



Oxygen Analyzer *DF-560E*

Operator Manual

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DF-560E Operator Manual

Firmware v3.0.9

Version 100711

Your NanoTrace Oxygen Analyzer has been designed, manufactured and is supported under ISO-9001 controls, thus helping to insure the highest possible standards of quality.

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

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

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

For more information or if you have questions, please do not hesitate to go to our website at Servomex.com, or contact your local Servomex Business Center as found on the back cover of this manual.

Read Me First...

Unpacking Procedure

Follow the procedure below to unpack your DF-560E Oxygen Analyzer.

1. Examine the condition of the packaging and its contents. If any damage is apparent, immediately notify the carrier and Servomex. Do not proceed with the installation.
2. Check the contents against the packing slip to make sure the shipment is complete. Unattached equipment may be shipped with the analyzer in supplemental packaging. Shortages should be reported to Servomex immediately.
3. All DF-560E analyzers are shipped with the following:

Item	Servomex Part Number
One bottle of Hummingbird Brand Electrolyte Gold	Electrolyte Gold
One bottle of Hummingbird Brand Replenishment Solution	210515
Power Cord with 115VAC connector NOTE - No power cord is supplied with 220 VAC or DC powered units	210408
Operator Manual	210762

4. Open the analyzer door, remove any shipping materials and verify that nothing has come loose during transit.
5. The analyzer is set at the factory to operate on 115VAC or 220VAC. Examine the voltage indicator on the rear panel to verify that the voltage is set as ordered.
6. Save the original container in the event you may need to ship the analyzer to another location or back to the factory (see Shipping in the Service section).

Installation and Maintenance

The DF-560E Analyzer provides years of accurate and dependable service if it is set up, operated and maintained properly. It is essential to make a careful and complete installation as outlined in the *Installation and Setup* section of this manual. It is assumed that DF-560E users are familiar with the techniques and precautions associated with Ultra-High Purity (UHP) gas, its plumbing, and devices such as UHP regulators and gas purifiers, and that the analyzer is used as designed and intended.

Unlike much UHP analytical equipment, DF-560E does not require constant maintenance. However the maintenance intervals for zero and span calibrations, as well as electrolyte and purifier maintenance, must be determined and followed carefully.

Thank You

Thank you for selecting the DF-560E Analyzer. Servomex designs, manufactures, exhaustively tests, and supports every analyzer under ISO-9001 control. You should expect every Servomex analyzer to arrive in perfect working order and, with good maintenance, provide years of trouble-free service.

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2 Cautions

There are a number of warnings and cautions that must be observed to avoid damage to the analyzer as well to insure the safety of its users. The analyzer must be operated in a manner specified in this manual. Servomex cannot be responsible for direct or consequential damages that result from installing 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. Servomex cannot be responsible for direct or consequential damages that result from using the analyzer with these gases.

2.1 Symbols and Explanations

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

CAUTION



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

NOTE



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

DANGER



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

2.2 Important Warnings

CAUTION



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

CAUTION



Do not setup or operate the 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.

DANGER



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

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

CAUTION



Over-pressurizing the sensor can result in permanent damage to the sensor. Limit the backpressure to the analyzer to ± 1 psig.

*Be sure the downstream isolation valve (if so equipped) is toggled open **before** gas flow is started.*

CAUTION



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

EMI DISCLAIMER



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

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

3 Specifications

Range of Operation:

0-20ppm

Lowest Detection Level (LDL):

75 ppt @ Constant Conditions

Resolution (Smallest Detectable Change):

50 ppt

Calibrated Accuracy:

±3 percent of reading or ±0.1 ppb (whichever is greater) @ Constant Conditions

Response Time:

Typically less than 15 seconds to read 90 percent of a step change. The equilibrium time is dependent on specific conditions.

Upset Recovery Time:

Typically less than 5 minutes from a high ppm upset to within 10 ppb of the previous stable reading.

Ambient Operating Temperature:

0° C to 45° C (32° F to 110° F)

Analog Output Range:

0-100 ppm (max) 0-2 ppb (min)

Operating Inlet Pressure:

15 to 25 psig (1.03 to 1.72 bar) (orifice restricted)

Return Pressure:

Maximum ±1.0 psig (atmospheric vent recommended)

Flow Rate:

1.0 to 2.0 scfh (0.5 to 1.0 slpm)

Sample Temperature:

0° C to 50°C (32° F to 122° F)

Moisture:

No limits (avoid condensation)

Background Gas Compatibility:

All inert and passive gases including N₂, H₂, He, Ar and so forth

Storage Temperature:

Not to exceed 50° C (122° F)

Gas Flow Construction Materials:

300 series stainless steel
1/4-inch VCR-type compatible inlet fitting
1/8-inch compression outlet fitting
orbital butt welded sample inlet assembly

Calibration System Components:

(Optional) Pneumatically or manually actuated springless diaphragm valve calibration system to provide zero and span calibrations. Orbital butt- welded assembly with one quarter inch VCR-type connections.

Sensor Warranty:

5 years, limited. See *Warranty* section on page 129.

Power Requirements:

100 to 120 Vac, 50/60 Hz, standard, .3 Amps
200 to 240 Vac, 50/60 Hz (optional), .15 Amps
NiMH battery supplemental power (optional)

Display:

2.5-inch by 3.75-inch super twist LCD graphics with backlighting

Output Signals:

Analog Output: Menu scalable from 0-2 ppb to 0-100 ppm
Non-isolated 4-20 mADC (1K maximum loop resistance, with built in 28 VDC loop supply), 0-1 VDC, 0-2, 0-5 VDC, or 0-10 VDC (standard - minimum load resistance is 1K)
Digital Output: Two-way RS-232 (optional), or 2-way RS-485 (optional)

Calibration Control:

Calibration-in-Process indication (requires an optional relay). Switched 6 VDC @ 0.25A for menu driven control of external, user-provided, zero/span solenoids and valves.

EMI Sensitivity:

SAMA Standard PMC 33.1, Class 3A, B for EMI susceptibility

Audible/Visual Alarm Status Indicators:

- Four oxygen, one temperature, and one electrolyte condition alarm (standard)
- One low flow alarm (optional)

Alarm Relays:

Up to 4, non-latching, independently assignable to alarms or to calibration-in-process indicators. SPDT contacts rated at 30 VDC @ 5A resistive load. (Do Not Switch AC Power) Fail safe action upon loss of power to alarm condition.

Construction:

NEMA 1, CE Approved

Dimensions:

12.2-inch (30.9cm) wide x 8.9-inch (22.7 cm) high x 10.0-inch (25.4 cm) deep
approximate (with handle and gas fittings)

Weight:

18 pounds (8.2 kg) (approximate)

- with optional manual calibration system add 2 pounds (.9 kg)

- with optional automated calibration system add 4 pounds (1.8 kg)

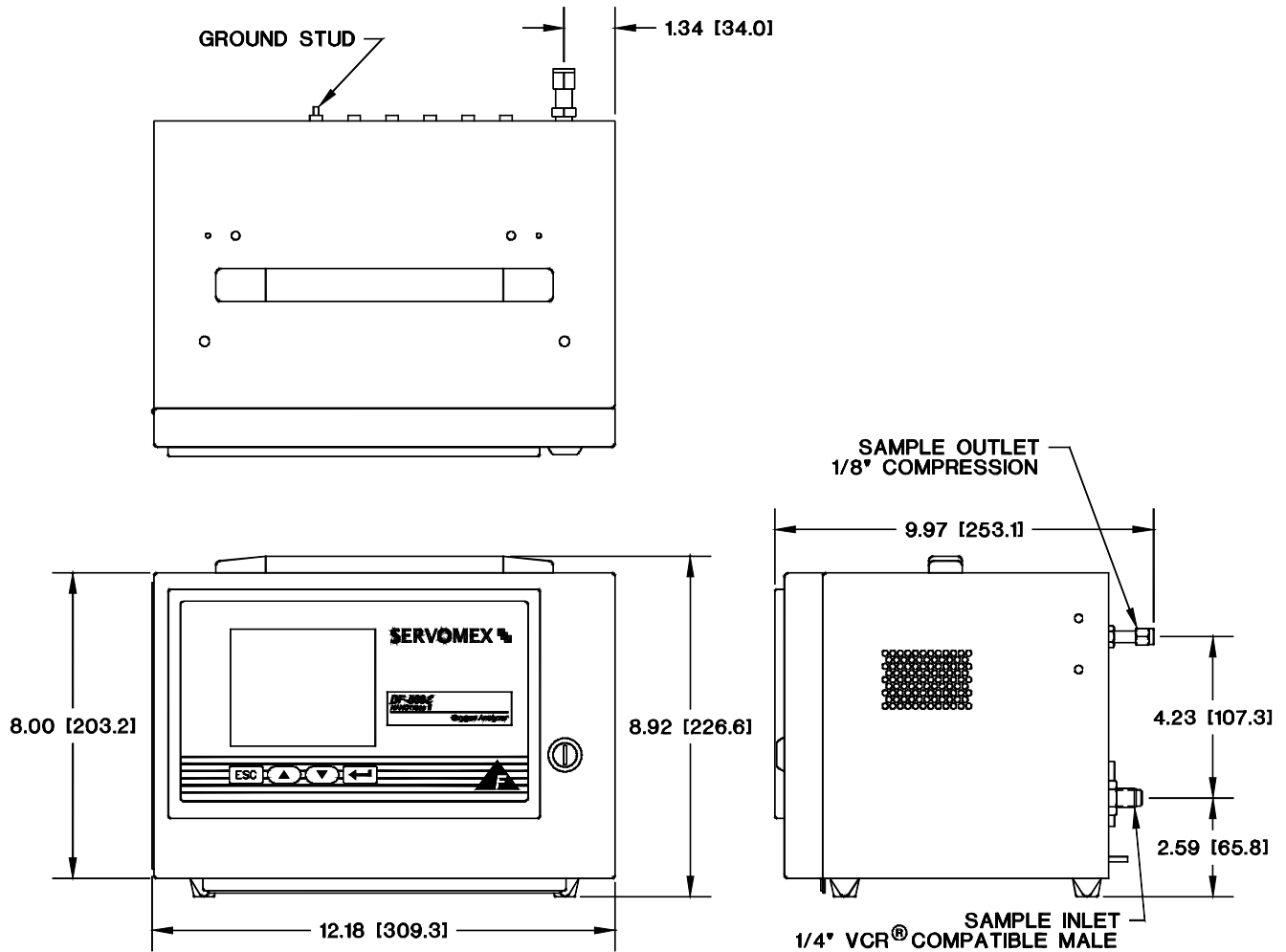


Figure 1: DF-560E Oxygen Analyzer

4 Installation and Setup

This procedure describes installation of the analyzer without options and with the voltage output set to 0-10 VDC. Options may affect the setup procedure described in this section. If your analyzer is equipped with options, refer to the appropriate section to determine changes to the setup.

NOTE



The screens shown in this manual have values that may not match the actual values displayed during your setup.

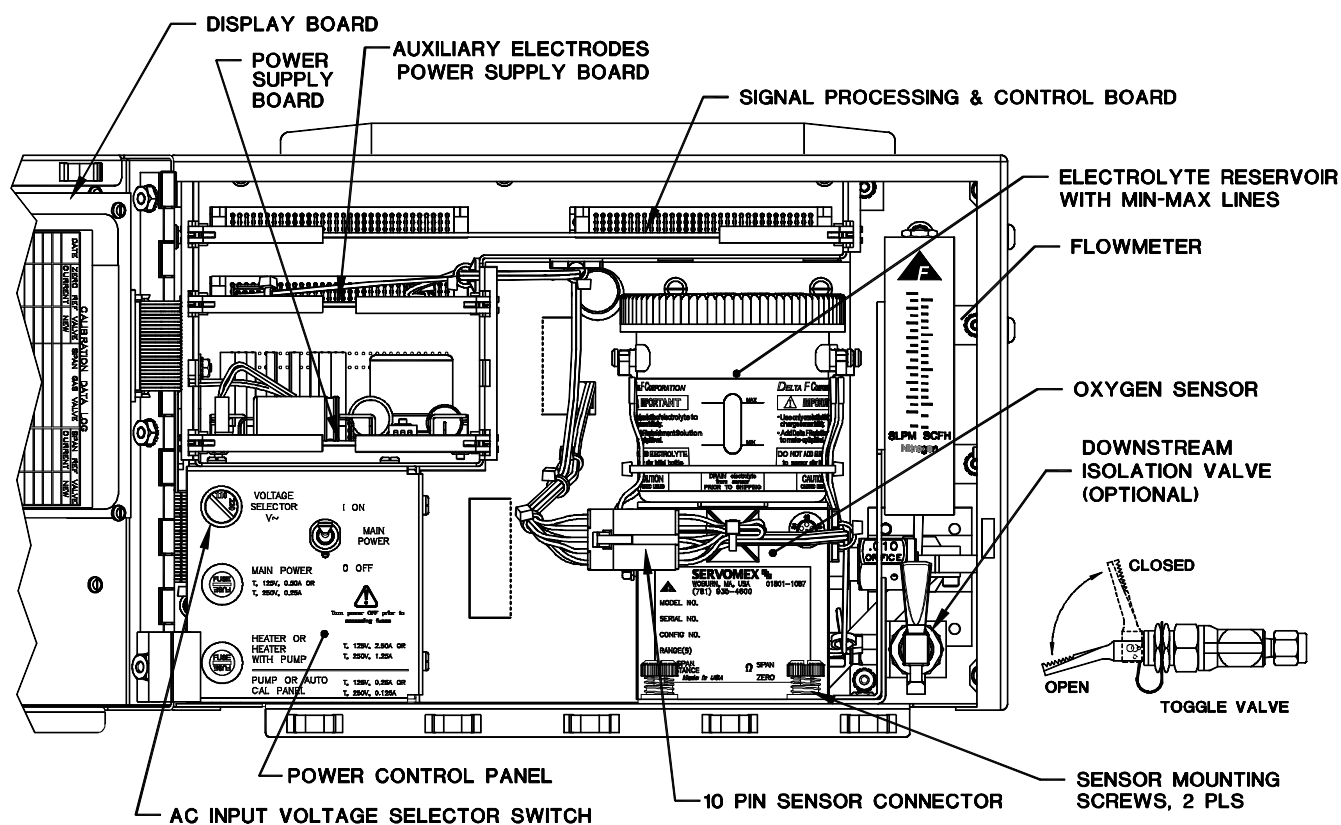


Figure 2: Major Internal Components

4.1 Adding Electrolyte

DANGER



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

NOTE



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

NOTE



Use only \mathcal{E} -lectrolyte Gold for the Platinum Series DF-560E Oxygen Analyzer. Failure to do so will void warranty. Install one bottle only.

NOTE



Do not apply power before adding electrolyte and thoroughly purging sample line.

4.1.1 Adding Electrolyte Procedure

Follow this procedure to add electrolyte:

1. Remove the 13/16-inch inlet bulkhead retainer nut and washer from the inlet bulkhead fitting at the back of the analyzer. Do not remove the four small socket screws.

NOTE



Always place a plastic protective cap (supplied) over the inlet fitting before removing the sensor assembly. It is imperative that the metal face seal not be damaged. If the plastic cap is not available, protect the fitting with a gasket and retainer.

2. Inside the enclosure, disconnect the 9-pin sensor connector located near the front of the sensor.
3. Unscrew both sensor-mounting screws at the front of the sensor-mounting bracket.
4. Pull the sensor assembly forward a few inches.
5. Disconnect the "quick-disconnect" fitting at the top of the flowmeter (for standard downstream sensor configuration) by pushing both halves of the fitting together and rotating one to the release position. See Figure 3.

For systems equipped with the Stainless Steel Outlet Line Tubing Option that is hard plumbed to the back of the unit, disconnect using a wrench on the retaining nut.

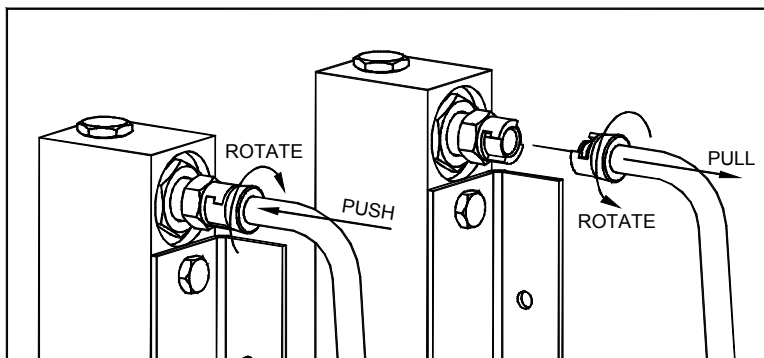


Figure 3: Quick Disconnect Fitting at Flowmeter

6. Remove the sensor assembly from the instrument.
7. Unscrew the cap from the electrolyte reservoir and add the entire contents of one bottle of electrolyte (Hummingbird Brand \mathcal{E} -Lectrolyte Gold) to the sensor. Replace the cap and hand-tighten securely.
8. Reinstall the sensor by repeating steps 1 through 6 in reverse order.
9. After adding the electrolyte to the sensor, allow the analyzer to sit with no gas flow for one hour before power up.

NOTE



The flats on the inlet bulkhead fitting are oriented to seat in an anti-torque plate on the inside back of the enclosure. When reinstalling the Sensor Assembly, be sure the flats on the bulkhead fitting properly seat in the slot of the anti-torque plate before replacing the washer and 13/16-inch retainer nut.

