
Ethylene	0.26
Helium	0.69
Hexane	0.15
Hydrogen	0.96
Methane	0.34
Nitrogen	0.26
Propylene	0.21

Table 4: Approximate Trip Point for Flow Switch

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 labeled on the front panel to the left of the numeric display.

Flow Control Valve

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

Stainless Steel Outlet Tubing

Stainless steel outlet tubing is available in place of the standard Tygon™ outlet tubing. Stainless steel tubing is recommended for combustible or toxic gases.

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 this downstream valve to control the gas flow rate and leave all up stream valves wide open.**

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

CAUTION



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

Pump Control

An on-board pump can be controlled by the Pump Switch located behind the door.

The following two options are not available on CE marked analyzers:

If factory configured, an on-board pump can be controlled via a remote switch wired to the PUMP connector on the back panel.

OR

If factory configured, a remote pump can be powered and controlled by the Pump Switch located behind the door.

See page 37 for additional information.

Isolated 4 to 20 mA Output

The 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 “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.

Quick Start

The Quick Start function allows trace range analyzers to obtain readings below 10 ppm more quickly during start-up.

A momentary press of the Quick Start button initiates a Quick Start sequence of approximately twenty seconds. Upon completion of the sequence, the analyzer will automatically return to normal operation.

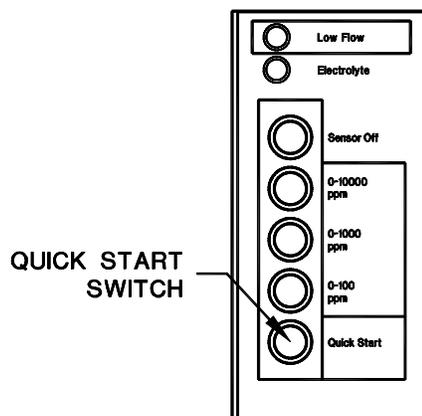


Figure 12: Quick Start Switch

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 N₂**, or **% H₂ in N₂**) 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: **% N₂ 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.

Adjusting the Gas Scale Factor Pot for Light Gases (He or H₂)

- 1) Open the front door.
- 2) Locate the View Ref. Toggle switch. See Figure 13.
- 3) Throw the toggle switch upward to % H₂ in N₂ (or % He in N₂, 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 % H₂ (or He) in N₂ 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.

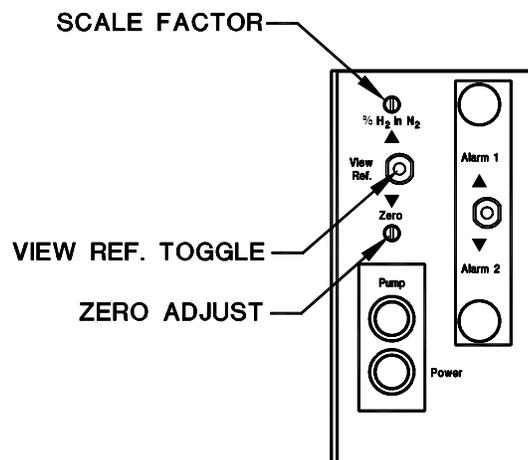


Figure 13: Gas Correction Factor Adjustment

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 13.
- 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	50-100 ppm	500-1,000 ppm	5000-10,000 ppm	2.5%-10%	25%
Argon (Ar)	1.03	1.03	1.04	1.05	1.02
Hydrogen (H ₂)	.61	.42	.51	.42	.74
Helium (He)	.69	.53	.48	.37	.72
Methane (CH ₄)	.94	.94	.92	.90	.96
Ethane (C ₂ H ₆)	1.15	1.15	1.19	1.23	1.10
Propylene (C ₃ H ₆)	1.22	1.22	1.27	1.33	1.14
Propane (C ₃ H ₈)	1.26	1.26	1.32	1.38	1.17
Butene (C ₄ H ₈)	1.45	1.45	1.57	1.68	1.30
Butane (C ₄ H ₁₀)	1.48	1.48	1.60	1.72	1.32
Butadiene (C ₄ H ₆)	1.42	1.42	1.52	1.63	1.28
Acetylene (C ₂ H ₂)	1.05	1.05	1.06	1.08	1.03
Hexane (C ₆ H ₁₄)	1.75	1.75	1.94	2.13	1.50
Cyclohexane (C ₆ H ₁₂)	1.57	1.57	1.71	1.86	1.38
Vinyl Chloride (CH ₂ CHCl)	1.35	1.35	1.44	1.53	1.24
Vinylidene Chloride (C ₂ H ₂ Cl ₂)	1.30	1.30	1.37	1.44	1.20
Neon (Ne)	.85	.85	.81	.78	.90
Xenon (Xe)	1.43	1.43	1.54	1.65	1.29
Krypton (Kr)	1.21	1.21	1.26	1.32	1.14
Sulfur Hexafluoride (SF ₆)	1.84	1.84	2.06	2.27	1.56

Freon 318 (C4F8)	2.54	2.54	2.93	3.31	2.03
Tetrafluoromethane (CF4)	1.61	1.61	1.76	1.91	1.40
Carbon Monoxide (CO)	1.01	1.01	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.

Enclosure Heater

The enclosure heater, if equipped, has been factory set to maintain an optimal internal sensor temperature depending on the application, typically 65–70 degrees F. No adjustments are necessary.