4.2 Sample Gas Connections

The sample gas inlet and outlet lines at the back of the instrument have stainless steel bulkhead fittings. The inlet fitting uses a VCR-type metal seal; the 1/8-inch compression outlet fitting accepts a tube. Before connecting your outlet gas tube to the analyzer, fully install the supplied gas nut and compression ferrule on your tubing. Connect the inlet and outlet lines to the bulkhead fittings at the back of the analyzer. A backup wrench is not needed since anti-torque plates inside the cabinet secure the bulkhead fittings. Do not over-tighten the fittings.

Supply the analyzer with an N_2 sample that is as low in O_2 as possible. When the analyzer is equipped with a calibration system, the purifier's life is greatly reduced

if the supply gas is over 0.5 ppm. If a bottled gas must be used, obtain a cylinder with $O_2 < 1$ ppm.

The DF-560E Analyzer is equipped with an orifice in the sample line at the sensor inlet connection. The orifice is sized to provide approximately 1.0 standard cubic feet per hour (scfh) at an inlet pressure of 15 pounds per square inch, gauge (psig). This flow rate to the instrument applies when the analyzer outlet is vented to atmosphere. All DF-560E Analyzers are designed to operate at approximately 15 psig sample inlet gas pressure. If the line pressure exceeds 15 psig, install a high integrity pressure regulator on the sample gas inlet.

If the analyzer outlet is at atmospheric pressure, a regulator can be used to set the flow rate to 1.0 standard cubic feet per hour (scfh) without danger of over-pressurizing the sensor. The back-pressure on the instrument should not exceed ± 1.0 psig and should be 0.0 psig on light gases such as H_2 and He.

If your installation requires long (> 4 feet) tubing runs (or has many bends or fittings) downstream of the analyzer, the resulting back-pressure may impose a pressure at the sensor that exceeds specifications. If this is the case, use larger outlet tubing (1/4-inch) and/or reduce the complexity of the outlet gas line.

NOTE



Over-pressurizing the sensor can result in permanent damage to the sensor. Limit the backpressure to the analyzer to ± 1 psig.

*Be sure the downstream isolation valve (if so equipped) is toggled open **before** gas flow is started.*

NOTE



Allow gas with very little oxygen (< 100 ppb) to flow through the analyzer for approximately 60 minutes before powering up.

4.2.1 Flow Control Valve

The optional flow control valve may be installed at the inlet to the analyzer and used to control the gas flow in applications where gas pressure is below 20 psig. It is not installed at the factory but is shipped separately.

4.3 Electrical Connections

Make sure the power switch in the analyzer is in the OFF position. Plug the supplied line cord into the receptacle at the back of the analyzer. Verify the operating voltage is proper and connect the line cord to the power source.

4.4 Powering Up

After installing the electrolyte and allowing the analyzer to sit for approximately one hour, turn on the power using the main power switch located inside the analyzer. The unit undergoes a series of Diagnostic Procedures during which the Servomex Corporation logo is displayed. After 30 seconds, a TEMP CAL message appears for 1.5 minutes. A display appears that is similar to Figure 4 (values shown are only representative).

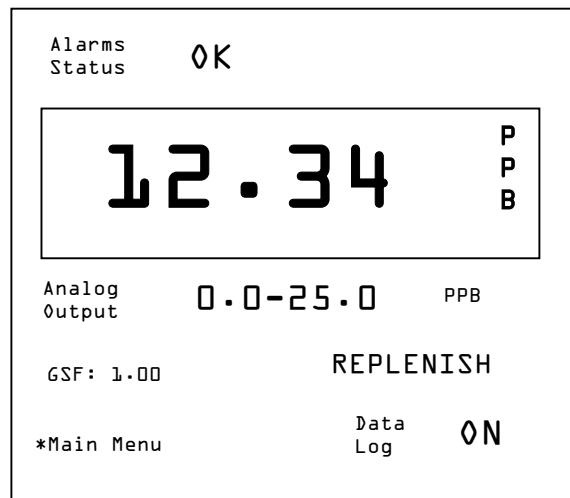


Figure 4: Data Display Screen

It should take less than 5 minutes for the analyzer to come on scale (<100 ppm). The concentration of oxygen is shown in parts per million (ppm) or parts per billion (ppb).

4.5 Calibration Systems

The proper operation of the analyzer depends upon the reliable establishment of the zero baseline. The analyzer can be equipped with either a Manual or Automatic Calibration option to provide span and zero calibration. Both options include a gas purifier that can be switched into the sample gas path to provide a zero gas for setting zero. The Auto Calibration System also accommodates a span gas input to set the analyzer span.

The required sample gas operating pressure is 15 psig. Bottled span gas (gas with a known oxygen concentration) must also be regulated down to 15 psig. An orifice located in the sample inlet line reduces the sensor inlet pressure to the required level at 1.0 scfh. Because of the orifice, setting 1.0 scfh by the internal flowmeter insures proper flow conditions at 15 psig inlet gas pressure.

NOTE



Zero gas is a sample gas that has been purified of all detectable oxygen by using a purifier in the sample line located as close to the analyzer as possible. The DF-560E uses this gas to calibrate the zero baseline of the sensor with the electronics. Both Servomex calibration systems, automated or manual, create their own zero gas (< 1 ppb O_2) for this purpose by purifying a sample gas of less than 100 ppb oxygen.

NOTE



Span gas is gas with a known concentration of oxygen. The DF-560E uses the Span Gas, along with the Zero Gas to calibrate the sensor and electronics. The DF-560E comes pre-calibrated to NIST traceable standards and as a result can be used to determine the concentration of user supplied span gases for future reference.

NOTE



Sample gas is the gas with unknown oxygen concentration that is to be measured. It may be a process gas or environment.

4.5.1 Gas Connections

Connect the process gas to the male VCR-type gas connection on the Calibration System. Check that the downstream shut-off valve, if equipped, is fully opened, and that all calibration system valves are closed. See Figure 4: Data Display Screen. Once this is verified, open the sample valve on the calibration system. While observing the flow meter inside the DF-560E enclosure, gradually bring the flow rate to the required setting.

The flow rate is set by adjusting the upstream gas pressure to obtain an indicated flow rate of 1.0 scfh for nitrogen and argon background gases, and 0.5 scfh for helium and hydrogen background gases.

Allow a low ppb oxygen sample gas to purge the analyzer for at least 30 minutes before turning the power on. After purging, turn the power on to the analyzer. The analyzer should come on scale within 5 minutes.

The analyzer requires 2 to 3 days of operating on zero gas to make readings at low ppb of oxygen. Once the rate of descent of the O_2 level is < 1 ppb/day, the zero on the analyzer can be set using the “Chk Adj Zero” screen and accurate low ppb readings can be made.

NOTE



An indicated flow rate of 0.5 scfh with helium or hydrogen as background gas corresponds to an actual flow rate that is within acceptable limits (1 scfh) for proper operation.

For gas pressures below 20 psig, the sample flow rate can be set using the optional bellows flow control valve, P/N NT-FCV-UHP.

CAUTION



*The optional downstream isolation toggle valve **MUST NOT** be used to control sample flow rate. Serious damage to the sensor may result if the valve is not fully open during operation*

NOTE



Gradually over 1 to 2 weeks, the sensor cleans the last traces of residual O₂ from the electrolyte. At this point, the zero needs to be reset, or the factory calibrated zero value can be restored..

4.5.2 Manual Calibration System Setup

The Manual Calibration System is designed to offer maximum portability in a small package. Figure 5 shows an outline of the DF-560E Oxygen Analyzer with the Manual Calibration System installed. Details on the operation of the manual calibration system can be found in the *User Interface* section.

An optional sample gas pressure regulator can be installed in the manual calibration system as illustrated in Figure 5.

NOTE



Make sure the downstream isolation valve (if equipped) in the analyzer enclosure is open before connecting the analyzer to span or sample gas.

The label on the rear side of the manual calibration panel shows how the valves can be positioned to direct sample gas through the purifier to provide a zero reference gas. This panel can be combined with an optional downstream shut-off valve located inside the enclosure to isolate the sensor from ambient air during transport.

NOTE



The analyzer requires 2 to 3 days of operating on zero gas to make readings in the low ppb area. Once the rate of oxygen reading descent is < 1 ppb per day, the analyzer zero can be set using the "Check/Adjust Zero" function on the (Chk Adj Zero) screen. Gradually, after 1 to 2 weeks, the sensor cleans the last traces of residual oxygen from the electrolyte. At this point, the zero needs to be reset, or the factory calibrated zero can be restored.

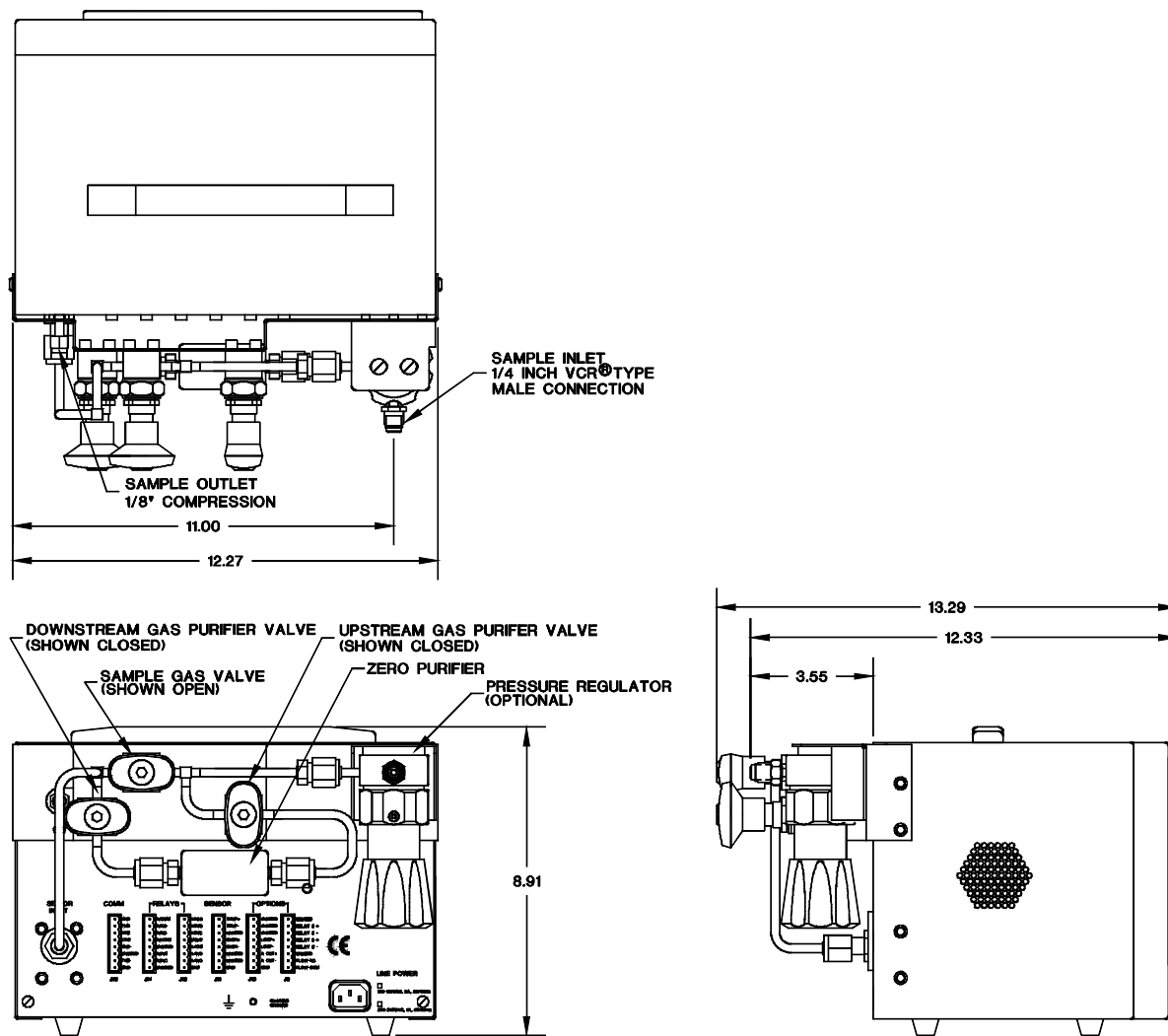


Figure 5: Outline of DF-560E Oxygen Analyzer with Manual Calibration System

4.5.2.1 Use of the Manual Calibration System

First-time analyzer operation usually includes a zero verification but does not require a span calibration. A zero check is performed by redirecting the sample gas through the gas purifier. Open both gas purifier valves and then close the sample gas valve.

Before attempting a zero calibration, leak check the sample system after thoroughly purging it by observing the oxygen readout at two flow rates: 0.5 and 2.0 scfh (flow can be adjusted by using a pressure regulator or upstream flow control valve.) If leakage in the plumbing system exists, the decreased flow results in a substantial increase in oxygen readout (>10 ppb.) Fix all leaks before proceeding.

NOTE



The gas purifier supplied by Servomex Corporation has a finite life that is greatly affected by the source gas oxygen level, flow rate, and duration of sampling. Always minimize the time sampling from the purifier (except during startup) and ensure that the source gas is below 50 ppb, for optimal life expectancy.

NOTE



A zero calibration should be performed only after the analyzer has been operating at least 24 hours. The door should be closed when calibrating the analyzer.

4.5.3 Automatic Calibration System Setup

The Automated Calibration System has two separate ¼-inch VCR-type male fittings for sample and span gas connections. Sample gas is directed through the gas purifier for use as a zero reference gas. A regulated span gas bottle is connected to the separate span gas inlet fitting. Locations of the sample inlet ports are shown.

Under deenergized conditions, the pneumatic sample gas valve is opened and the pneumatic span gas valve and both pneumatic zero gas valves are closed. Therefore, Power OFF default allows process gas to flow through the sensor. Mount the analyzer with its Automated Calibration System before making gas connections.

Filtered, dried plant air or nitrogen (recommended) at 70 to 100 psig is required for the pneumatic gas supply. The pneumatic gas line is connected at a 1/8-inch compression fitting shown.

The Automatic Calibration System enables user initiated or user scheduled zero and span calibrations to occur automatically. Zero calibration is accomplished when the analyzer activates a set of pneumatically actuated valves, (70 to 100 psig pneumatic service is required), to direct the sample gas through the built in purifier to provide a zero reference gas. Span calibration is achieved when the analyzer switches the analyzer inlet from sample gas to a user provided span gas.

After all connections are completed, check that the downstream isolation valve is open. Gradually open the sample gas regulator until the required flow rate is observed on the flowmeter in the DF-560E enclosure. Allow low-ppb oxygen sample gas to flow for 30 to 60 minutes **before** turning on power to the analyzer. The analyzer will come on scale within 2 minutes.

To perform an automated calibration, review and follow the procedures in *the Automated Calibration System Setup* section in this manual. To thoroughly purge the sample system, switch the analyzer via the Controls Menu to alternately sample process gas (both **Span** and **Zero Valves OFF**) and zero gas (**Zero Valves ON**) for 15 minutes duration each. Continue purging for several hours while

intermittently sampling process gas until readings are stable to within a reading decay of 4 to 5 ppb per hour.

Leak check the sample delivery system by lowering the sample pressure until the flow drops to 0.5 scfh. Oxygen readings should increase by no more than 1.0 ppb, assuming the system is completely purged.

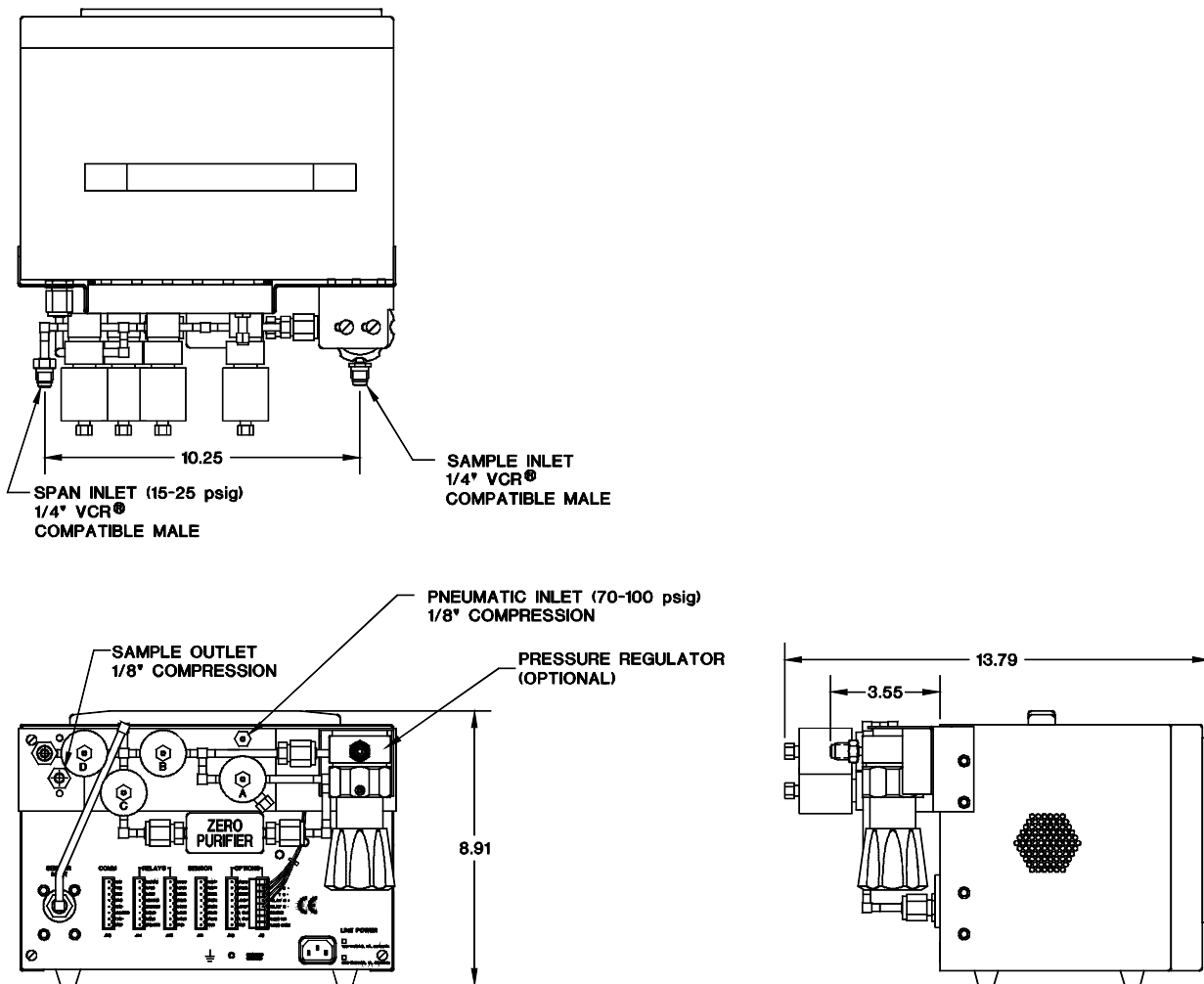


Figure 6: Outline of DF-560E Oxygen Analyzer with Automatic Calibration System

NOTE



Make sure the downstream isolation valve (if equipped) in the analyzer enclosure is open before connecting the analyzer to span or sample gas.