NOTE: Certain applications may require that the enclosure temperature be set higher. Tighter year round temperature performance in warmer climates or the need to avoid sample condensation with samples dew points near 60 F are two examples of these conditions. Do not set the temperature above 100 F.

See page 27 for additional information on changing the temperature setting.

NOTE: The customer must supply the electrical power (110/220 VAC, 150 Watts) for this option.

Enclosure Z-Purge

The enclosure Z-Purge, if equipped, must be adjusted and tested before analyzer start-up.

The alarm relay contacts can be wired to a customer supplied DCS to provide a loss of purge protection signal. The contacts are rated at 15A at 125/250/480 VAC and both normally open and normally closed contacts are provided. It is preferred that the analyzer supply voltage be wired through these contacts. Loss of sufficient purge pressure will then shut the analyzer down.

NOTE: All electrical penetrations to the enclosure must be sealed to enable the Z-purge system to properly pressurize the system. A kit of material is included for this purpose. A valve is provided on the bottom of the enclosure to provide over-pressure relief.

Z-Purge Set-up Procedure

- 1) Check that the pressure calibration screw on the pressure switch is backed out as far as possible to the minimum setting of .15 inches of water.
- 2) Close the Z-purge regulator by turning it fully counter-clockwise.
- 3) Fully open the Z-purge flowmeter needle valve.
- 4) Open the air (nitrogen) supply to the regulator. NOTE, this gas supply should be pre-regulated to the minimum pressure required to supply a flow of 50 scfh.
- 5) Open the Z-purge regulator to provide a flow of 50 scfh to the enclosure as indicated on the flowmeter.
- 6) Verify that the alarm contacts have switched to the de-activated position.
- 7) Reduce the flow rate to 5-10 scfh with the flowmeter needle valve and confirm that the alarm contacts do not switch from the de-activated position.
- 8) Turn the analyzer on after completing the steps in the front of this manual under start-up.

Remote Sensor Installations

The oxygen sensor for a DF Series analyzer may be installed remotely (if equipped with this option). Areas of high convected or radiated heat must be avoided.

If installed outdoors the sensor enclosure must be shielded from the sun to avoid overheating. In addition, a heater must be installed in the enclosure in areas where the temperature goes below freezing.

Care must be taken to use high quality cable and techniques when making remote connections. Refer to Table 6 on page 36 and Table 7 on page 37 for wire sizes and lengths. Following are two possible remote sensor configurations and wiring diagrams. Contact Delta F for additional information on remote sensor installations.

Sensor in NEMA 4 Enclosure

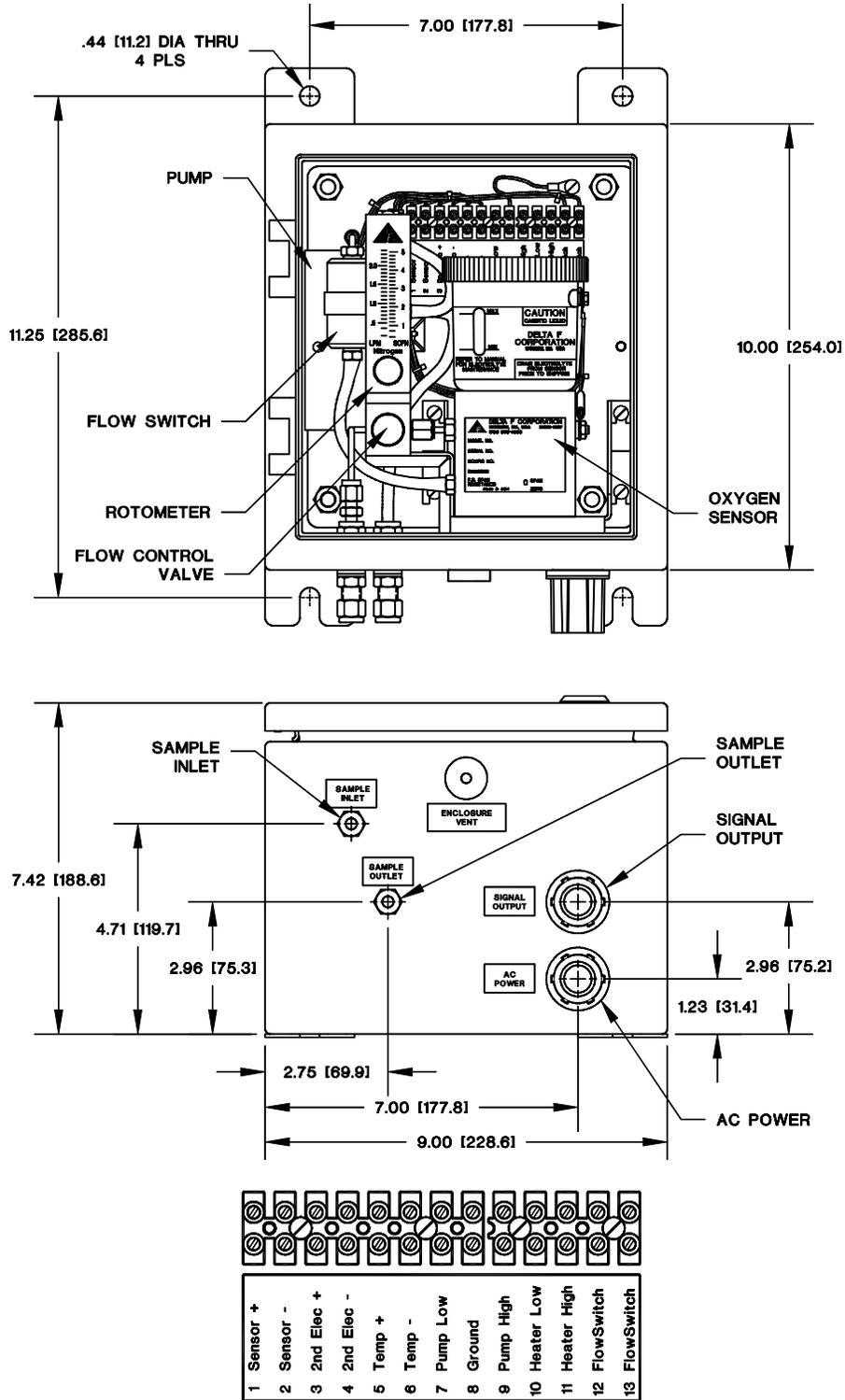


Figure 14: NEMA 4 Remote Sensor Enclosure and Wiring Pin-out

Sensor in NEMA 7 Enclosure

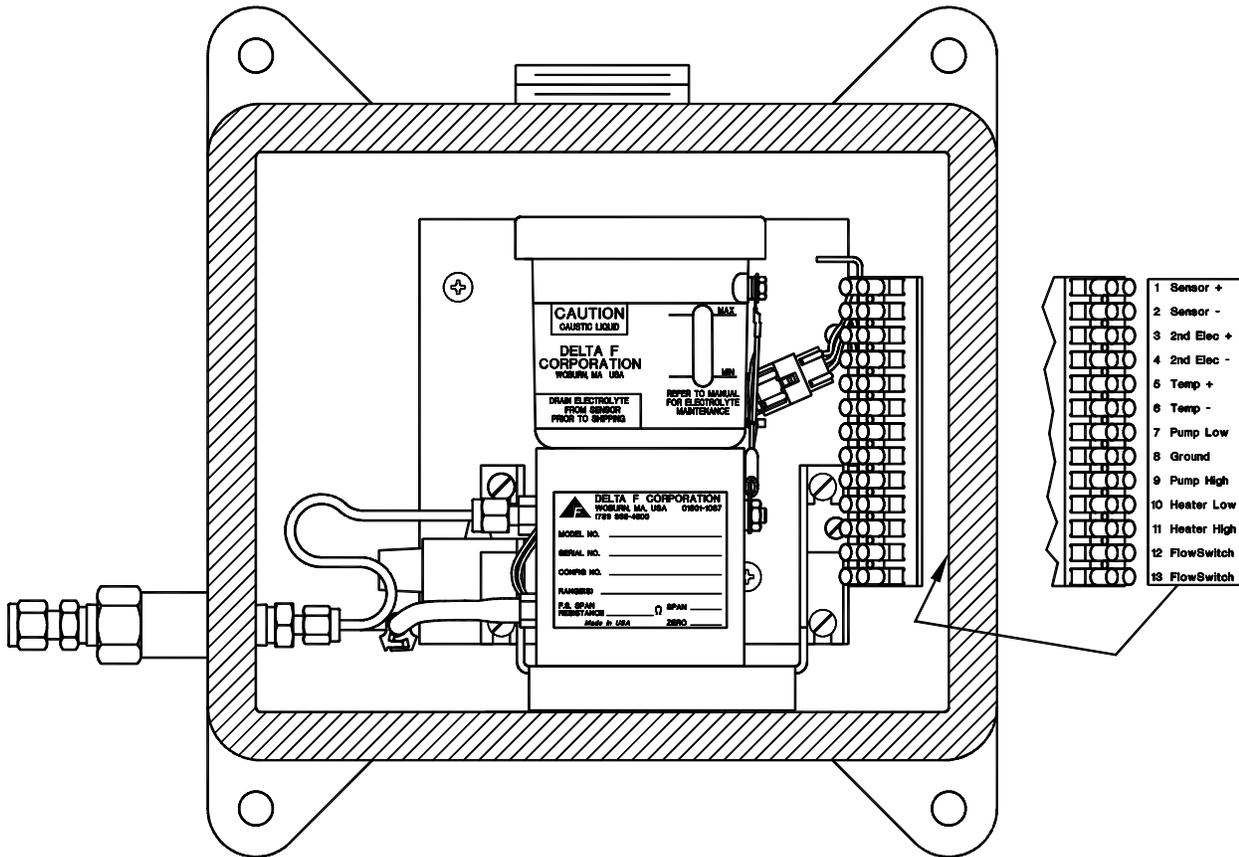


Figure 15: NEMA 7 Remote Sensor Enclosure and Wiring Pin-out

Temperature Control in R4/R7 Enclosures

R4 and R7 remote sensor enclosures may be supplied with the temperature control option. Typically this option is installed in an effort to minimize diurnal changes in outdoor installations, or when the sensor must be kept at an elevated temperature in order to minimize condensation.

NOTE: The customer must supply the electrical power (110/220 VAC, 150 Watts) for this option.

For most applications, the sensor and electronics are maintained at a temperature of 65-70 degrees F. The temperature controller, located in the R4 or R7 enclosure, is set at the factory and typically requires no adjustment unless components are changed or application conditions require higher

temperatures. In the event that the enclosure temperature must be adjusted, follow the steps below.