NOTE



The analyzer requires 2-3 days of operating on zero gas to make readings in the low ppb area. Once the rate of oxygen reading descent is < 1 ppb per day, the analyzer zero can be set using the "Check/Adjust Zero" function on the (Chk Adj Zero) screen. Gradually, after 1-2 weeks, the sensor cleans the last traces of residual oxygen from the electrolyte. At this point, the zero needs to be reset, or the factory calibrated zero can be restored.

NOTE



Be sure the system is adequately purged and is reading close to zero. Do not attempt to Auto Zero when the process or calibration gas exceeds 50 ppb.

4.5.4 Automated Control of User-Supplied Calibration Components

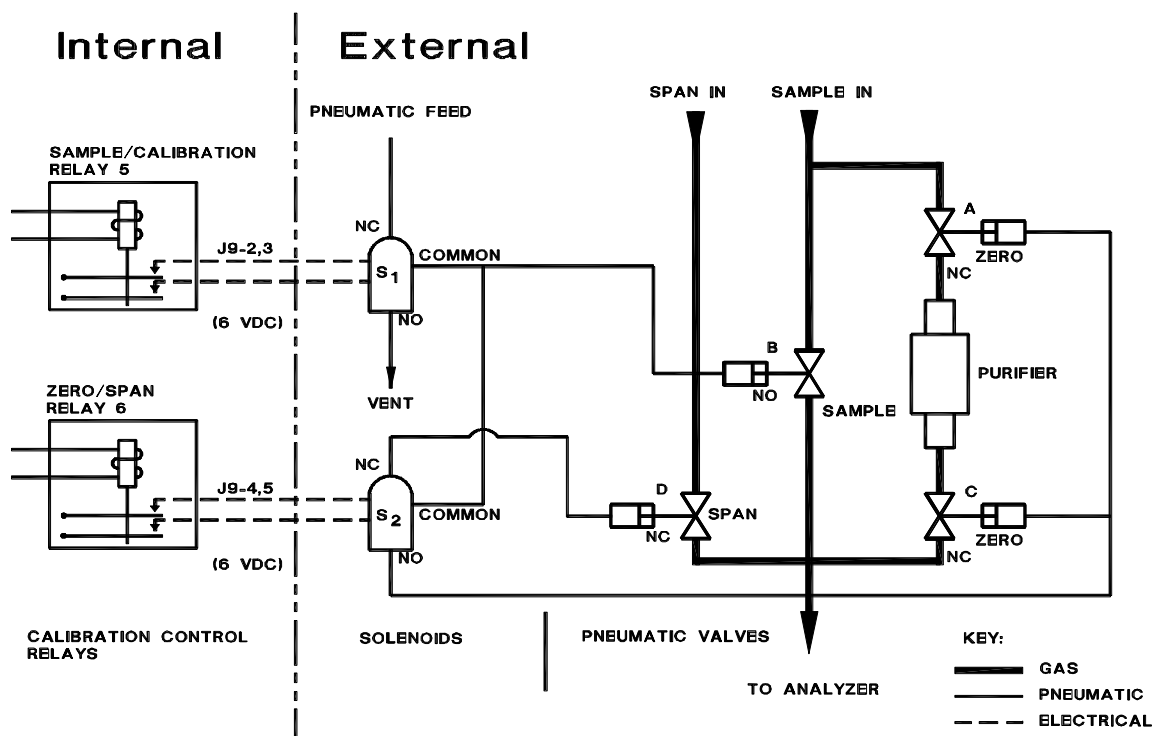


Figure 7: Calibration System Controls

For users who wish to design their own calibration system, this option provides all the necessary internal components and firmware to control the user-supplied equipment. Two switched 6 VDC .25A signals are provided. As an aid in the design of the required calibration system, the system logic and diagram of the Servomex automatic calibration system are shown below. The construction of such

a system must be of the highest quality, located as close as possible to the analyzer and must be free from dead legs and excessive runs or the software dwells and sequencing will not be adequate for a successful calibration.

	Relays		Solenoids		Valves			
	Sample/ Cal	Zero/Span	Zero	Process	Zero		Span	
Mode	#5	#6	S1	S2	A(NC)	B(NO)	C(NC)	D(NC)
Process	∅	∅	DE	De	C	O	C	C
Zero	1	∅	E	De	O	C	O	C
Span	1	1	E	E	C	C	C	O
1	Relay Closed				∅	Relay Opened		
E	Solenoid Energized				DE	Solenoid De-energized		
O	Opened				C	Closed		

Table 1: Calibration System Logic

NOTE



Relay 5 is connected to Solenoid S1 and Relay 6 is connected to Solenoid S2.

4.6 Standard Outputs

An output signal indicating oxygen concentration can be sent to other instruments by using the non-isolated 4-20 mA output or the 0-10 VDC output at the back of the analyzer. The analyzer arrives with required mating connectors plugged into the back panel.

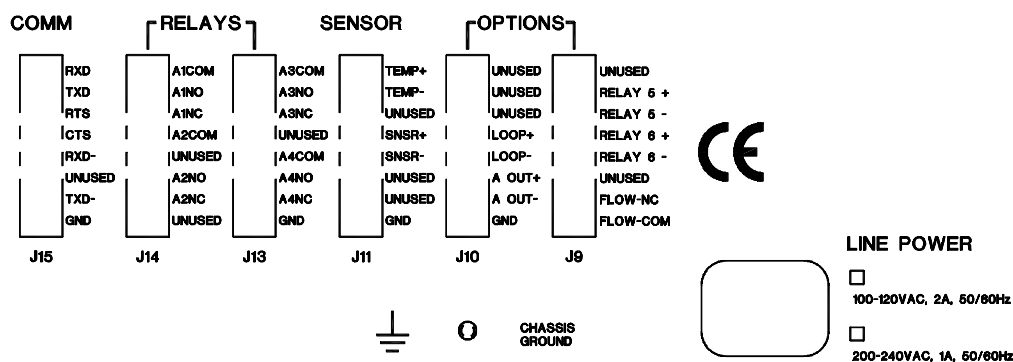


Figure 8: Rear Panel Connector Pinouts

The outputs use the Options Port, J10 shown in Figure 8. A standard feature of the analyzer is the 4-20 mA output that is isolated from earth (chassis) ground. An

internal 28 VDC loop supply is provided. This output is not electrically isolated from the voltage output.

The 4-20 mA output is connected to pins J10-4 (LOOP+) and J10-5 (LOOP-); the VDC output is connected to pins J10-6 (AOUT+) and J10-7 (AOUT-).

4.7 Low Flow Alarm

The optional low flow alarm includes a flow switch that is located in the enclosure on the right side. It is connected with vinyl tubing to the outlet of the flowmeter. The switch sounds an alarm when flow drops below a factory-set value. The switch can also be used with an optional alarm relay.

Figure 9 shows schematics of the gas flow path for various Analyzer configurations. The optional low-flow switch is included in configurations c and d.

If the stainless steel outlet option is ordered with a low flow alarm, the flow switch is mounted in the sample outlet line as part of the sensor assembly. A 2-pin connector is used to disconnect the switch from the analyzer.

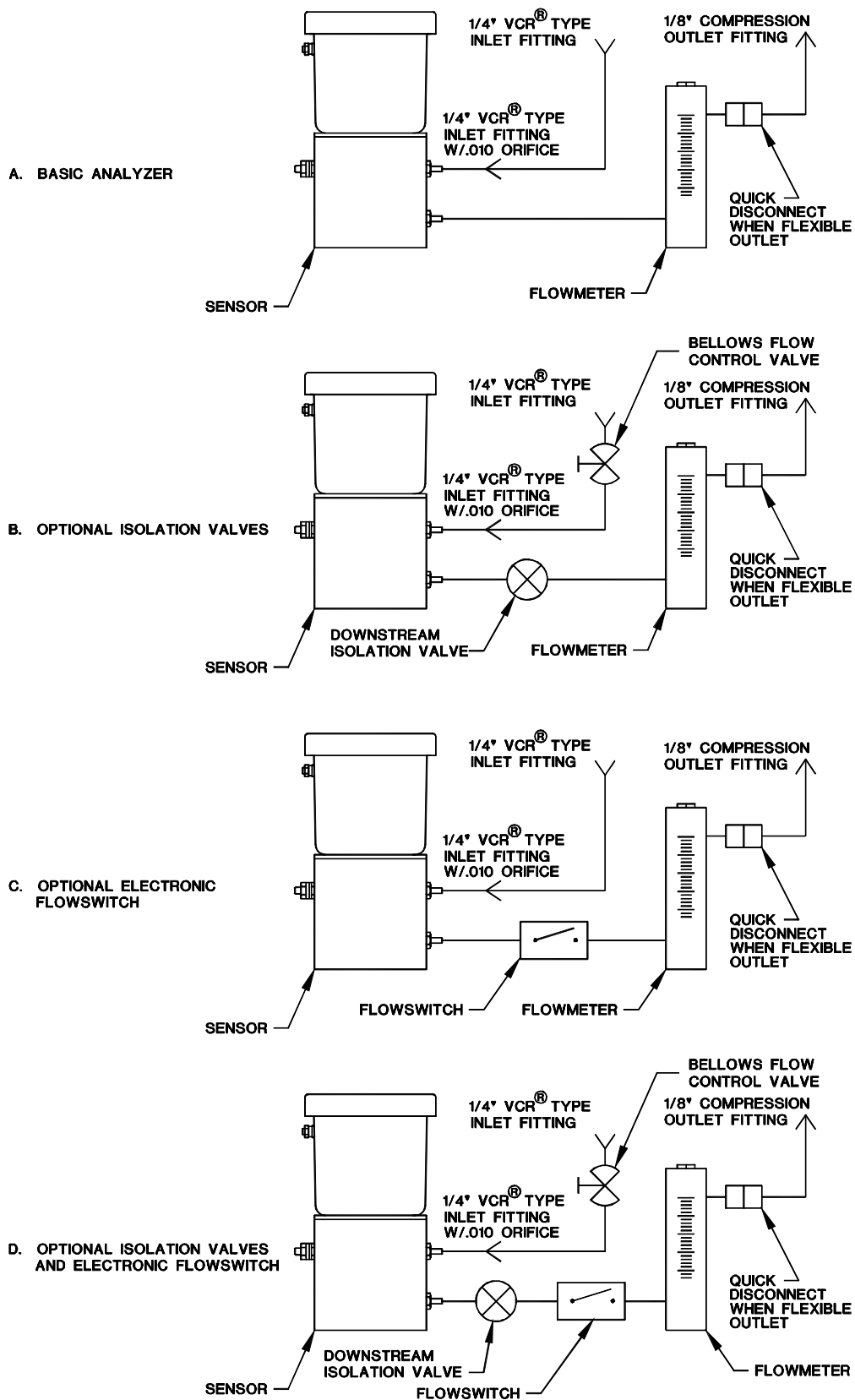


Figure 9: Plumbing Configuration Options

4.8 Pressure Regulator Installation

If your Analyzer is not equipped with a calibration system, you may need to install the optional gas pressure regulator. Three PEM nuts are installed in the back panel of the analyzer for mounting the regulator bracket. Mount the regulator to the supplied bracket with two 1/4-20 truss head screws and PEM nuts (supplied). The assembly mounts on the back panel as shown below.

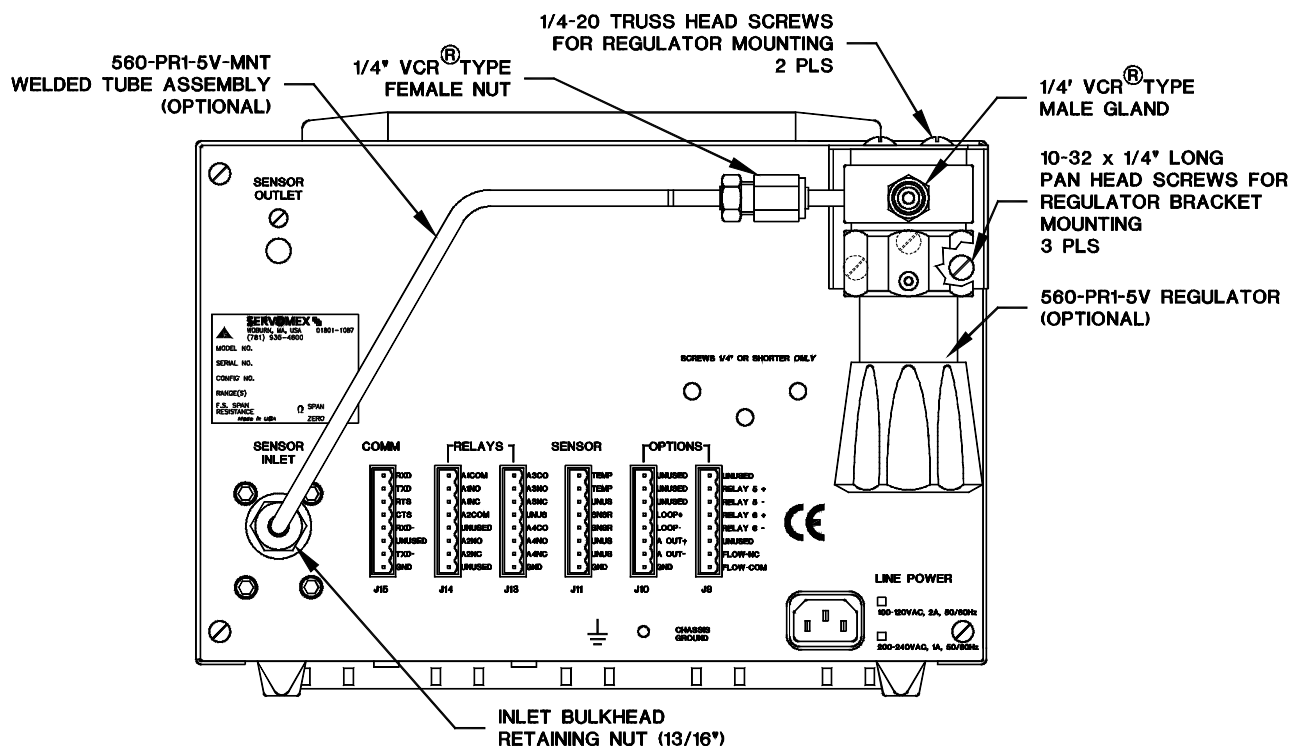


Figure 10: Regulator Installation

CAUTION



It is very important to use the supplied screws (or their equivalent - steel pan head 10-32 by 1/4-inch long) to mount the bracket. Longer screws damage the backplane printed circuit board which is located immediately behind the regulator mount.

An optional formed tube is available. The welded assembly consists of a formed tube and fittings to connect the outlet of the mounted regulator to the analyzer inlet.

4.9 Gas Regulator Purge

Regulators used on bottled calibration standards are typically equipped with 2 Bourdon pressure gauges, one to measure the cylinder pressure, and the other to measure the outlet pressure. The regulator must have a metal (preferably stainless

steel) diaphragm. It is good practice to install a flow control valve to adjust the flow after the regulator.

All user-added upstream plumbing should be consistent with the instrument gas delivery components so that the highest level of integrity can be maintained. All connections should be welded or include metal face-seal components.

Pressure gauges are not recommended on regulators used on process sample lines because they add measurement delay time and offer opportunities for leaks.

4.9.1 Regulator Purge Procedure

Before the calibration gas is connected to the analyzer follow the procedure listed below to purge ambient air from the regulator:

1. After securely attaching the regulator to the cylinder, fully open the regulator flow control valve. Open the cylinder valve. Set the regulator to give a delivery pressure of 20 psig.
2. Adjust the flow control valve to allow a modest flow rate (hissing sound).
3. Close the cylinder valve until the cylinder pressure falls to approximately 200 psig.
4. Open the cylinder valve to restore full delivery pressure.
5. On the regulator, turn the delivery pressure down to approximately 2 psig.
6. On the regulator, increase the delivery pressure to the maximum level.
7. Repeat steps 3 through 6 five to 10 times to thoroughly purge the regulator and gauges.
8. Close the flow control valve.
9. Set the delivery pressure to 5 psig.

The above procedure insures that any ambient air trapped in the pressure gauges and cavities of the regulator is purged prior to performing a gas calibration. Once the regulator is mounted, do not remove it from the cylinder until a fresh cylinder is required.