- 1) Obtain a temperature measurement device capable of measuring the desired operating temperature to an accuracy of +/- 2 degrees F.
- 2) Open the R4 door or remove the R7 cover. Attach the temperature measuring probe to the side of the oxygen sensor. Be sure to cover the enclosure opening to prevent cooling.
- 3) Turn on the analyzer and heater. Allow at least four hours for the enclosure temperature to stabilize.
- 4) Locate the temperature control potentiometer on the circuit board in the enclosure above the terminal strip. See Figure 16 Turn it clockwise to increase the temperature and counter-clockwise to decrease it. After each adjustment re-cover the enclosure and allow at least an hour for it to stabilize at the new temperature.

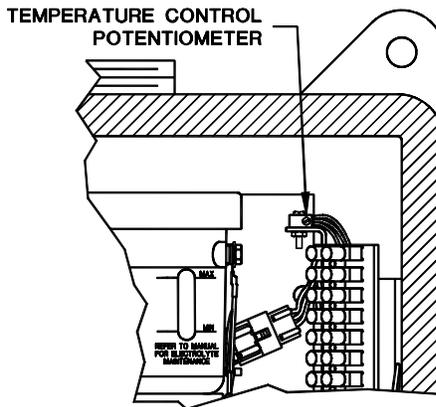


Figure 16: Enclosure Temperature Control

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.

Contact Delta F for specific sample conditioning recommendations.

Normal Operating Conditions

Physical Parameter	Recommended Range	Normal Operating Range
Sample Pressure (See note)	Atmospheric + (.2 - .5 psig)	-2 psig to 2 psig
Sample Flow	2 scfh (1 slpm)	1 – 3 scfh (.5 – 1.5 slpm)
Sample Temp (See note)	75F +/- 10F (25C +/- 5C)	40F – 113F (5C – 45C)
Ambient Temp	75F +/- 10F (25C +/- 5C)	45F – 95F (7C – 35C)

Note: Sample pressure and temperature measured at sensor inlet

Condensation/ Liquid Slugs

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. In these applications it is good practice to pitch the lines to allow any minor condensation to drain away from the analyzer.

Careful attention should be paid to the location of the process sample tap to avoid the possibility of liquid slugs from entering the analyzer sample line. Possible process upset and maintenance conditions should be considered in the decision.

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.

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 rates: 0.5 and 3.0 scfh. In a tight plumbing system, only a slight readout change will occur as the flow is varied. If a leak does exist, an increase in flow, and the resulting dilution of the sample, will cause a decrease in the oxygen readout. Similarly, a reduction in gas flow will cause an increased oxygen reading as the concentration goes up. Readings can vary as much as 25% to 50% in gas delivery systems with leaks.
2. As the user becomes familiar with the analyzer it can be used to determine the distance to a leak by noting the relationship between the time it takes for the analyzer to react to the change in gas flow rate.
3. When flow sensitivity is observed, check the external plumbing for leaks. If the gas delivery lines are tight, remove the sensor assembly from the enclosure to check the internal connections. See page 53.
4. Carefully check the stem and packing on the sensor inlet flow control valve (if equipped).
5. 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.

NOTE



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

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.

NOTE



If the sensor remains on while exposed to oxygen concentrations significantly higher than 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 on the front panel. (See Figure 3)

The installation of gas valves to block the process gas flow, and/or direct inert gas flow to the sensor is highly recommended to minimize the possibility of damage to the sensor under process upset or maintenance conditions.

Reactivity with KOH Electrolyte

Many process sample streams contain various concentrations of acid gases which will react with the basic electrolyte. The sensor will not operate properly if the electrolyte is neutralized by the presence of acidic gas species in the background. For applications containing modest amounts of acid gases, the STAB-EL sensor can be used. See page 13 for details.

Outputs and Remote Connections

Several connectors can be found inside the enclosure on the rear panel:

- The I/O connector is available on all versions of the DF Series, however, options indicated by labels on the connector may not have been included in the analyzer.
- The Remote Sensor connector is not available on the CE Qualified DF-140 analyzers.

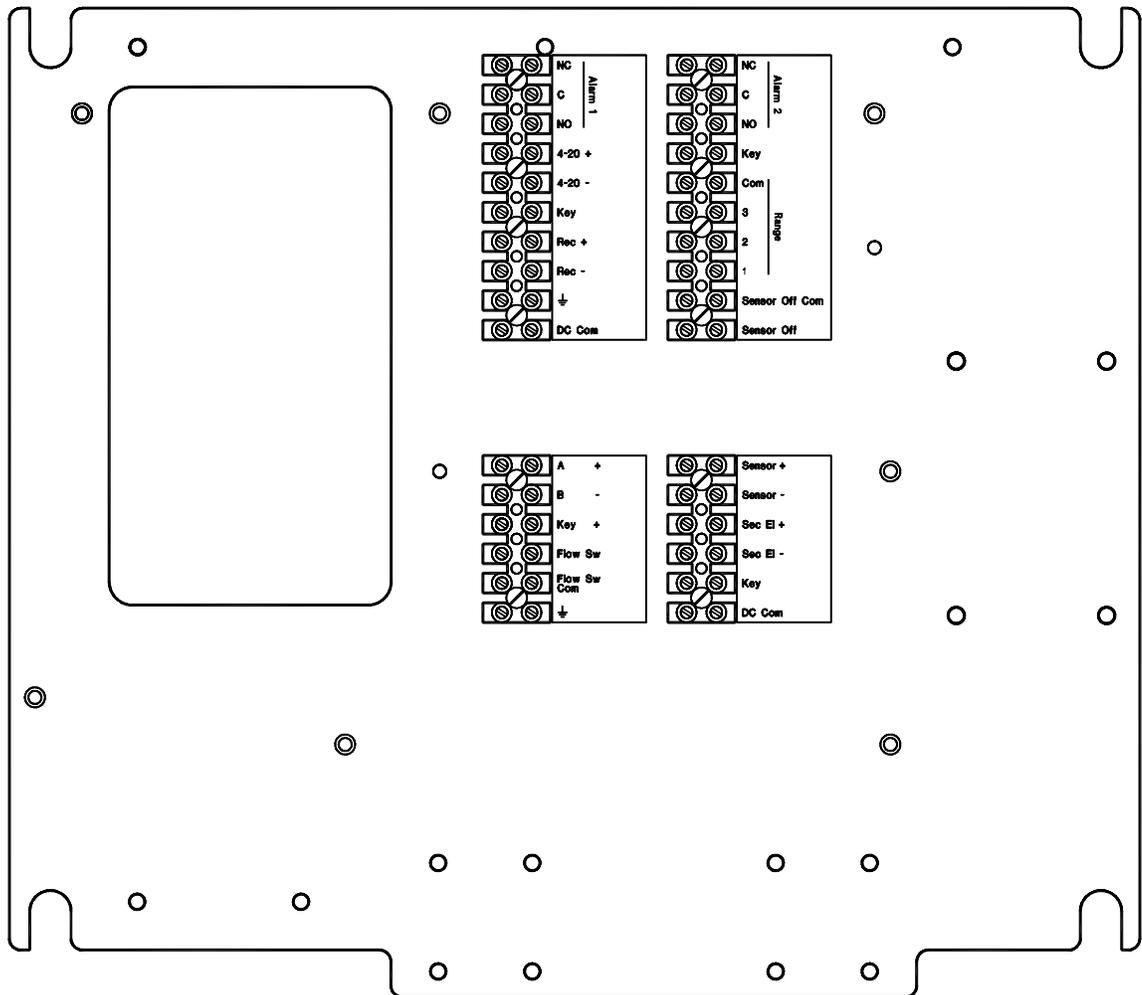


Figure 17: Rear Panel Connections

The I/O Connection

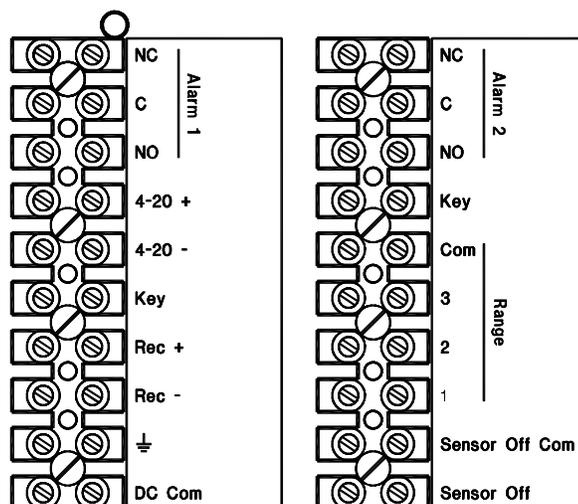


Figure 18: I/O Connector Pin-out

Alarm 1 and 2 (NC-C-NO)

Alarms are optional. Two alarms are available on the DF-140. Typically, the alarms are configured for high and low oxygen set points. If the analyzer is equipped with a Low Flow Alarm (see below), it will be wired to Alarm 1.

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.

Non-CE Qualified Analyzers

Each alarm has a SPDT relay rated at 125/250 VAC at 5 Amps or 30 VDC at 5 Amps resistive load.

CE Qualified Analyzers

Each alarm has an SPDT relay rated at 30 VDC at 5 Amps. Exceeding this rating may cause damage to the analyzer. Not to be used for switching AC voltage.

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 the chassis (earth) ground.

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

Connections to the 4-20 mA output should be through a shielded, twisted pair with the shield tied to the nearest ground stud.

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. See the sticker on the inside of the front door for the current setting of the analog output voltage.

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.

Connections to the analog output should be made through a shielded, twisted pair with the shield tied to the nearest ground stud.

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

The analog output is proportional to the oxygen reading of the analyzer. On three range analyzers, 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.

The contacts are rated at 24 VDC, .5 Amps.

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 front panel Sensor Off switch. See Figure 3. The Sensor Off switch position is indicated by a SPST contact across the “Sensor Off” contacts. Sensor On is indicated by an “open” and Sensor Off is indicated by a contact “closure”. The contact is rated 24 VDC, .5A.

DC Common (DC Com)

Do Not Use.

Ground (⊥)

Do Not Use.

The Remote Sensor Connections

The Remote Sensor connectors are not available on CE Qualified DF-140 analyzers. A single shielded cable can be used for all signals on this connector.

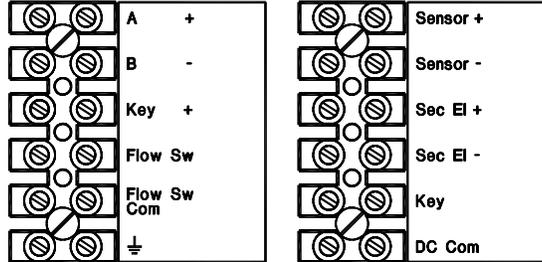


Figure 19: Remote Sensor Connector Pin-out

Remote Sensor (Sensor +, Sensor -)

If the sensor is located remotely from the analyzer, 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 stud on the analyzer back panel. To avoid ground loops, the shield should be left open and *not* attached to the remote sensor chassis. The polarity must be maintained on the Sensor + and Sensor - connections.