NOTE



The procedure described above should be used at any inlet connection to minimize intrusion of ambient air in the gas lines. For ppm standards, a continuous bleed flow of approximately 0.5 lpm for two to four hours is recommended when the regulator is first connected before using the new setup for calibration

4.10 Flow Control (Shutoff) Valve

The optional Ultra High Purity (UHP) flow control valve can be used as a flow control valve and an upstream isolation valve. This option is recommended when the upstream pressure does not exceed 20 psig.

The valve also can be used in conjunction with the optional Sensor Downstream Isolation Valve, to completely isolate the sensor.

4.11 Downstream Isolation Valve

For analyzers used in portable applications, an optional downstream outlet valve can be fitted to the sensor. When used with the optional Regulator or upstream UHP Shutoff, the sensor can be completely isolated from ambient air when transporting the analyzer to other test locations. An isolated sensor is rapidly returned to zero after reconnection.

CAUTION



*To avoid over-pressurizing the analyzer, always be certain to shut off the external upstream valve or regulator **before** closing the internal downstream isolation valve. Always open the internal downstream valve completely **before** restoring flow to the analyzer.*

4.12 Nitrogen Case Purge System

The DF-560E Analyzer uses a fan to cool the electronics. This fan circulates sufficient air to prevent accumulation of combustible gases, such as hydrogen. As a backup, in case of a failure of the fan, the analyzer can be equipped with an inert gas (nitrogen) purge system. The purge system provides improved protection against an explosion hazard by purging the enclosure to a concentration level below the lower explosive limit.

With a 20 scfh flow, the nitrogen purge system provides a minimum of thirty volume changes per hour of the atmosphere inside the analyzer's enclosure. A low-flow switch controls the failsafe feature. AC power is connected to the analyzer through the purge control as long as the low-flow switch contacts are closed. In the event of a partial or full loss of purge gas flow, the low-flow switch opens causing a hermetically sealed relay to disconnect power to the analyzer.

The electrical and purge gas connections are at the rear of the analyzer. The purge system has a maximum supply pressure rating of 100 psig and is connected via a 1/8-inch compression fitting. Dry nitrogen is recommended. AC power is connected by the user at the three-terminal connector block next to the purge gas inlet.

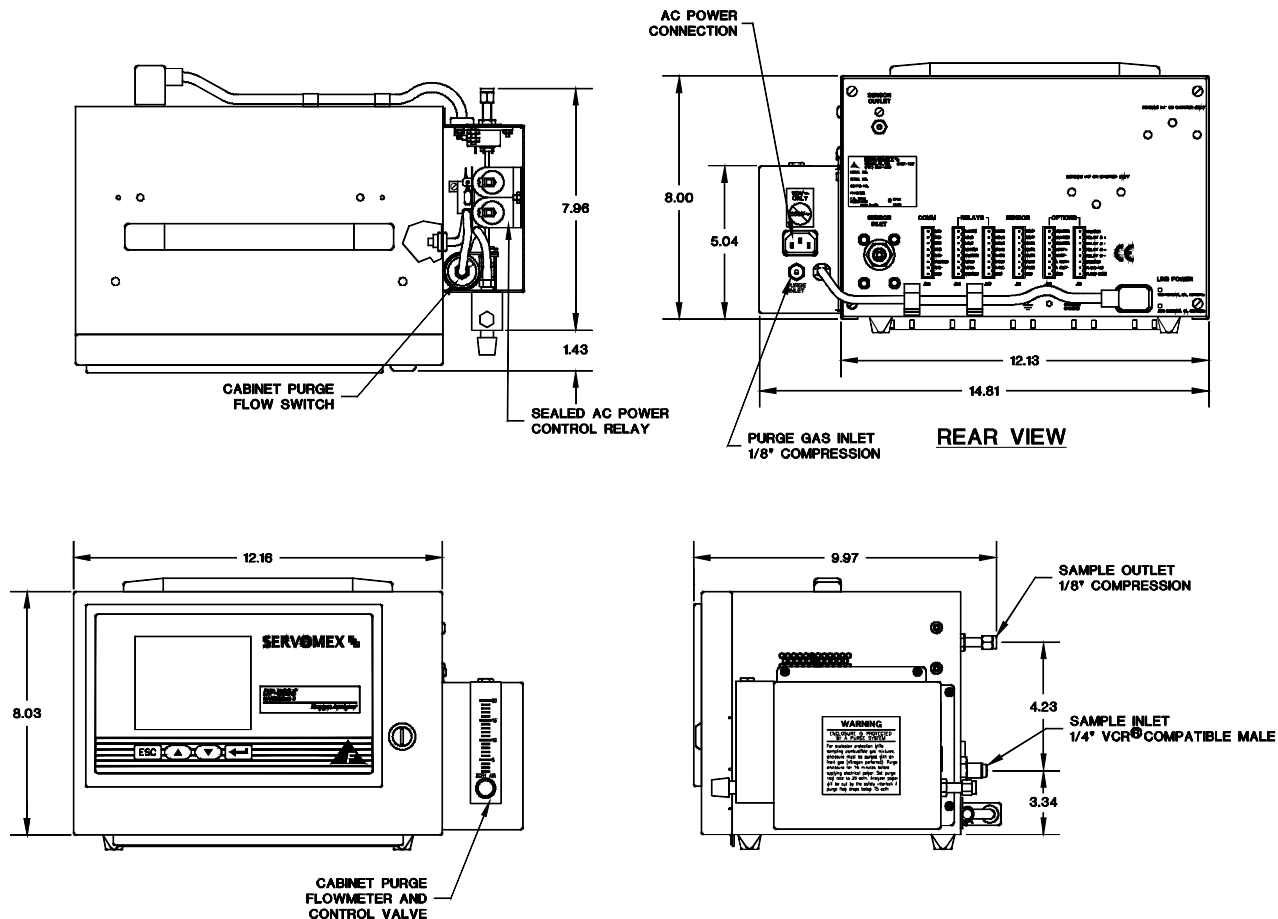


Figure 11: Case Purge System

CAUTION



*In the event that the NiMH Battery Option is installed in an analyzer that also has the Case Purge Option, the NiMH Battery system **must** be disabled. This will enable the analyzer to shut down properly in case the purge gas flow is reduced or lost.*

4.12.1 Portable Operation Procedure

When the DF-560E Analyzer is equipped with the optional NiMH battery power and a downstream isolation valve, it can be hand-carried from station-to-station for measurements.

The following procedure is recommended for portable operation:

NOTE



*Analyzer power **must** be turned off if the sensor cannot be isolated from exposure to air. Isolation requires use of the optional downstream isolation valve P/N NT-ISO-DSV that is mounted inside the enclosure.*

1. If equipped with a pressure regulator or a flow control valve, close it.
2. If equipped with a calibration system, close all three diaphragm valves in the calibration system.
3. Immediately close the downstream isolation valve in the enclosure, if available, by turning the toggle off. Closing the valve as quickly as possible after completing step 1 minimizes back diffusion of ambient air prior to achieving sensor isolation.
4. With the sensor isolated by valves on each side, the oxygen concentration likely increases. A non-zero reading with no flow can be attributable to oxygen leaks past the valve seats and packing in the downstream valve. The oxygen reading should remain below 150 ppb between relocations when the sensor is isolated for best performance.

NOTE



When isolated and operating on battery power, it is possible for the reading to rise above 150 ppb during the first half-hour of isolation. If the reading does not drop after a half-hour, or if the reading exceeds 500 ppb, check the fittings for leakage, and check the downstream isolation valve packing nut.

5. Disconnect the sample gas line from the analyzer. Discard the VCR-type gasket.
6. Disconnect the power cord.

4.12.2 Reconnection Procedure

To reconnect the analyzer to another sample tap, follow this procedure:

1. Reconnect the power cord.
2. Connect the sample gas line to the calibration system *just finger tight*. Use a new VCR®-type gasket.
3. Allow the sample gas to purge through the loose inlet connection for 15 minutes. Periodically lightly “snug-up” the fitting, then loosen the fitting to allow gas to escape. This pressure-cycling action purges the air trapped inside the inlet tubing and/or regulator. Securely tighten the fitting after a minimum of 20 cycles and 15 minutes of purge time.
4. Open the downstream isolation valve in the enclosure by flipping the toggle valve open.
5. Open both purifier valves so that gas initially flows through the purifier.
6. If equipped with a pressure regulator or a flow control valve, open it slowly while observing the flow meter inside the enclosure. Set the required flow rate.

7. After 5 to 10 minutes of purging through the purifier, open the sample valve, and then close both purifier valves.

NOTE



If the instrument is not equipped with a downstream isolation valve, it is important that disconnection, transportation, and reconnection be done quickly to minimize oxygen intrusion into the sensor between measurements. Turn off power to the analyzer if it cannot be reconnected within one minute.

When making measurements on gas streams where the molecular weight of the gases is very different, allow a few hours extra for the previous background gas to be purged from the sensor.

Be sure to use the appropriate gas scale factor (GSF) when measuring in different background gases. See “Gas Scale Factor (GSF)” under Background Gas Effects in Calibration Gas Considerations in the User Interface Section for information on selecting background GSF.

Avoid any exposure that drives the analyzer over 10 ppm. This minimizes the time required to reach low ppb levels.

5 Options

5.1 Stainless Steel Outlet Tubing

Analyzers can be equipped with a 1/8-inch compression stainless steel outlet tube. When this option is provided, the analyzer cannot be equipped with the quick-disconnect fitting at the flowmeter outlet. Because of the rigid outlet tube, the Sensor Assembly can only be removed after both inlet and outlet bulkhead retainer nuts are removed. You need a 3/16-inch wrench for the inlet nut; a 1/2-inch wrench is used on the outlet nut. When reinstalling the sensor, make sure both bulkhead fitting hex sections are oriented to seat in the retainer blocks on the inside rear of the enclosure.

5.2 NiMH Battery Pack

Analyzers equipped with a battery pack can be operated on battery power for three to eight hours, depending upon configuration (see Table 2). Battery charging occurs only while the analyzer is connected to AC power with the power switch turned on. The batteries can be charged while the instrument is not in service by turning off power to the sensor. See *Sensor Power in the User Interface* section under *Controls Menu*.

Approximately 15 hours is required to fully charge a battery pack. The charger PCB is mounted on the wall of the card cage, to the left of the sensor. It has two LEDs. When illuminated, the top (red) LED indicates operation on batteries; an illuminated lower (green) LED indicates high charge rate (as opposed to a trickle charge).

The Alarm Status in the analyzer's display (**Figure 18: Data Display Screen**) indicates low battery power, "[BAT LOW]". When the BAT LOW signal comes on, approximately 10 minutes of operating time remain. The unit gradually ceases to function as the voltage declines.

To conserve battery power, if the unit has the Isolated Outputs option, jumper JP11 may be removed. However, removing this jumper disables the analog recorder output and the 4-20 mA output. Turning off the backlighting also conserves battery power.

Analyzer State	Length of Time the Battery will Hold Power
Basic Analyzer (Outputs off, Backlight off)	8 hours
Backlight on, outputs off	6 hours
Isolated Outputs on, Backlight off	6 hours
Backlight on, Isolated Outputs on	3.5 hours

Table 2: Battery Operation Time

NOTE



Use only Servomex P/N 210603 when replacing the NiMH battery pack.



*In the event that the NiMH Battery Option is installed in an analyzer that also has the Case Purge Option, the NiMH Battery system **must** be disabled. This will enable the analyzer to shut down properly in case the purge gas flow is reduced or lost.*

5.3 Key Lock

An optional key lock can be installed in the door of the analyzer to prevent access to the power switch and other internal components. The lock is supplied with two keys.

If the analyzer is operating, the key lock does not prevent adjustments from the front panel. Password Protection, described in the *User Interface* section under *Setup Analyzer Menu*, must be used to lockout front panel control changes.

5.4 Panel/Rack Mount

A panel mount and a 19-inch rack mount are available for the analyzer. The panel mount requires a cut-out for installation. Figure 12: Rack Mount Configuration shows the rack and panel mounts; the cutout for mounting the panel is shown in Figure 14: Cutout Dimensions for Panel Mount.

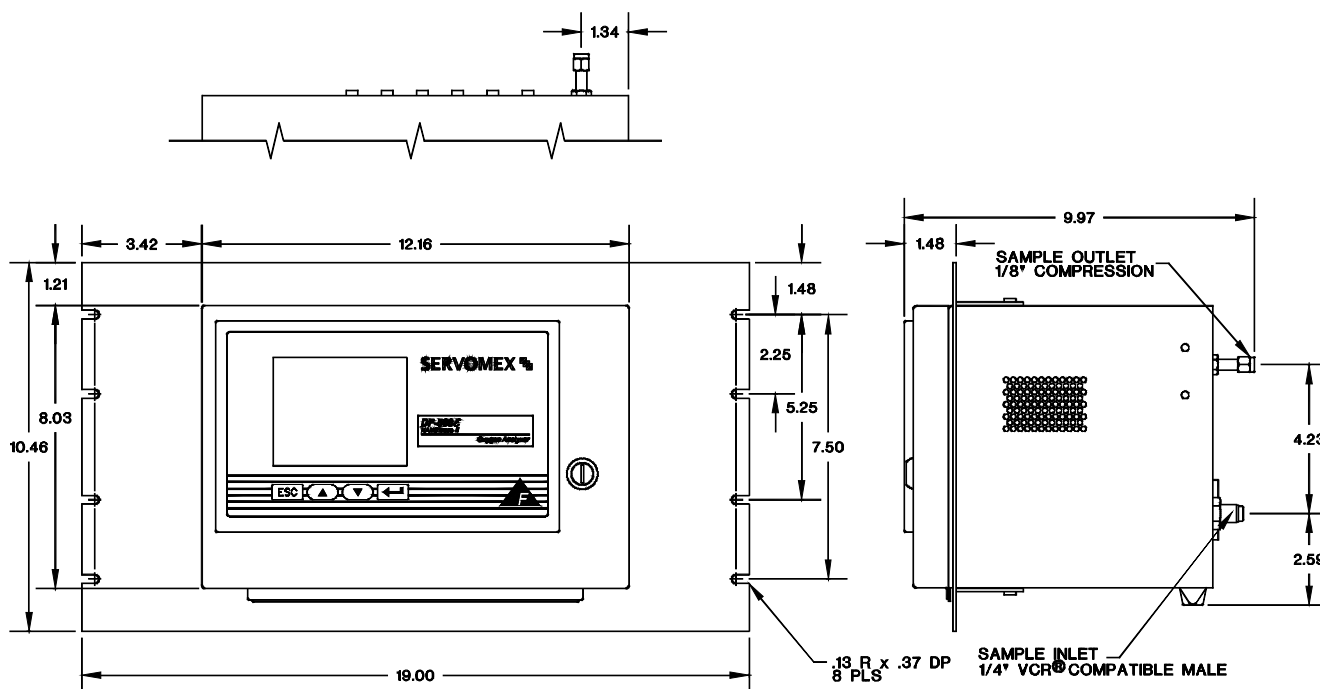


Figure 12: Rack Mount Configuration

5.5 4-20 mA Output

The analyzer can be equipped with an optional 4-20 mA, 1000 Ω maximum loop resistance, fully-isolated output which is completely isolated from all other analog outputs and earth ground. An internal 28 VDC compliance voltage is provided.

Connections are made at pins J10-4 (LOOP+) and J10-5 (LOOP-) at the back of the instrument.

5.6 Relays

Up to four optional form C (SPDT) relays (contact closures) are available to assign to alarms. One or more alarms can be assigned to one or more relays. The contacts are rated at 30 VDC @ 3A or 15 Vac @ 3A under a resistive load. Pin assignments provide relay connecting details.

5.7 Comm Ports

Either of two communication ports are available at the time of order: RS232C or RS485. This allows interfacing between the analyzer and other operating systems. A “C” language software library package is available for customized development of communication software.

NOTE



The Fully-Isolated Outputs Option is recommended with the COMM Ports option to prevent ground loop problems.

5.8 Fully-Isolated Analog Outputs

The standard analog output 0 to 10 VDC (or optional 0 to 1, 2 or 5 VDC) and 4-20 mA output are isolated from Earth Ground, but share the same ground as the communication port. In applications where the voltage or current output are used, in addition to the communication port, it is possible to create a ground loop. The Fully-Isolated Outputs option isolates the analog output and 4-20 mA output ground from the communication port ground.

6 Sample Gas Preparation and Delivery

6.1 The STAB-EL Acid Gas System

The optional STAB-EL system consists of a special electrode, which reduces the sensitivity to low levels of acids in the sample gas. Limitations on the amount of acid the STAB-EL system can handle are given in the table below.

CO ₂ *	SO ₂	H ₂ S	NO _x	Cl ₂	HCl
%	ppm	ppm	ppm	ppm	ppm
0.05	50	50	50	25	25

Table 3: Maximum Allowable Acid Gas Limits for the STAB-EL Sensor

*Concentrations of CO₂ are in percent. One percent is equivalent to 10,000 ppm.

6.2 Sample GSF

Data Display ⇨ Main Menu ⇨ Setup ⇨ Sample GSF

SAMPLE GSF	
*N2:	0.00%
AR:	0.00%
H2:	0.00%
He:	0.00%
CO:	0.00%
NH3:	0.00%
More Gases...	
GSF:	1.000
Update and Quit	

Figure 15: The Sample Gas Scale Factor

The optional **GSF** (Gas Scale Factor) is used to correct for changes in the rate of oxygen diffusion when background gases other than nitrogen are present in the span calibration gas. The Sample GSF menu can be entered through the Setup Analyzer Menu, Figure 41.

In many applications, the sample GSF does not need to be altered from the default value of 1.00. However, if the sample gas has a significantly different diffusivity compared with nitrogen (such as helium or hydrogen), the GSF should be applied. To use the GSF feature, enter the volumetric percentages of the sample gas as

described below. The GSF is automatically calculated. Alternately, the GSF factor can be entered manually.