Remote Sensor and Flow Switch Cable	
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

Secondary Electrodes (Sec EI +, Sec EI -)

If the sensor is located remotely from the analyzer, the secondary electrode connections on the sensor should be wired through a shielded, twisted pair cable. The shield should be terminated at the Ground stud on the analyzer back panel. To avoid ground loops, the shield should be left open and *not* attached to the remote pump chassis. The polarity must be maintained on the Sec EI + and - connections.

Flow Switch (Flow SW, Flow SW Com)

When a remote sensor is equipped with a flow switch, it can be wired to the analyzer through the terminals on the Remote Sensor connector labeled Flow Sw. It should be wired through a shielded, twisted pair cable of sufficient size for the required run. See Table 6 on page 36 for wire sizes.

Pump Control Connections

Pump Control

(Not available on CE Qualified analyzers.)

The analyzer can be factory configured to allow a user-provided switch to provide control of an on-board pump or to power and control a remote pump. An on-board pump can always be controlled by the pump switch located behind the front door.

Analyzer Control of a Remote Pump

If factory configured, a remote pump can be powered and controlled through the Pump Control connector on the back panel.

DANGER



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 control wires should be in a shielded cable (separate from the sensor signal) with the shield attached to the ground stud on the back panel. To avoid ground loops, the shield should left open and *not* attached to the remote pump chassis. The three wires in the pump cable should be attached to the pump connector on the analyzer back panel labeled AC HI, AC LOW and 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

Remote Control of the On-board Pump

If factory configured, an on-board pump can be controlled via a remote, user provided switch wire in series with the PUMP connector. The pump switch located behind the front door is in series with any external remote switch. See the rear panel of the analyzer for pump control information.

DANGER



The pump connector will have 110 VAC present.

NOTE



The pump switch located behind the front door 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.

Maintenance and Calibration Checks

Sensor Maintenance

Delta F analyzers require no routine maintenance other than the occasional addition of distilled or de-ionized water to the sensor.

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

It is good practice to check the sensor level every 1 to 2 months initially to determine the rate at which the water level in the sensor is lowering based on your application. Quarterly additions of water are typical.

NOTE



If the electrolyte is low, add only distilled or de-ionized water. Do not add electrolyte solution! Do not overfill.

Adding Water

1. Open the front door.
2. Remove the lid from the sensor tank.
3. Using the water bottle included with the analyzer, gently add distilled or deionized water to raise the electrolyte level to the “max” mark. *Do not over fill. Do not add electrolyte.*
4. Re-install the lid securely.

Calibration

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

Depending on the application, the calibration should be *checked* approximately every twelve months using a gas of known concentration and high quality plumbing components. For applications with background gases containing aldehydes, alcohols or acids the span calibration should be checked every three months and electrolyte changes may be necessary. Contact Delta F for specific maintenance recommendations.

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. See the section on Gas Scale Factor on page 21.

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. Open the front door.
2. Locate the View Ref. toggle switch. See Figure 20
3. Throw the toggle switch to Span, and record the Span Calibration Reference Value as shown on the 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. Similarly record the Zero Calibration Reference Value.
5. Release the toggle switch.
6. 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.

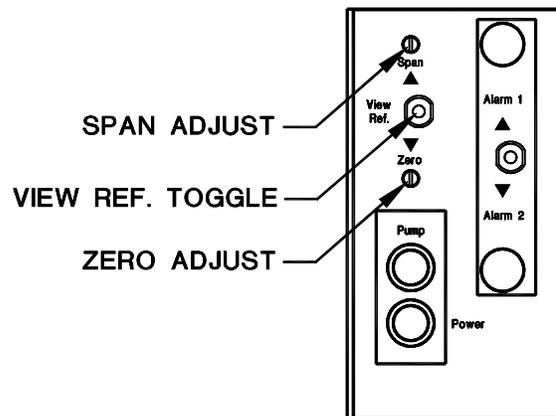


Figure 20: Calibration Controls

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.

Adjusting Calibration (with the Gas Scale Factor Option installed)

For analyzers that have Scale Factor installed, the Span calibration potentiometer is located to the right of the range switches.

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.

Cleaning the Analyzer

Before attempting to clean the analyzer, turn off all power and unplug the cord. Clean the outside of the enclosure with a soft cloth dampened slightly with water. Avoid the use of solvents or ammonia based cleaners.

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.

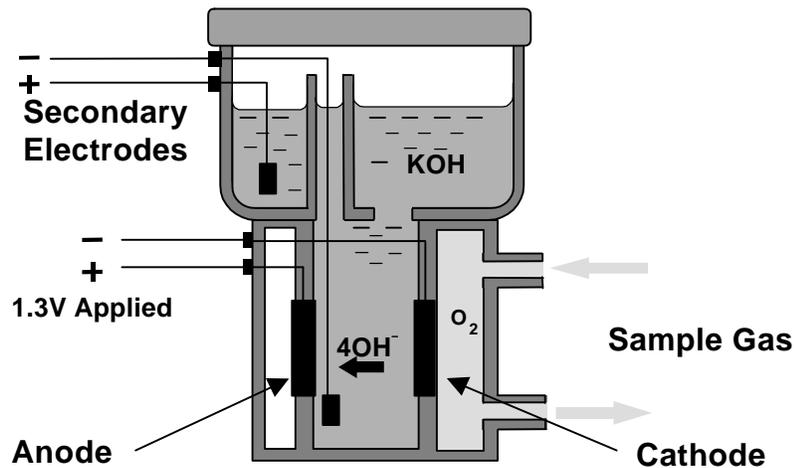
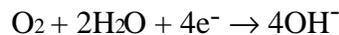
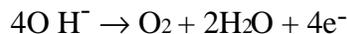


Figure 21: Schematic of DF Series Oxygen Sensor

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:



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.



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

Troubleshooting

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 53.

Problem Observations

Observation	Recommended Action (See Table Below)
1. Analyzer reads low	A B D E H I F 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 H K
6. Slow speed of response	G C D E F K
7. Electrolyte residue visible on the sensor	K
8. Electrolyte Condition indicator ON	E K

Table 8: Problems and Observations

Remedy Table

	Remedy Description
A.	Check the analyzer calibration using a gas of known oxygen concentration. See page 40.
B.	Check to see that the Zero Calibration Value agrees with the factory value marked on the sensor. See page 40
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 30
D.	<p>Verify that the correct voltages are being supplied to the sensor. These voltages should be checked with the cable disconnected from the sensor.</p> <p>Primary Electrodes</p> <p>wht/yel (-) to wht/blk/red (+) = 1.3 +/- 0.03 VDC (For 25% sensors only = 1.4 +/- 0.03 VDC)</p> <p>Secondary Electrodes</p> <p>wht/blue (-) wht/red (+) = 7.0 +/- 0.5 VDC</p> <p>Voltage levels between any other combination of wires should be less than 0.1 VDC.</p>
E.	Change the electrolyte using the procedure described in the Analyzer Start-up Procedure section of this manual on page 5. Rinse the sensor with de-ionized or distilled water prior to refilling and use only DF-E05 electrolyte. Allow several hours of operation on gas to equilibrate.
F.	<p>Turn the analyzer off and reverse the position of the two lower leads on the sensor. Establish a gas flow and allow the analyzer to operate in this fashion for more than one hour but not more than three hours. Return the wires to their original position and change the electrolyte using the procedure described in the Analyzer Start-up Procedure section of this manual on page 5..</p> <p>Rinse the sensor with deionized or distilled water prior to refilling and use only DF-E05 electrolyte. Allow several hours of operation on sample gas to equilibrate.</p>
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.	Call the Delta F Service line at 781/935-5808 for assistance or E-mail us service@Delta-F.com .

Table 9: Possible Solutions

Troubleshooting Considerations

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.

If the analyzer is not vented to atmosphere, downstream conditions may impact sensor pressure. If the vent pressure is outside the range of +/- 2 psi, a recalibration under operating conditions may be desirable to remain within the stated analyzer accuracy.

Positive Pressure Operation

Gas pressure should be set to establish a nominal flow of 1.0 to 3.0 scfh. A regulator may be used to adjust the flow rate if there is no downstream restriction on the flow.

If the analyzer is not vented directly to atmosphere, downstream conditions may restrict flow. Keep downstream plumbing lengths and restrictions to a minimum. Do not exceed +/- 5 psi pressure on the sensor.

NOTE



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

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.

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

NOTE



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

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

Table 10: Typical Output Drift by Analyzer Range

Flow Rate Effects on Sensor Performance

Assuming a perfectly leak tight gas delivery system, flow rates above the standard 1.0 – 3.0 scfh may increase the O₂ readout by a few percent of reading. Similarly, lower than standard flow rates may cause a decrease in the readout by a few percent of reading.

At very low flow rates (< .2 scfh) O₂ readings are much more sensitive to flow rate changes. As a result, if the analyzer is recalibrated at lower than normal flow rates, the new flow rate must be held within +/- 10%.

The normal insensitivity of Delta F sensors to flow rate changes is the basis for the Flow Sensitivity Leak Check Method described in the section on Leaks found on page 30.

Replaceable Spare Parts

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

Description	P/N
Display 3.5 digit	54218506
Display 4.5 digit	54218508
Electrolyte	DF-EO5
Filter Element – Coarse	64005011
Filter Element – Fine	64005012
Flow Meter	11220841
Flow Meter w/Valve	11220842
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	99000028
PCB - Alarm	10423440
PCB - Main	10423430
Pump	63000303
Ribbon Cable – Display to Main PCB	13323560
Sensor	Call Delta F

Table 11: Spare Parts

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.

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 (RMA) 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.

Draining the Sensor

Remove the Sensor

1. Open the front door.
2. Turn power off.
3. Disconnect the electrical cable that runs to the sensor.
4. Using a 7/16 inch backing wrench, remove the compression nut on the gas inlet bulkhead fitting on the bottom of the enclosure interior.
5. If the analyzer is equipped with the stainless steel outlet tubing option:
Using a 7/16 inch backing wrench, remove the compression nut on the gas outlet bulkhead fitting also on the bottom of the enclosure interior.
6. Use a screwdriver to loosen (do not remove) the four sensor bracket mounting screws on the back panel.
7. Carefully lift the sensor and bracket assembly over the screw heads.
8. Pull the sensor and bracket assembly forward a few inches and remove the quick disconnect at the top of the flowmeter. (Skip this step if the analyzer is equipped with the stainless steel outlet tubing option.)
9. Finish removing the sensor from the enclosure.
10. Carefully un-screw the lid from the sensor.