The software in the analyzer supports the following gases in the GSF calculation:

	Gas	GSF Value
Nitrogen	N ₂	1.00
Argon	Ar	1.03
Hydrogen	H ₂	0.61
Helium	He	0.69
Carbon Monoxide	CO	1.01
Ammonia	NH ₃	0.90
Nitrous Oxide	N ₂ O	1.25
Sulfur Hexafluoride	SF ₆	1.84
Trifluoro-methane	CHF ₃	1.69
Tetrafluoro-methane	CF ₄	1.61
Hexafluoroethane	C ₂ F ₆	2.20
Octafluoropropane	C ₃ F ₈	2.58
Methane	CH ₄	0.94
Ethylene	C ₂ H ₄	1.10
Ethane	C ₂ H ₆	1.15
Propylene	C ₃ H ₆	1.28
Butane	C ₄ H ₁₀	1.48
Hexane	C ₆ H ₁₄	1.75

Table 4: Gas Scale Factors

Contact your local Servomex Business Center for assistance with gases not listed above.

The Sample Gas Scale Factor allows the user to enter the composition of the sample gas, from which the correct GSF is be calculated.

Entries for additional gases can be accessed by using the ▲ or ▼ key to scroll through the list. The entries spread across three screens. Selecting **More Gases** gives access to the additional choices, shown in Figure 44. By moving the asterisk to the appropriate line and pressing ↵, the volume percentage of the sample gas can be adjusted.

After the volumetric percent of the selected gas is entered, continue to press ↵ until the number is no longer in reverse video. Repeat the process for the other gases in the sample gas composition.

NOTE



An error message appears if the sum of gases does not equal 100%. If that occurs, adjust one (or more) value(s) and press ↵ again.


```

      SAMPLE GSF
*N2O:  0.00%
SF6:   0.00%
CHF3:  0.00%
CF4:   0.00%
C2F6:  0.00%
C3F8:  0.00%
More Gases...
GSF: 1.000
Update and Quit

```

Figure 16: Second Page GSF Menu

Entries to the second page of the Sample Gas Scale Factor Menu are added to entries on the first page to calculate the correct GSF.

```

      SAMPLE GSF
*CH4:  0.00%
C2H4:  0.00%
C2H6:  0.00%
C3H8:  0.00%
C4H10: 0.00%
C6H14: 0.00%
More Gases...
GSF: 1.000
Update and Quit

```

Figure 17: Third Page GSF Menu

Entries to the third page of the Sample Gas Scale Factor Menu are added to entries on the first and second pages to calculate the correct GSF.

When the composition of the gas has been entered, move the asterisk to **Update and Quit** and press ↵. The GSF is calculated and displayed.

If the GSF of the gas used to calibrate the system is already known, it can be entered directly. To enter the GSF directly, move the asterisk to the **GSF** line and press ↵. If the GSF menu is being used to reset all gases to 0%, just manually enter a GSF of 1.00. Use the ▲, ▼ and ↵ keys to enter the value.

6.2.1 Disclaimer

The method used to correct the calibration of the Platinum Series DF-560E 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 percent accurate. In addition, there

is further error introduced when correcting for a "multi" component background gas. This may result in up to an additional 3-5 percent error.

An alternate method when using a non-nitrogen or "multi" component background gas for spanning is to obtain a certified Calibration standard that has been prepared in a background gas that models the average process sample. Care must still be used, however, as certified standards may also have an inaccuracy associated with them.

Questions regarding the calculation of a background gas correction factor for a specific application should be directed to your local Servomex Business Center.

6.3 Sample Flow Rate and Pressure

The analyzer is factory calibrated at a flow rate of 2.0 scfh, in N₂, and should be operated at that level for optimal accuracy. However, the Servomex Sensor is relatively unaffected by gas sample flow rate, within limits. Sample flow rate should be maintained within the recommended range of 1.0 to 2.0 scfh. The analyzer can be operated at flow rates outside that range, but it should be recalibrated at that different flow rate to maintain optimal accuracy.

The analyzer has a small pressure drop (0.2 to 0.5 psi), so relatively small changes in inlet or outlet pressure causes dramatic changes in flow rate. Consequently, it is preferable to vent the outlet to atmosphere so that outlet pressure remains constant, leaving inlet pressure as the only variable to control.

6.3.1 Flow Rate Effects on Sensor Performance

Assuming a leak-tight system, higher flow rates may cause O₂ readings to increase by a few percent of reading above the level that would be displayed if flow was within the recommended 1.0 to 2.0 scfh range. Lower flow rates similarly cause O₂ readings to decrease by a few percent of reading. Very low flow rates (below 0.2 scfh) should be avoided as the sample inside of the sensor is no longer representative of the actual sample.

The insensitivity to flow rate changes is the basis for the sample system leak detection described below. The sensor output should be virtually constant for readings between 0.5 and 4.0 scfh. Therefore, if O₂ readings become higher at lower flows, then ambient O₂ is leaking into the sample system, or venting from a dead space (closed pocket with trapped higher O₂ level gas) in the sample system. A higher flow rate dilutes the O₂ entering the sample system decreasing the reading. O₂ readings in a leak free sample system should not go up or down significantly with flow changes between 0.5 and 4.0 scfh.

6.3.2 Checking for Plumbing Leaks using Flow Rate Effects

Significant measurement error can be caused by leaks in the plumbing system. A simple test can be performed to identify oxygen leaks.

Observe the analyzer readout at two flow levels: 0.5 and 2.0 scfh. Only a slight increase, if any, in readout will occur in a tight system as the flow is increased. If leakage in the plumbing system exists, then the increased flow results in a substantial decrease in oxygen readout -- typically dropping by 25 to 50 percent.

When flow sensitivity is observed, check the external plumbing for leaks.

6.3.3 Background Gas Effects on Indicated Flow Rate

If the molecular weight of the background gas is much different from N₂, the flowmeter reading is not accurate. The Rotometer type flowmeter used in the DF-560E is calibrated for use in air (or N₂). Most other gases have molecular weights within ± 25 percent of air. Since the required flow rate is not extremely critical most gases produces reasonably correct readings. The exceptions are light gases such as Helium and Hydrogen whose flow rates should be set to approximately one-third that of Nitrogen or 0.5 scfh.

6.3.4 Regulator requirements

If the sample gas is at constant pressure between 0.2 psig and 10.0 psig, the flow control valve at the sensor inlet can be used to adjust flow rate.

If the pressure in the sample line varies, but does not drop below 2.0 psig, use a regulator to drop the pressure to approximately 1.0 psig. Set final flow rate with the sensor flow control valve.

If a regulator is not used, the flow rate changes when the pressure at the inlet of the flow control valve changes. As long as this pressure variation does not bring the flow rate out of the recommended flow range (1.0 - 2.0 scfh) no regulator is required. A flow change of ± 1.0 scfh may result in a small change to the oxygen reading.

If a pressure change causes the flow rate to move outside the recommended range, an adjustment of the flow control valve must be made. If the adjustment is not made, and the flow rate remains outside the recommended range, the analyzer may not be operating within its stated accuracy.

6.3.5 Pressure Effects on Sensor Performance

If the analyzer is not vented to atmosphere, the sensor pressure is influenced by the conditions downstream of the analyzer. A recalibration under these operating conditions may be desirable to remain within the stated accuracy specifications. However, in most cases the error introduced is relatively small, and may not affect the process application.

NOTE



It is not recommended that gauges be installed upstream of the analyzer. The presence of a gauge increases response times and introduces potential leaks to ambient.

Sample gas line lengths, fittings and bends should be kept to a minimum to maintain low pressure drops. Larger diameter tubing and fittings reduce pressure drop and also lengthen response time. In general, 1/8-inch tubing should be limited to 15-foot runs; longer runs should be made with 1/4-inch tubing.

6.3.6 Sample Outlet Backpressure Effects

It is always recommended to vent the analyzer to atmospheric pressure. However, if a sample vent or return line is used, attention must be given to maintain a low and consistent backpressure so as not to affect the flow rate.

The allowable backpressure on the sensor is ± 1 psig. If variations in the vent line pressure are expected, a sub-atmospheric backpressure regulator should be installed on the vent line to maintain an even backpressure on the analyzer. Consider the regulator's pressure drop (typically 1 psi) when designing the sample vent system in order to stay within the ± 1 psig pressure limits at the sensor.

When not venting the analyzer to atmosphere, it is also suggested to install a fairly high resolution pressure gauge immediately at the analyzer outlet.

NOTE



If a regulator or gauge is installed on the analyzer outlet, the Stainless Steel Downstream Plumbing option should be installed.

6.4 Sample Gas Compatibility

There are a wide range of considerations in determining the gas sample compatibility of the DF-560E. Servomex attempts to identify all pertinent application details prior to quoting and order processing. All non-typical applications concerning gas sample compatibility must be reviewed by our in-house Application Engineers. It is impossible to accurately predict all of the chemical tolerances under the variety of process gases and process conditions that exist.

6.4.1 Condensation

The analyzer should be installed and operated with a sample gas that is preconditioned (if necessary) to avoid condensation in the gas lines. Several methods are available to minimize the possibility of condensation. If the sample gas is a hydrocarbon, maintain the gas temperature 20° F to 40° F above its dew point. In some applications, it may be necessary to chill the sample gas before it enters the analyzer so that the hydrocarbons can be condensed, collected, and removed. It is good practice to pitch the sample gas lines to allow condensables to drain away from the analyzer. Gas sample delivery lines that contain sample gases with high moisture content must not be exposed to temperatures below the dew point.

6.4.2 Gas Solubility in Aqueous KOH Solution

Some sample gas constituents are soluble in the sensor's potassium hydroxide (KOH) electrolyte. Gases that are rated as "Soluble" to "Infinitely-Soluble" may pose a threat to the sensor.

The sensor should have limited exposure (less than 1% by volume on a continuous basis) to highly water soluble alcohols, such as methanol, and/or be supplemented with periodic electrolyte changes to limit buildup within the electrolyte.

Many gas species with infinite solubility in aqueous KOH (such as nitrous oxide (N_2O), however, do not affect the electrode or sealing materials, or interfere with the O_2 reduction/oxidation reactions. Contact your local Servomex Business Center for recommendations on a specific application.

6.4.3 Reactivity with KOH Electrolyte

Many process sample streams contain various concentrations of acid gases. Acid gases are gases that react with the basic KOH electrolyte solution to form a neutralized solution. The sensor does not operate properly when the electrolyte solution is neutralized.

Besides a neutralization of the electrolyte, a base reactive sample gas may have other negative effects, such as a base-catalyzed polymerization reaction. The O_2 electrode reaction sites may become blocked by the polymerized byproduct residue at the interface where the gas sample meets the electrolyte.

6.4.4 Flammable Sample Gas

There is nothing within the analyzer sample system that can ignite a flammable sample gas. However, it is critical to ensure that the sample gas does not escape from the sample system into the analyzer enclosure, or the room, where ignition is possible. Stainless steel plumbing should be used throughout the entire sample system if the sample gas is flammable.

Also, the analyzer enclosure can be purged with nitrogen, or the entire Analyzer can be mounted in a purged enclosure, so that any sample gas that escapes the plumbing is diluted.

6.4.5 Trace acids in the sample gas

With the STAB-EL Acid Gas system, oxygen measurements in sample gases containing certain levels of acids are possible. Trace acids are common byproducts of gas distribution system assembly and its accessories. Trace acids can compromise the accuracy of the sensor and its construction if they are not managed properly. See the section *STAB-EL Acid Gas Option* for more detail.

Contact your local Servomex Business Center for recommendations on using the STAB-EL sensor on acid gases other than those listed above.

6.4.6 Sample Gas Temperature

Gas temperature should not exceed 50 °C (122° F), nor should it fall below 0° C (32° F). Gas temperature can be controlled by passing the gas through 5 to 10 feet of metal tubing that is within the recommended sample temperature. Because of its low thermal mass, the gas sample quickly reaches the gas sample line temperature.

The analyzer has software to correct the sensor output for sensor temperature changes. Temperature compensation adjustments apply to temperature drift only when the oxygen level is below 10 ppb.

Ideally, the analyzer should be operated at a nominal temperature of 70° F. Calibration temperature should be close to operating temperature. If the analyzer is to be operated at an average ambient temperature outside 65° F to 80° F, it should be recalibrated at the operating temperature for optimal performance.

NOTE



The temperature can be displayed at any time by accessing the Diagnostics Menu, Figure 38. This temperature value is updated at intervals of 15 to 45 seconds.

6.4.7 Protecting the Analyzer from Process Upsets

The analyzer should be protected from extended exposure to high concentrations of oxygen or hostile gases. Automatically solenoid controlled valves should be installed to switch the analyzer over to an N₂ purge when the process reaches some identifiable condition.

Gas line maintenance operations must also be examined for their effect on the analyzer. For example, in many pipeline process or normal gas applications the plumbing system is cleaned with either a liquid solvent or detergent solution. Since either causes damage to the sensor, switch the analyzer over to a N₂ bypass purge, or shut off sample flow and power to the analyzer prior to initiating the potentially hazardous process.

6.5 Calibration Gas Considerations

Calibrations performed from a bottled, calibrated sample gas, may introduce additional issues that could adversely affect the analyzer calibration.

6.5.1 Calibration Standards

Certified calibration standards are available from gas manufacturers. These standards are available in steel and aluminum cylinders. Steel cylinders are less expensive but do not dependably maintain a stable oxygen concentration for long periods of time.

Calibration standards in aluminum cylinders are recommended. Servomex has found that calibration standards in aluminum cylinders are very stable for long

periods of time (between 6 and 24 months) where steel cylinders should be recalibrated every three months.

6.5.2 Calibration Cylinder Regulators

Regulators used on bottled calibration standards are typically equipped with two Bourdon pressure gauges, one to measure the cylinder pressure, and the other to measure the outlet pressure. The regulator must have a metal (preferably stainless steel) diaphragm. Install a flow control valve after the regulator to adjust the flow.

6.5.3 Purge Procedure

Before the calibration gas is connected to the analyzer follow the procedure listed below to purge ambient air from the regulator which prevents contamination of the gas in the cylinder rendering it useless:

1. After securely attaching the regulator to the cylinder, fully adjust the regulator (clockwise) to its maximum outlet pressure capability. Slightly open the regulator flow control valve. Open the cylinder valve.
2. Adjust the flow control valve to allow a modest flow rate (hissing sound).
3. Close the cylinder valve until the cylinder pressure falls to nearly 0.0 psig on the secondary pressure gauge, or until flow almost stops.
4. Immediately open the cylinder valve to restore full delivery pressure.
5. Close the cylinder valve to again drop the outlet pressure and flow to near zero.
6. Repeat steps 4 and 5 at least 10 times to thoroughly purge the regulator and gauges. This pressure cycling action acts to flush out all the air trapped in the dead space and cavities inside the regulator.
7. Adjust the regulator to set the delivery pressure at about 5 - 10 psig.
8. Close the flow control valve.

Once the regulator is mounted and purged, do not remove it from the cylinder until a fresh cylinder is required.

6.5.4 Sample Gas Delivery and Vent Pressure during Calibration

The most accurate calibration is obtained when the analyzer is plumbed into the gas sample system so that the analyzer is under actual process operating conditions. But when the process sample is being delivered to the analyzer under Vacuum conditions, or being returned from the sample outlet under either positive pressure or Vacuum conditions the operating pressure at the sensor is likely to be quite different than under factory calibration conditions.

For systems where the gas sample is not vented to atmosphere, the analyzer outlet should remain connected in the same manner during calibration, if possible. This

ensures that downstream pressure effects on the sensor are the same during calibration and process monitoring.

Use the flow control valve on the regulator to meter the calibration gas to the analyzer at the suggested 1.0 scfh flow. By leaving the analyzer's flow controls untouched from when the analyzer is used on process, the calibration pressure duplicates the process sampling pressure.

6.5.5 Background Gas Effects on Calibration

6.5.5.1 Flow rate

Ideally, the calibration gas and the sample gas have the same gas composition, and as a result, the indicated flow rate during calibration and process sampling are identical. However, if the composition of the calibration and sample gases are not the same, the flow rate indicated on the rotometer may need to be adjusted. Light gases, such as H₂ and He, have a higher flow rate than is indicated on the flowmeter. As a result, the flow rate of the light gas should be set to one third of the flow specifications found in this manual. For example: The recommended flow rate for N₂ is 1.0 to 2.0 scfh. In H₂ or He service, the recommended flow rate (*as indicated on the analyzer*) should be 0.3 to 0.5 scfh.

6.5.5.2 Gas Scale Factor (GSF)

If possible, the background of the calibration gas should be the same as the process sample gas. If not, a gas scale factor may have to be applied to the calibration gas oxygen readings because of the difference between the diffusion rate of oxygen in nitrogen (factory calibration gas) versus the diffusion rate in the user's calibration gas. *The Sample Gas Preparation and Delivery* section discusses the proper setting of the gas scale factor option during calibration as well as during process gas measurement.

7 Connecting to External Devices

The analyzer can be interfaced to a variety of external devices via the ports on the rear panel. Alarm contacts, voltage, and current outputs, and serial communications are supported.

NOTE



It is important to note that the shield of all connecting cables should be attached only to the stud on the rear of the PNT II analyzer and left open (ungrounded) at the other end.

7.1 The Comm Port

The optional Comm port is used for communication via RS-232C or RS-485 protocol. Up to 32 units may be accessed via RS-485. Operating parameters are 8 bits, no parity, and one stop bit. Baud rate may be selected from the menu on the display.

A library of interface functions, written in C, is available to allow programmers to create custom interface program for accessing the communication port.