11. Tip the sensor, carefully capture the liquid, and dispose of it appropriately.
12. Rinse sensor with distilled or de-ionized water.
13. Screw the lid securely onto the sensor.

Re-install the Sensor

1. Carefully place the sensor and bracket assembly in the enclosure a few inches.
2. Re-connect the quick disconnect at the top of the flowmeter. (Skip this step if the analyzer is equipped with the stainless steel outlet tubing option.)
3. Carefully set the sensor bracket on the four mounting screws. Tighten the screws.
4. If the analyzer is equipped with the stainless steel outlet tubing option, replace the compression nut on the outlet bulkhead fitting.
5. Replace the compression nut on the inlet gas bulkhead fitting.
6. Re-connect the electrical cable that runs to the sensor.

Draining Sensors in R4 and R7 enclosures

1. Make up the supplied compression fitting, ferrule and ¼ inch PVC tube to the drain valve on the side of the sensor.
2. Place the end of the PVC tube in a suitable container with a minimum capacity of .75 liters.
3. Remove the cap on the top of the sensor.
4. Open the drain valve on the side of the sensor.
5. Allow sufficient time for the electrolyte to drain completely.
6. Flush the sensor with .5 liters of distilled or de-ionized water.
7. Close the drain valve and remove the tube.

Safety and Operating Notices

Safety Notices

DANGER



Line voltage exists in the Oxygen Analyzer Enclosure behind the door. DO NOT touch any of the electrical components when the analyzer is connected to AC power.



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

Operating Notices

NOTE



The sensor is shipped dry and must be charged with electrolyte before it is operated. Use only Electrolyte DF-E05. Failure to do so will void the warranty.

NOTE



If the electrolyte level is low, only distilled or deionized water 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. The sensor 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 sensor or the instrument.

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 the analyzer unless a sample gas is flowing through the sensor.
- This analyzer must be operated in a manner consistent with its intended use and as specified in this manual.

Material Safety Data Sheet (MSDS)

The Material Safety Data Sheet begins on page 65.

Seguridad

PELIGRO



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



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 DF-E05. 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 oxígeno estén demasiado altas. Se pueden dañar los sensores, si se exponen por largo tiempo (>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..

Avisos Generales

- No exponga este instrumento a la lluvia ni a alguna rociada de agua, al menos 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 más de 50°C (122°F).
- Verifique que la línea de voltaje del analizado esté correcto.
- Exceso de presión al analizador puede resultar en daños permanentes al sensor.
- No use el analizador al menos que una muestra de gas esté pasando por el sensor.

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.



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 DF-E05. 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.

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 Celsius (113 Grad Fahrenheit).
- Setzen Sie diesen Analysator keinen Temperaturen über 50 Grad Celsius (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.

Mesures de sécurité

DANGER



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



L'électrolyte est une solution caustique. Revisez les instructions 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 expédié à sec et devra être chargé avec l'électrolyte avant d'être employé. Utilisez uniquement l'électrolyte DF-E05. L'inobservance de cet avis annulera 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 électrolyte pour rétablir le niveau de l'électrolyte.

Ne remplissez pas au dessus du niveau requis.

PRECAUTION



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

PRECAUTION



N'actionnez pas l'analyseur à des concentrations d'oxygène au dessus des limites pendant des périodes prolongées. Les senseurs pourraient être endommagés s'ils sont exposés à des haut niveau d'oxygène, c'est à 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.

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 réglé correctement.
- Supression 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.

Misure di sicurezza

PERICOLO



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



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

ATTENZIONE



Il sensore è spedito a secco, dunque dovrebbe essere caricato col'elettrolito prima di azionarlo. Usare solo il ELECTROLYTE DF-E05 per l'Analizzatore dell'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 dovrà 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 danneggiati quando esposti ad alti livelli di ossigeno, cioè, aria, per lunghe durate di tempo. (più di 15 minuti) quanto collegati alla corrente elettrica.

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

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'analizzatore sia allegata a una corrente con un voltaggio adatto.
- Sovrapressione dell'analizzatore potrebbe risultare in un danno permanente del sensore.
- Non si deve azionare un'analizzatore a meno che un gas conforme a campione circola nel sensore.

ELECTROLYTE SOLUTION

MATERIAL SAFETY DATA SHEET (MSDS)

1. IDENTIFICATION OF THE SUBSTANCE

Trade Name Electrolyte Solution, 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)	
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2. COMPOSITION

CAS #	Component	EC Code/class	Concentration	Risk Phrase	Risk <u>Description</u>
1310-58-3	Potassium Hydroxide in aqueous solution	215-181-3 C	1N: 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/m³
NIOSH, (8hr TWA) 2mg/m³
ACGIH, Ceiling 2mg/m³
OSHA, not listed

9. Physical & Chemical Properties

Molecular Formula	KOH Mixture
Physical State	1N 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. Toxicological Information

Toxicity (Potassium Hydroxide)	CAS# 1310-58-3: Oral, rat: LD50 = 273 mg/kg
Carcinogen Status	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.

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 one-year 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 at the then current purchase price, equal to such current price multiplied by a fraction thereof in which the numerator is the number of months from the date of shipment by the Seller of the defective sensor to the time it is received back at Delta F Corporation and the denominator of which is sixty (60).

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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