The Comm port (J15) terminals are defined as follows:

J15-1	RXD	Data received by the analyzer from the device (RS-232 or RS-485)
J15-2	TXD	Data transmitted from the analyzer to the device (RS-232 or RS-485)
J15-3	RTS	Request to Send (Not used)
J15-4	CTS	Clear to Send (Not used)
J15-5	RXD-	4-wire RS-485 Received Data (Paired with RXD)
J15-6	UNUSED	Key
J15-7	TXD-	4-wire RS-485 Transmitted Data (Paired with TXD)
J15-8	GND	Ground – Connect to ground stud on rear of cabinet

Table 5: Comm Port (J15) Connector Pinout

NOTE



To avoid ground-loop conflicts when using RS-232C or RS-485 for communications, make connections to external recorders or data acquisition systems through a differential input, or a single-ended input that is not referenced to Earth Ground.



When connecting the DF-560E Analyzer to a computer via an RS-232 or RS-485 communication cable, a Ferrite Sleeve may be required around the cable in a single-turn configuration. It is recommended that the proper Servomex cable be used for this purpose.

NOTE



Use of the Fully-Isolated Comm Ports Option (which isolates the grounds of the 0-10v and 4-20mA outputs from the communication port) avoids any ground-loop conflict.

NOTE



In order to prevent spikes from appearing in the oxygen output reading while using the communications option, it is critical to connect pin 8 of connector J15 (GND) to the ground stud on the rear of the cabinet.

7.2 Relay Ports

J14-1	A1COM	Alarm 1 Common
J14-2	A1NO	Alarm 1 Normally Open
J14-3	A1NC	Alarm 1 Normally Closed
J14-4	A2COM	Alarm 2 Common
J14-5	UNUSED	Key
J14-6	A2NO	Alarm 2 Normally Open
J14-7	A2NC	Alarm 2 Normally Closed
J14-8	UNUSED	
J13-1	A3COM	Alarm 3 Common
J13-2	A3NO	Alarm 3 Normally Open
J13-3	A3NC	Alarm 3 Normally Closed
J13-4	UNUSED	Key
J13-5	A4COM	Alarm 4 Common
J13-6	A4NO	Alarm 4 Normally Open
J13-7	A4NC	Alarm 4 Normally Closed
J13-8	GND	Ground

Table 6: Relay Port Connectors (J13, J14) Pin Out

Four optional form C (SPDT) relays (contact closures) are provided on the analyzer. These are used in conjunction with up to seven alarms. The contacts are rated at 30 VDC, 5A resistive load. Not to be used for switching AC power.

The relay contacts can be programmed for up to four Oxygen Alarms, plus Temperature, Low Flow, and Electrolyte Condition. A relay can be assigned to any alarm through the display menu.

The Normally Open (No alarm) contact connects to common when an alarm occurs or when power to the instrument is lost.

7.3 Option Ports

Two option port connectors, J10 and J9, are provided. Connector J10 is the interface for an analog recorder (0 to 1 VDC, 0-2 , 0 to 5 VDC, or 0 to 10 VDC, selectable) and the 4 to 20 MA loop. Connector J9 interfaces with the optional automated calibration systems.

J10-1	ILOOP+	Unused
J10-2	UNUSED	Key
J10-3	ILOOP-	Unused
J10-4	LOOP+	4-20 mA output (+)
J10-5	LOOP-	4-20 mA output (-)
J10-6	AOUT+	Voltage Output +(per customer order, see Section 7.3.1)
J10-7	AOUT-	Voltage Output - (per customer order, see Section 7.3.1)
J10-8	GND	Ground

Table 7: Analog Output Connector (J10) Pin Out

J9-1	UNUSED	Key
J9-2	RELAY 5+	Sample/Calibration Relay 5 +
J9-3	RELAY 5-	Sample/Calibration Relay 5 -
J9-4	RELAY 6+	Zero/Span Relay 6 +
J9-5	RELAY 6-	Zero/Span Relay 6 -
J9-6	Not Used	Not Used
J9-7	FLOW-NC	Flow Switch (Opens on Low Flow)
J9-8	FLOW-COM	Flow Switch Common

Table 8: AutoCal System Control Connector (J9) Pin Out

Terminals J9-2, J9-3, J9-4, and J9-5 are used with the Servomex Corporation Automated Calibration System. J9-2 and J9-3 provide 6 VDC at .25A to control the sample/calibrate mode. J9-4 and J9-5 provide 6 VDC at .25A to control the zero/span mode.

7.3.1 Change Analog Output Procedure

The analyzer is shipped from the factory with 0-10 VDC range. However, you can field-adjust the analog output to one of the following: 0 to 1 VDC, 0 to 2 VDC, 0 to 5 VDC, or 0 to 10 VDC. To change the voltage output, you need a small, straightedge screwdriver or tweaking tool, and a digital voltmeter, Fluke Model 8060 or equivalent. To make analog voltage output changes, proceed as follows:

1. Turn off the main power switch. Above the power switch is a card cage with three narrow slots and one wide slot. Locate and remove the Signal Processing and Control PCB that is located in the wide slot.
2. Insert a single jumper to select the desired voltage output (see table below).
3. Remove any other jumpers in these locations.

Jumper	Voltage Range	Max. Low Output (Volts)	Max. High Output (Volts)
None	10 Volts	0	10.000
JP15	5 Volts	0	5.000
JP14	2 Volts	0	2.000
JP 1	1 Volt	0	1.000

Table 9: Analog Output Jumper Settings

4. Reinstall the board.
5. Connect the digital voltmeter to J10-6 (A OUT+) and J10-7 (A OUT-).
6. Locate the calibration adjustment potentiometers, RV4 and RV2 that are at the front edge of the Analog Output PCB.
7. Turn on the analyzer.
8. When the oxygen display comes up, press ↵ to reach the Main Menu. Select **Maintenance, Diagnostics** and then select **Test Analog Output**. Set the desired output level to 0.00 percent.
9. Observe your Digital Voltmeter. Using a slotted screwdriver, adjust RV4 until the meter reads 0.000 volts.
10. Return to Test Analog Output. Enter 100.0 percent. Adjust RV2 until the output matches the Maximum high output voltage given in Table 9.

The Analog Output is now calibrated for the new range.

8 User Interface

8.1 The Data Display Screen

When powered up, the 210762DF-560E Oxygen Analyzer goes through a series of internal diagnostic tests that take about 1.5 minutes.

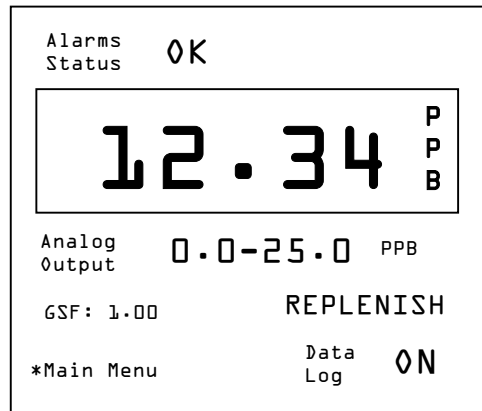


Figure 18: Data Display Screen

8.1.1 Numerical Information

The numerical information displayed on the Data Display Screen is representative and is described as follows:

- **Alarm Status** - Provides alarm information which continues if the condition remains after the audible signal or overwrite message is canceled.
- **Data Line** - Indicates the measured oxygen concentration (for instance, 12.34 ppb). If the analyzer is in an abnormal state, the data line alternately shows the measured oxygen and a message about the state.

8.1.2 Messages

The following messages may be displayed on the Data Display Screen:

- **Oxygen- over-range** - The measured oxygen is higher than the range of the analyzer (for example, >100 ppm).
- **Oxygen-under-range** - The measured oxygen is lower than the range of the analyzer (for example, <-50 ppb).
- **Temperature-over range** - The temperature is outside of the range of 5° C to 45° C.
- **Sensor OFF!** - The sensor is turned OFF.

- **Zero delay** - The sensor is in calibration mode.
- **O2 alarm (1, 2, 3 or 4)** - Any unacknowledged alarms are also displayed here.
- To acknowledge an alarm, press the ESC key. To clear the alarm, restore it to its prior existing condition. Once an alarm has been acknowledged, a number or letter is continuously displayed as the Alarm Status.

8.1.3 Analog Output Range

The Analog Output Range indicates which of the three possible oxygen ranges are currently used by the analog output.

8.1.4 System Flags and Messages



System Flags - Alert the user to potential maintenance conditions.



The following messages may be displayed:

- **Replenish** - Indicates that the Replenishment interval has expired.
- **Low Bat** - Indicates that the optional backup battery should be recharged.
- **Uncal** - Warns the user that the analyzer is not calibrated.
- **Fail Zero** - Warns that an AutoZero calibration was unsuccessful.
- **Fail Span** - Warns that an Auto Span check or recalibration was unsuccessful.
- **SPAN in xx** - Indicates the number of minutes (xx) until the calibration relays enter Auto Span mode. Relay 5 (Terminals J9-2 and J9-3) and Relay 6 (Terminals J9-4 and J9-5) are energized.
- **ZERO in xx** - Indicates the number of minutes (xx) until the calibration relays enter AutoZero mode. Relay 5 (Terminals J9-2 and J9-3) are energized. Relay 6 (Terminals J9-4 and J9-5) is not energized. If any alarm has been acknowledged, shows as the Alarm Status
- **GSF Tag** - Indicates the value of the current Gas Scale Factor. If a GSF value is entered or calculated by the analyzer, GSF: X.XX is displayed in the Data Display screen. If the GSF is not shown in the Data Display screen, the analyzer is using the default value of 1.00 that represents Nitrogen.
- **Data Logging Status** - Shows whether the system is currently logging data in the short-term mode.
- **CAL ZERO** - Warns the user that a zero calibration should be performed.


8.2 Keypad

















The four pressure-sensitive keys displayed below the Data Display Screen are described as follows:

-  - Returns the display to the previous screen.
-  - Scrolls up in a menu or data selection.

-  - Scrolls down in a menu or data selection.
-  - Accepts the selected asterisk (*) entry and allows data field selection.


The keypad allows you to move through the menu tree and to change values at various points.

The  key - accepts the current entry or and advances to the next item or screen.

- Pressing the  key while in the Oxygen display brings up the Main Menu display (Figure 19: Main Menu).
- Use the  or  keys to move the asterisk up and down through the items. An asterisk (*) is displayed in many screens to indicate a selected item.
- Press  to activate a choice.
- Press  to cancel a choice
- Use the  key to edit a numerical value. Highlight (reverse video) the digit to be changed. Continue pressing the  key to highlight additional digits to the right. Press the  key to increase the rightmost highlighted digit (the  decreases the digit). When one digit is highlighted, the display increments from 0 to 9 before returning to 0 or incrementing to 10 by adding another digit (depending upon the acceptable value). Once the correct value is reached, press the  key until the number no longer appears in reverse video. (The  key moves the highlighting to the left and cancels any adjustment.) **Note:** It may be easier to add and change a digit-editable digit by stepping down through zero.
- Press the  key to return to the previous screen without changing parameters. If any parameters have been edited and  is pressed, the display presents the message: Abandon **Changes?**  **For yes.** All parameter changes are **lost** if the  key is pressed.
- Press the  key if the **Update and Quit** message is displayed. Changes are saved and you are automatically returned to the previous menu.

8.3 Main Menu

The analyzer menu tree is large but simple to navigate. To help you quickly locate a particular screen from this manual, the steps required are located above each menu (see Figure 19).

To reach the Main Menu from the Data Display (because the asterisk is always in front of “Main Menu”) press . Alarm status and abnormal state information, if any, is displayed over the Main Menu.

Data Display ⇌ Main Menu

```

MAIN MENU
Time: 00:00:00
Date: January 1, 2011
Version 1.00
S/N 000001
*Controls...
Oxygen Calibration...
Maintenance...
Setup Analyzer...
Data Logging/Viewing...
Password Level: NONE

```

Figure 19: Main Menu

From the Main Menu, all other menus are accessed by moving the asterisk with the ▲ and ▼ keys and pressing ←.

If a password is required, enter it by selecting **Password Level** and entering the correct password. For additional information, refer to the *Analyzer Setup* section. If the password is required, the **Password Level** line is not displayed on the Main Screen.

8.4 Controls Menu

The Controls Menu allows the user to set up default conditions and to activate optional features. See Figure 20: Controls Menu.

Data Display ⇌ Main Menu ⇌ Controls

```

CONTROLS
*Reset Averaging Filter
Zero Gas Valves
Span Gas Valves
Sensor Power: ON
Sensor Off Relay: NU
Backlight: ON
Update and Quit

```

Figure 20: Controls Menu

8.4.1 Reset Averaging Filter

Selecting **Reset Averaging Filter** instantaneously resets data in the signal filter used to average the oxygen. It displays **Filter OFF** on the Data Display for 10 seconds. At the end of this time the current oxygen measurements are used to fill

the filter registers. This feature is useful to reduce time lags resulting from heavy filtering, or if the data in the filter is corrupted by a momentary spike.

After the Averaging Filter has been reset, the display automatically returns to the Data Display Screen.

8.4.2 Zero Gas Valves

This optional relay is used to control external valves for zero calibrations. When the option is not available, this choice reads NA. Manually turn the valves ON and OFF by using the ▲ or ▼ key to move the asterisk to **Zero Gas Valves**. Press ← to toggle the zero gas relay OPEN or CLOSED. When the Zero Relay is OPEN, 6 VDC is switched to the relay terminals J9-2 and J9-3, (relay 5) only.

NOTE



Switching the Zero Gas Valve OPEN automatically toggles the Span Gas Valve CLOSED.

The instrument does not store the zero relay state (OPEN or CLOSED). If AC power is lost, and then restored, the zero relay defaults to CLOSED. Battery equipped instruments are not affected by the loss of AC power.

8.4.3 Span Gas Valves

This optional relay is used to manually control a valve for span calibrations. When the option is not available this choice reads N/A. Manually turn the valves on and off by using the ▲ or ▼ key to move the asterisk to the **Span Relay** position. Press the ← to toggle the Span Relay OPEN or CLOSED. When the Span Relay is OPEN, 6 VDC is available at the relay terminals J9-2 and J9-3, (relay 5) and at relay terminals J9-4 and J9-5, (relay 6). See the Section on *Option Ports* for relay terminal pin-outs.

NOTE



Switching the Span Gas Valve OPEN automatically toggles the Zero Gas Valve CLOSED.

The instrument does not store the span Relay State (OPEN or CLOSED). If AC power is lost and then restored, the span and zero relays default to CLOSED. Battery equipped instruments are not affected by the loss of AC power.

8.4.4 Sensor Power

After accessing the **Sensor Power** screen, the sensor power is toggled ON or OFF by pressing ←. The sensor ON command applies the required polarizing voltage to the sensor.

The analyzer is programmed to protect the sensor from extended operation at high oxygen concentrations. For the Platinum DF-560E Analyzer (PNT II), there are

two distinct conditions that are considered over-range. The first condition occurs when the analyzer reaches 20.0 ppm O₂. At this point, the letters OVR is displayed on the screen. An oxygen reading can still be observed as well as any other information which typically appears on the screen. This holds true until the analyzer reaches a concentration of 100 ppm. The screen is then entirely overwritten with an over range message. The range of 20 to 100 ppm is an extended range feature that is an enhancement to the PNT analyzer and is intended only for the purposes of observing the analyzer purge itself of oxygen after a severe process upset or a startup. The analyzer is not intended for long-term use in this range. The firmware protects the analyzer from over-exposure in this range by turning OFF the polarization voltage to the sensor after 20 minutes. When over 100 ppm, the analyzer turns off the polarization voltage to the sensor after 10 minutes. It must be understood that if an analyzer is exposed to an oxygen concentration between 20 and 100 ppm for 20 minutes, the sensor loses its polarization and all outputs from the analyzer go to zero.

NOTE



The analyzer is programmed to protect the sensor from extended operation in either of two over-range conditions. If such a condition exists, the software turns off the polarizing voltage to the sensor. A message is displayed indicating that the sensor is isolated from all circuitry. The audible annunciator sounds at 1-second intervals during this condition. The user should lower the oxygen concentration, and then restore power to the sensor via the Controls menu, as described above.

The instrument does not store the SENSOR OFF state (ON or OFF). If AC power is lost and then restored, the SENSOR setting is set to the default (ON) position.

8.4.5 Sensor Off Relay

The Sensor Off Relay can be used to signal a remote acquisition or control system that the sensor has been turned of either automatically or manually. Use the ▲ or ▼ keys to toggle the relay assignment among the available relays (1-4).

8.4.6 Backlight

A light behind the display allows for easier viewing. To minimize power consumption, this light can be turned off or set to automatically light when the keypad is used, and turn off after a preset time. Use the ▲ or ▼ keys to toggle the backlight to ON, 5 Min Timeout (automatically turns off after 5 minutes idle), 15 Min Timeout (automatically turns off after 15 minutes idle) or OFF.

Note: The Backlight option activates immediately. Scrolling to “Update and Quit” is not required for input to take affect.

8.4.7 Update and Quit

Update and Quit stores changes made while accessing the Controls Menu.

8.5 Oxygen Calibration Menu

Data Display ⇒ Main Menu ⇒ Oxygen Calibration

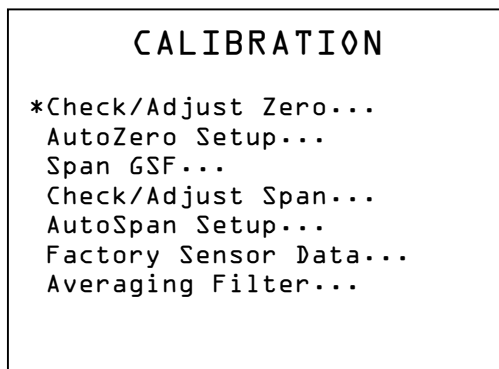


Figure 21: Oxygen Calibration Menu

The Oxygen Calibration Menu is entered from the Main Menu, as shown in Figure 19: Main Menu, when the user wants to check the calibration or recalibrate the analyzer. The Oxygen Calibration Menu is shown in Figure 21.

8.5.1 Calibrating the Analyzer

The analyzer can be calibrated by selecting **Oxygen Calibration** from the Main Menu, Figure 19. This menu leads to other menus that provide options for automated (with optional equipment) and manual calibration. A zero or span calibration can be independently performed in either the automated or the manual mode.

If the analyzer has failed either a zero or a span calibration, a flag is added to the Calibration Menu: **Reset Fail AutoZero flag** or **Reset Fail AutoSpan flag**. To reset the flags, use the ▼ key to scroll to the entry. Use the ← key to reset the flag.

The following information should be noted on the calibration log at each zero or span calibration:

- Date
- Current Zero Ref Value
- New Zero Ref Value
- Span Gas Value
- Current Span Ref value
- New Span Ref value



NOTE

*Over-pressurizing the sensor can result in permanent damage. Always be sure to open a downstream isolation valve or any similar flow restricting device **before** pressurizing the sample inlet. The sample outlet line should not add more than 1.0 psi resistance at a gas flow rate of 1.0 scfh. If the span gas supply pressure exceeds 15.0 psig, install a pressure regulator in the inlet calibration gas line to regulate the flow rate to 1.0 scfh while at the same venting (back) pressure that occurs under normal sample measurement.*

8.5.2 Check/Adjust Zero

From the **Main Menu**, select **Oxygen Calibration** and then **Check/Adjust Zero**. The Check/Adj Zero Screen shown in Figure 22 is displayed.

NOTE



A zero calibration should be performed only after the analyzer has been operating at least 24 hours. The door should be closed when calibrating the analyzer.

Data Display ⇌ Main Menu ⇌ Oxygen Calibration ⇌

Check/Adjust Zero

CHECK/ADJ ZERO

O2: 0.01 ppb

Zero Reference: 0.00ppb

*Active (User) Zero Offset:0.00ppb

Zero Gas Valves: NA

Do an AutoZero

Do a Manual Zero

Update and Quit

Figure 22: Check/Adjust Zero Screen.

The **Zero Reference** value is a reflection of the deviation of the zero current from the original factory calibration. Instruments are shipped from the factory with the zero reference set to 0.00. After a manual or autozero is performed, the zero reference may change slightly.

NOTE: The Zero Reference should not fall outside the range of -10 to +75. If the value is outside these limits contact Servomex.

If the system has been previously re-calibrated by the user, an additional line is added to the Check/Adj Zero Screen, that states **Restore Factory Zero**.

O2: Displays the current oxygen measurement.

Selecting **Restore Factory Zero** restores the factory calibration data.

8.5.2.1 User Zero Offset

Upon initial startup of the analyzer, and whenever the electrolyte is changed, the electrolyte itself causes a higher current to flow than normal. As the electrolyte ages (for a period of about 3 weeks) the zero current gradually decreases. To prevent this decrease from causing a display of negative oxygen concentration, the User Zero Offset can be used. A value from 0 to 9.99 ppb can be set. The value does not effect zero calibration; it is simply added to the calibrated zero.

For example, an offset of 1.0 ppb could be put into an analyzer reading 0.0ppb to allow a chart recorder attached to the output to read slightly above zero. Under these conditions the analyzer will read 1.0 ppb.

NOTE: When the Active Zero Offset feature is enabled from the Diagnostics menu the User Zero Offset feature is disabled. See page 76 for more information on the Active Zero Offset.

8.5.2.2 Zero Gas Valves

The **Zero Gas Valves** selection toggles RELAY 5 **ON (Open)** or **OFF (Closed)**. The relay terminals are located at the back of the instrument on connector J-9, labeled RELAY 5+ and RELAY 5 -. This function is used to manually control the zero gas valve when the instrument is equipped with Servomex's optional Automated Calibration System or with the External/User Calibration Components option.

NOTE



The gas purifier supplied by Servomex Corporation has a finite life that is greatly affected by the source gas oxygen level, flow rate, and duration of sampling. Always minimize the time sampling from the purifier and ensure that the source gas is below 50 ppb for optimal life expectancy.

8.5.2.3 Do an AutoZero

NOTE



This selection should be made only after the analyzer has been operating on zero gas with a stable output. Use a chart recorder to determine whether the output is stable.

When an optional Automated Calibration System or Automated Control of External/User-Supplied Components is supplied, **Do an AutoZero** initiates a sequence to automatically perform a calibration between the electronic zero and the sensor, accept the new calibration data, and then automatically return the analyzer to the process measurement mode. Selecting this entry brings up Figure 23: Do an AutoZero Screen. To prevent erroneous data logging or alarming by an

upstream data acquisition systems, the oxygen analog output can be automatically frozen in the state just prior to calibration. The output resumes normally once the calibration is completed. To activate this option, set **CAL FREEZE** to **ON** (see Analog Outputs Screen, Figure 42).

NOTE



Be sure the system is adequately purged and is reading close to zero. Do not attempt to AutoZero when the process gas or calibration gas exceeds 50 ppb.

Data Display ⇒ Main Menu ⇒ Oxygen Calibration

⇒ Check/Adjust Zero ⇒ Do An AutoZero

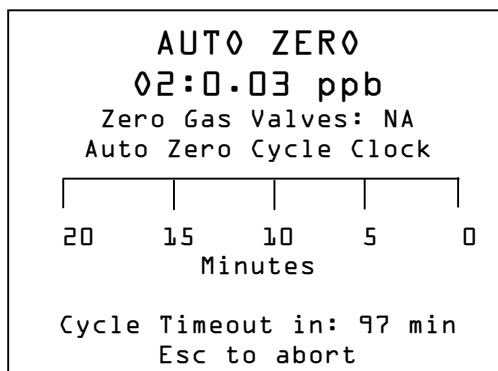


Figure 23: Do an AutoZero Screen.

Selecting **Do an AutoZero** from the Check/Adjust Zero Menu begins the process of verifying or recalibrating zero. The Process Mode can be restored manually by pressing **ESC**, or it is automatically restored at the completion of the AutoZero cycle.

O2: Displays the current oxygen measurement.

ZERO GAS VALVES OPEN – Notification of gas valve states. No user action is available.

AUTOZERO CYCLE CLOCK - Displays a graphical timer that begins counting down from 20 minutes. During the 20 minute cycle, the analyzer applies stability criteria. If after 20 minutes the oxygen reading has acceptable stability the analyzer automatically accepts the reading, updates the **ZERO Reference**, and returns to the Data Display Screen. If the reading is not stable, the analyzer continues the stability monitoring until the criteria has been met or until the cycle timer expires. In the latter case, the analyzer returns to operation on sample gas with no adjustment to the zero calibration and reports a failed zero calibration. See the section on *AutoZero Setup* for a description of the **Cycle Timeout** function.

After the analyzer completes the AutoZero cycle, the display returns to the Data Display Screen . (see Figure 18). The automated calibration system control relays

(relays 5 and 6) deenergize returning the analyzer to operation on process gas. The Data Display screen indicates **ZERO DELAY** for the next 2 minutes during the electronics zero adjustment before real-time oxygen readings resume. The **CAL FREEZE** and **IN-CAL RELAYS** are released.

8.5.2.4 Do a Manual Zero

Selecting Do a Manual Zero from the Check/Adjust Zero Screen initiates a 5-minute countdown, graphically displayed in Figure 24.

NOTE



This selection should be made only after the analyzer has been operating on zero gas with a stable output. Use a chart recorder to determine whether the output is stable..

**Data Display ⇒ Main Menu ⇒
Oxygen Calibration ⇒ Check/Adjust Zero ⇒ Do a Manual Zero**

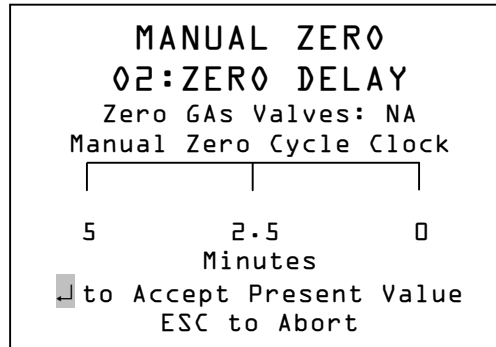


Figure 24: Do a Manual Zero Screen

At the end of the countdown, the new zero is logged, and the display is returned to Figure 22. If the signal is not stable, such as in the case of a rapidly falling zero baseline after an initial startup, the clock cycle resets to 5 minutes and repeats the procedure. This process continues indefinitely until a stable signal terminates the process. To accept the zero value from the Manual Zero Adjust Screen, press . (The message “↓ to accept present value” is displayed for several seconds, then “ESC to Abort” is displayed.

The Zero Reference value changes to reflect the deviation from the original factory calibration. A line is added to Figure 22 below the O2: reading that says Restore Factory Zero. At this point, the user can choose to keep the zero calibration by selecting Update and Quit, return to the previously used Zero Reference value by selecting ESC, or return to the factory calibration by moving the asterisk (*) to Restore Factory Zero and pressing ↓.

NOTE



The live **O2** reading as well as the Data Display Screen and every other location where oxygen is displayed indicates **Zero Delay** for approximately 2 minutes while the instrument completes an electronic zero adjustment. Following this period, the displayed oxygen may oscillate slightly, but should quickly stabilize to the value of 0.0 plus the Zero Offset.

8.5.3 AutoZero Setup

Selecting “AutoZero Setup” from the Calibration Menu displays the screen shown in Figure 25. This screen allows for automatic zeroing of the analyzer at preset times. An optional warning period allows the user to disable the AutoZero function at critical measurement periods.

*Data Display ⇌ Main Menu ⇌
Oxygen Calibration ⇌ AutoZero Setup*

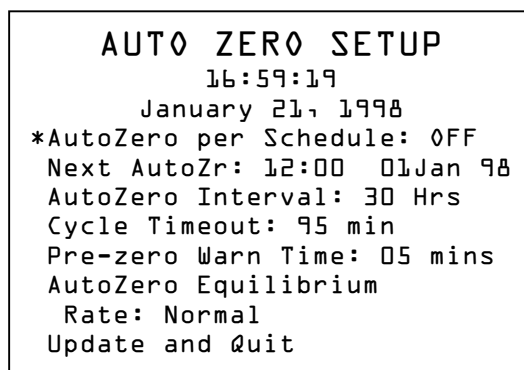


Figure 25: AutoZero Setup Screen

Next AutoZero - The time and date the analyzer performs the next AutoZero.

Cycle Time Out - The time allowed for a stabilization. If the required stable period is not achieved during this time, the AutoZero is automatically aborted and the Fail Zero Flag is set.

Pre-zero Warn Time - The system provides warning of a scheduled AutoZero before the calibration takes place, per the time set in the Pre-zero Warn Time.

Auto Zero Equilibration Rate - The Zero Acceptance allows the user to select the stability criteria required before the zero value is accepted. The **Stable** selection ensures the most accurate zero calibration but takes the longest time to execute. The **Quick** selection takes the least time and as a result is the least precise. The **Normal** selection applies an average of the two.

8.5.4 Check/Adjust Span

A Span Calibration is performed by connecting a regulated span gas to the sample inlet fitting. Local gas suppliers can provide certified span gas between 4 and 8

ppm oxygen. It is recommended that the span gas be in a background gas that is the same as the sample background gas.

The span gas bottle must be equipped with a regulator with a downstream shutoff valve to bring the bottled gas pressure to 15 psig. Before setting-up the analyzer for a Span Calibration, close the shutoff valve at the bottle and adjust the regulator to provide 15 psig at zero flow. Crack open the shutoff valve on the bottle to allow span gas to purge through the lines. With the gas purifier valves closed, open the sample valve. Connect the span gas line (while it is still flowing) to the calibration system.

CAUTION



*The downstream isolation valve must be fully opened immediately **BEFORE** the sample gas valve is opened and span gas is connected to the instrument.*

NOTE: If the GSF must be changed before the span check/calibration is initiated (i.e. the process is in H₂ and the span gas is in N₂), then the analyzer must be given time to stabilize before the span is initiated (12+ hours).

Selecting **Check/Adjust Span** from the Calibration Menu displays the Check/Adj Span Screen, Figure 26.

Data Display ⇨ **Main Menu** ⇨ **Oxygen Calibration** ⇨ **Check/Adjust Span**

CHECK/ADJ SPAN

02:0.02

Span Reference: 1000

*Span Gas Value: 1.00 ppm

Span Gas Valves: NA

Do an Auto Span RECAL

Do a Manual Span RECAL

Update and Quit

Figure 26: Check/Adj Span Menu

NOTE



A span calibration should be performed only after the analyzer has been operating at least 24 hours on a zero or low-ppb gas. The door should be closed when calibrating the analyzer. Be sure to set the GSF before performing a calibration, if necessary.

It is advantageous to use a span gas with the same background gas as the process gas to minimize stabilization time and reduce the probability of measurement error.

The **Span Reference** value is a reflection of the deviation from the original factory calibration. Instruments are shipped from the factory with the Span Reference set to 1000. After a manual or autospan is performed this value may change.

NOTE: The Span Reference value should not fall outside the range of 500 to 1500. If the value is outside this range contact Servomex.

If the system has been previously recalibrated by the user, when the **Check/Adjust Span** selection is made, an additional line is added to the Span Check Menu, Figure 26: **Restore Factory Span**. Selecting **Restore Factory Span** restores the factory calibration data.

O2 - Displays the current oxygen measurement.

The **Span Gas Value** of the calibration gas can be entered directly. Only values less than 10 ppm are accepted.

If an auto calibration system is installed, the **Span Gas Valves** entry toggles *both* RELAYS 5 AND 6 **ON (Open)** and **OFF(Closed)**. The relay terminals are located at the back of the instrument on connector J-9 RELAY 5+, RELAY 5-, RELAY 6+, and RELAY 6-. This function is used to manually control the span gas control valve when the instrument is equipped with an optional automated calibration system.

NOTE



Protection against false high alarms after a span calibration is provided by the firmware. Following a successful or aborted Span Calibration, the analyzer delays reactivation of its internal alarms until oxygen readings have fallen below the lowest active high alarm level, stabilized or increased. Also, the In-Cal Relay and Cal Freeze functions can signal external devices that oxygen readings are not yet valid.

8.5.4.1 Do an Auto Span RECAL/CHECK

Data Display ⇒ Main Menu ⇒ Oxygen Calibration ⇒ Check/Adjust Span ⇒ Auto Span RECAL

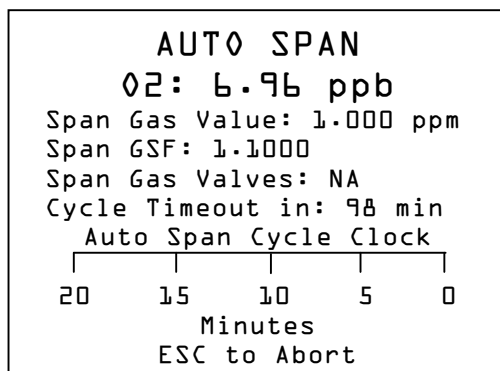


Figure 27: Auto Span Screen

If the optional Automatic Calibration System is installed, **Do an Auto Span** initiates an automated check or calibration using the gas connected to the span port. For best results, make sure the analyzer operates on a low ppb gas for several hours and Zero has been calibrated before performing a span check.

The span gas must not exceed 10 ppm and it should have approximately the same composition as the sample gas. All calibrations should be done after the analyzer has operated for over 24 hours and with the door closed.

After entering the span gas value, the display automatically shows the Auto Span Screen shown in Figure 27.

O2 - Displays the current oxygen measurement.

SPAN GAS VALUE - Displays the oxygen concentration entered for the span gas.

SPAN GAS GSF - Displays the GSF for the Span Gas.

The **Span GSF** - (Gas Scale Factor) is used to correct for changes in the rate of oxygen diffusion when background gases other than nitrogen are present in the span calibration gas. Enter the Span GSF Menu through the Setup Analyzer Menu (Figure 41) then through the Calibration Menu (Figure 21).

In many applications, the span GSF does not need to be altered from the default value of 1.00. However, if the sample gas has a significantly different diffusivity compared with nitrogen (such as helium or hydrogen), a span gas with diffusivity similar to the sample gas increases the accuracy of measurements. In this case, the GSF should be applied. To use the GSF feature, enter the volumetric percentages of the sample gas as described below. The GSF is automatically calculated. Alternately, the GSF can be entered manually.

NOTE: If the GSF must be changed before the span check/calibration is initiated (i.e. the process is in H₂ and the span gas is in N₂), then the analyzer must be given time to stabilize before the span is initiated (12+ hours).

More GSF information appears in the *Setup Analyzer Menu* on page 82 and in the *Sample Gas Preparation and Delivery* section on page 35.

SPAN GAS ON - Notification that span gas is being supplied to the analyzer. No user action is available.

AUTOSPAN CYCLE CLOCK - Displays a graphical timer that begins counting down from 20 minutes. During the 20 minute cycle, the analyzer begins to apply stability criteria. If after 20 minutes the reading meets the criteria, the analyzer accepts the reading, updates the Span Reference value, automatically Updates and Quit, and returns to the Data Display Screen to complete the calibration. If the reading is not stable, the analyzer repeats the stability monitoring until the criteria is met or the span timeout is exceeded in which case the analyzer returns to the Data Display and reports Fail Span.

If the **CAL FREEZE** selection is **ON**, the analyzer output is frozen prior to entering the calibration process.

If the **IN-CAL RELAY** is used to signal a data acquisition system via optional relays 1, 2, 3 or 4 that a calibration is in process, the designated relay changes state upon entering the CALIBRATION screen.

After the analyzer completes the automated span calibration, the display returns to the Data Display Screen and the automated calibration control (relays 5 and 6) returns the analyzer to measuring process gas. However, if the alarms are set, the **CAL FREEZE** and **IN-CAL RELAY** is not released until the oxygen reading has stabilized, increased, or the oxygen value has dropped below the lowest active high alarm set point (minus the deadband).

8.5.4.2 Do a Manual Span RECAL

NOTE



For optimal performance, operate the analyzer on low ppb gas for several hours before performing a span check (above 1 ppm). Setting a zero baseline after a ppm-level exposure without sufficient purge time results in a zero baseline that drops slightly over time. The preferred technique is to set the zero baseline prior to the ppm span exposure.

Data Display ⇒ Main Menu ⇒ Oxygen Calibration ⇒ Check/Adjust Span ⇒ Do a Manual Span RECAL

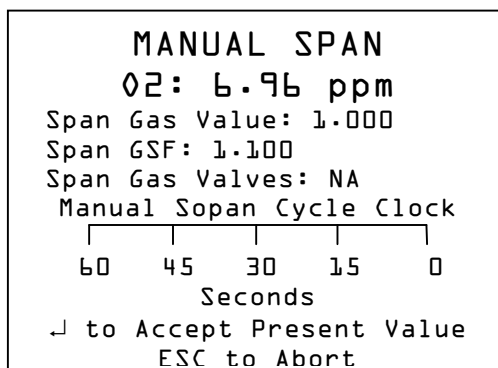


Figure 28: Manual Span RECAL Screen

A manual calibration can be performed after the span gas is connected and the analyzer is stable. After initiating a manual calibration, it may take up to five minutes before convergence occurs and the 60 second time bar begins to move. During convergence, the analyzer is verifying stability of the reading before accepting the data. After convergence, two short beeps can be heard. The analyzer's electronics can be updated to the new calibration information by selecting Update and Quit.

If convergence does not occur within 5-10 minutes, check the following:

1. Make sure the gas connections are leak free. See the section on *Checking for Plumbing Leaks Using Flow Rate Effects* on page 38.
2. Make sure the sensor has had sufficient time to attain a stable reading on the calibration gas by installing a chart recorder and monitoring the signal over a period of time.
3. Check the electrical connections to the sensor.

NOTE



The IN-CAL Relay and CAL FREEZE function is released in the same manner as that for Auto Span.

To abort the calibration before completing convergence, press **ESC**. The previous calibration data remains in effect.

8.5.5 AutoSpan Setup

Select the AutoSpan Setup Screen from the Calibration menu (see Figure 29). This screen allows for automatic span calibration or checks of the analyzer at preset times. An optional warning period allows the user to disable the auto span function at critical measurement periods.

AutoSpan Per Schedule - Choose whether or not the analyzer automatically performs spans on a schedule.

Next AutoSp - Set the time and date the analyzer performs the next auto span.

AutoSpan Interval - Set the time in weeks between auto spans.

Cycle Time Out - Set the time allowed for a stabilization. If the required stable period is not achieved during this time, the AutoSpan is automatically aborted, and the Fail Span flag is set.

Pre-span Warn Time - Set the amount of warning time the system provides before a scheduled Auto Span calibration takes place.

Data Display ⇒ Main Menu ⇒ Oxygen Calibration ⇒ Auto Span Setup

```
AUTOSPAN SETUP
16:59:19
January 21, 1998
*AutoSpan Per Schedule: OFF
Next AutoSp: 12:00 01 Jan 98
AutoSpan Interval: 000 Wks
Cycle Timeout: 99 min
Pre-Span warn time: 05 min
AutoSpan Process: RECAL

Update and Quit
```

Figure 29: Auto Span Setup Screen

AutoSpan Process - Choose whether the system performs a span check or complete recalibration. If the span check mode is selected the screen will appear as in Figure 30. Note the additional line for Span Check Limit. This value is adjustable and expressed as a percent of the entered span gas value. It is recommended not to use limits of less than +/- 10% of the span gas value. When in the check mode, the span value obtained after a span check is compared within the

limits set up. No actual recalibration takes place. If the resulting value is outside the span check limit, a fail span message will appear on the Data Display Screen.

NOTE: If the GSF must be changed before the span check/calibration is initiated (i.e. the process is in H₂ and the span gas is in N₂), then the analyzer must be given time to stabilize before the span is initiated (12+ hours).

Data Display ⇒ Main Menu ⇒ Oxygen Calibration ⇒ Auto Span Setup

```
AUTOSPAN SETUP
16:59:19
January 21, 1998
*AutoSpan Per Schedule: OFF
Next AutoSp: 12:00 01 Jan 98
AutoSpan Interval: 000 Wks
Cycle Timeout: 99 min
Pre-Span warn time: 05 min
AutoSpan Process: Check
Span CHECK Limit: +/- 10%
Update and Quit
```

Figure 30: AutoSpan Check Screen

8.5.5.1 Reset Fail AutoZero Flag

If an AutoZero is unsuccessful (due to a cycle timeout without the required stability), the Fail AutoZero Flag is set (enter the Calibration Screen and select the Reset “Fail AutoZero” Flag).

8.5.5.2 Reset Fail AutoSpan Flag

If an Auto Span is unsuccessful (due to a cycle timeout without the required stability), the Fail AutoSpan is set. To reset it, enter the Oxygen Calibration Screen and select Reset “Fail AutoSpan” Flag.

8.5.6 Factory Sensor Data

The Sensor Data Screen displays the calibration values that were established when the sensor and analyzer were calibrated at the factory. If a new sensor is required, the replacement sensor is factory calibrated and arrives with installation instructions that include a new set of Sensor Data values.

NOTE



These values should not be changed unless the sensor is changed.

NOTE



Do not edit this entry without specific instructions from Servomex Corporation. If the entry has been accidentally accessed, press ESC.

Data Display ⇒ Main Menu ⇒ Oxygen Calibration ⇒ Factory Sensor Data

```

      SENSOR DATA
      This option is only to
      install a new sensor.
      Enter info supplied by
      Delta F below
*(1) 0000000000
(2) 0000313000
(3) 0003211003
(4) 0318750300
(5) 1043593977
Factory Temp idx: 0
Update and Quit
```

Figure 31: Sensor data screen

8.5.7 Signal Averaging Filter

The DF-560E Oxygen Analyzer is equipped with two types of electronic digital filtering that conditions the output signal to smooth out noise and spikes.

The standard Weight and Threshold technique, which has been used very effectively in the original NanoTrace Oxygen Analyzer, is available for users making typical O₂ measurements >1 ppb. The second type of digital filtering called ULTROX (Ultra Low Trace Residual Oxygen) is designed especially for making O₂ measurements in the <1 ppb region.

The AVERAGING FILTER menu is shown in Figure 32. This menu displays the offset between the displayed reading **O2 AVG:** and the real-time reading **O2 RAW:**. The difference between the two readings illustrates the time lag and noise reduction effects of the filter while in use. Observing the relative changes to these readings can help the user to establish optimum filter settings for a specific process or application. See the tables at the end of this section for a comparison of the various modes and the benefits of each.

8.5.7.1 Filter Mode: Weight and Threshold Average

The signal output from the oxygen sensor can be filtered for noise by a Weighted Moving Average Filter. The filter weight is user adjustable for optimum measuring conditions in a particular application. As the weight value is increased, noise is reduced and response time is lengthened. Clearly, the weight should not be set higher than that which yields acceptable peak to peak noise based on the required analytical resolution.

In addition, a second signal conditioning filter can be added to the weighted moving average filter to provide enhanced noise suppression by setting the **Response** parameter to **Low Noise**. The **Low Noise** feature is a rate-of-change filter that retards a rapid rise or fall event which is generally due to electronic noise. As a result, this **Low Noise** filter can be used with lower WEIGHT settings, and is more effective in displaying gradual reading changes which are generally due to real oxygen changes in the process.

A Filter Cutoff feature automatically removes filtering if the difference between the filtered moving average and new, unfiltered readings exceed the value of the user-set **Threshold**. The **Threshold** feature insures the instrument will quickly display a large oxygen intrusion. Experience with a particular application determines optimum settings for Weight, Response, and Threshold settings.

Data Display ⇒ Main Menu ⇒ Oxygen Calibration ⇒ Averaging Filter

```

      AVG FILTER
02  AVG: 1.00 ppb
02  RAW: 1.00 ppb
*ULTR0X Mode: NA
  Transient Rejection: NA
  Threshold: 0.01
  Filter Weight: 100
  Response Type: FAST
  Update and Quit
  
```

Figure 32: Averaging Filter Menu – Weight and Threshold Mode

8.5.7.2 Using Weight and Threshold Filtering

Three parameters are used to adjust the instrument's peak-to-peak noise and response time.

Filter Weight - Weight is a measure of the relative dampening (averaging) factor of the filter. The greater the weight, the more the dampening effect.

This setting affects both the speed-of-response and the time constant imposed on the real-time process signal. Weight also affects the high-frequency cut-off of the filter. The greater the weight, the lower the frequency cut-off. The value of the Weight can be from 0 to 200 (maximum filtering). The value can be related to approximately a two second time interval per unit weight to reach 99.9 percent of a step change. (See examples that follow.)

Response Type - The user may choose **FAST** or **LOW NOISE**. The LOW NOISE setting applies additional filtering (typically a factor of two) to the signal.

Threshold - The Filter Threshold setting is in ppm units. Filtering is active for oxygen concentrations changes below the user set value. When the concentration change exceeds the threshold value, the filtering functions are deactivated. While

the filtering is deactivated, a real-time rate of change to the measured value is displayed. This feature allows the user to apply heavy signal noise reduction, while maintaining real-time, high-speed response for larger oxygen changes.

EXAMPLE: With settings of **Weight: 100**, and **Response Type: FAST**, the time to reach 99.9 percent of a step change is ~200 seconds (2×100); with a setting of **Response Type: LOW NOISE**, the time to reach 99.9 percent of a step change would be ~400 seconds.

This example assumes that the oxygen change is less than the setting of **Threshold**. As such, the filtering is not interrupted to permit quicker response. If **Threshold** is set to 0.01 (10 ppb), then filtering is deactivated when a change in the raw signal is more than 10 ppb different from the averaged signal. Filtering is reapplied when sequenced raw readings fall back within the 10 ppb window. Therefore, the analyzer responds in almost real-time, except for the last 10 ppb or so when the filtering is reapplied. As a result, low **Threshold** settings can dramatically increase the analyzers speed of response.

8.5.7.3 Filter Mode: ULTROX

The ULTROX filtering technology allows reliable oxygen purity measurements down to 75 ppt and can detect “upsets” as low as 50 ppt. The ULTROX filter activates Servomex’s proprietary noise rejecting algorithm which dynamically monitors the sensor signal and eliminates noise and unwanted artifacts which can obscure the detection of small oxygen changes. The algorithm uses artificial intelligence (AI) to verify all sensor information before it is presented to the user. This allows the DF-560E to detect significantly lower oxygen impurity levels than the original NanoTrace analyzer.

With the ULTROX mode activated, users should be aware that under some conditions the shape of the response curve may look different than the typical single order response of the NanoTrace and other instruments using traditional filtering methods. The differences in the oxygen response curves may include:

- The response curve for sub-ppb step changes sometimes appear linear.
- The 90 percent response times for sub-ppb step changes may range between 2 and 32 minutes.
- The response curves for repetitive sub-ppb step changes may not reproduce each time.
- There are two settings to select from in the ULTROX filter mode: Ultra Low LDL and Low LDL. The Ultra Low setting should be used when trying to make accurate oxygen measurements below 500 ppt. The Low LDL setting typically is for use in the 0.5 ppb to 1 ppb range.
- The second part of the ULTROX filter mode setup is the Transient Rejection feature. Since there are occasions when the sensor electronics experience brief but false signal transients, the Transient Rejection feature has been designed to identify and ignore them since they do not represent useful process control data. With Transient Rejection selected, the filter algorithm holds back

updating the oxygen data for a pre-selected time period. This delay is designed to ignore typical fast moving signal spiking due to sensor random noise, vibration, EMI interference, and so forth. The response to real oxygen changes are delayed by the pre-selected period of 60 seconds.



Data Display ⇒ Main Menu ⇒ Oxygen Calibration ⇒ Averaging Filter

```

      AVG FILTER
02 AVG: 1.00 ppb
02 RAW: 1.00 ppb
*ULTROX Mode: Low LDL
  Transient Rejection: OFF
  Threshold: NA
  Filter Weight: NA
  Response Type: NA
  Update and Quit
  
```

Figure 33: Averaging Filter Menu – ULTROX Mode

8.5.7.4 Using the ULTROX Filtering

Select ULTROX Mode from the Average Filter Display as shown in Figure 33 and press  to toggle through the available filters for sub-ppb Oxygen measurements. Pressing  toggles from Ultra Low LDL to Low LDL to OFF. While ULTOX Mode is ON, the Transient Rejection can be toggled ON or OFF, but Threshold, Filter Weight, and Response Type are unavailable. Toggling ULTROX Mode to OFF, makes Transient Rejection unavailable. A value is displayed in Threshold and Filter Weight, and Response Type can be toggled Fast or Low Noise.

8.5.7.5 Summary of Signal Filter Modes

Oxygen Level	Filtering Mode
<0.5 ppb	ULTROX w/ Ultra Low LDL
<1.0 ppb	ULTROX w/Low LDL
>1.0 ppb	Weight and Threshold w/Low Noise
Initial startup or upset recovery	Weight and Threshold w/Fast Response

Table 10: Signal Filter Mode

The following tables provide nominal filtering values for a variety of applications. These recommendations should be used as a starting point for setting the Averaging Filter. Experience with the specific application leads to optimum settings.

	Weight	Threshold	Response
< 2 ppb	> 500	> 0.02	Low Noise
< 10 ppb	> 100	> 0.01	Low Noise or Fast
> 10 ppb	< 100	.01	Fast
Upset Recovery	0-100	.01	Fast

Table 11: Typical Weight and Threshold Filter Settings by O2 Level

ULTROX Mode		Peak to Peak Signal Noise
Ultra Low LDL		0.01 ppb
Low LDL		0.02 ppb
Weight and Threshold Mode		
Weight	Response Type	
200	Low Noise	0.20 ppb
200	Fast	0.30 ppb
100	Fast	0.35 ppb
50	Fast	0.40 ppb

Table 12: Typical Peak to Peak Noise by Filter Setting

NOTE



Use **Reset Averaging Filter** in the Controls Menu to restore operation after a spike.

NOTE



Analyzers shipped from the factory are configured with the following filter settings: ULTROX Filtering is enabled with the Ultra Low LDL option and Transient Rejection is also turned ON. If the user switches to the Weight and Threshold mode, the following settings are preset from the factory: Weight = .01 ppm, Threshold = 100 and Response = FAST.

8.6 Maintenance Menu

The Maintenance Screen is activated by selecting “Maintenance” from the Main Menu as shown in Figure 19. The Maintenance Screen in Figure 34 provides access to logs and diagnostics.

Data Display ⇨ Main Menu ⇨ Maintenance



```

      MAINTENANCE
*Reset the "Replenish"
  Reminder Flag
  Record a "Replensihment"
    into Maintenance Log
  Set "Replenish" Reminder Fla
g
  Frequency: 04 weeks
  Maintenance Log Display...
  Diagnostics...
  Update and Quit



```

Figure 34: Maintenance Screen

8.6.1 Reset the “Replenish” Reminder Flag

If the Replenish flag is displayed on the Data Display Screen, the first line of the Maintenance screen allows this flag to be reset. You are asked “Are you sure?” Press  to confirm or  to keep the flag.

8.6.2 Record a “Replenishment” into the Maintenance Log

If the Replenish flag is not being displayed on the Data Display Screen, the first line of the Maintenance Screen allows a replenishment to be recorded. Selecting this line causes the screen to display “Replenishment Solution Added?”. Press  to confirm or  if solution has not been added. This action also clears the Replenishment flag from the Data Display Screen.

8.6.3 Set the “Replenish” Reminder Flag Frequency

The Maintenance Screen allows the period of time between Replenishment Solution additions to be automatically tracked by the analyzer. When the time period ends, the Replenishment flag shows on the Data Screen, reminding the user to add Replenishment Solution to the sensor. The flag can be set from 0-99 weeks, in increments of one week.

8.6.4 Maintenance Log Display

The Maintenance Screen allows access to the Maintenance Logs. The Maintenance Log Display provides access to maintenance and calibration logs as shown in Figure 35.

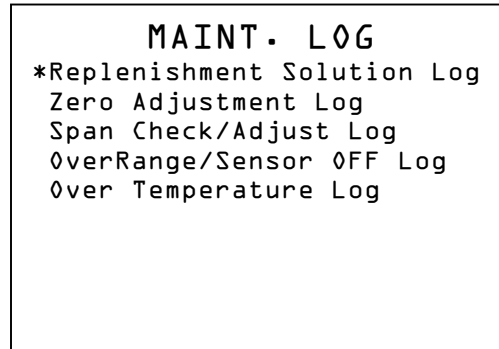


Figure 35: Maintenance Log Display Screen

The maintenance log includes abbreviations that are defined as follows:

Log	Abbreviation	Definition
Span or Zero	A	Auto
	M	Manual
	S	Schedule
	R	Recal Span (does not apply to Zero)
	C	Check Span (does not apply to zero)
	F	Failed
	X	Aborted
Replenishment Solution	A	Add replenishment solution
	C	Clear flag
	E	Electrolyte condition (level too low for two hours)

Table 13: Maintenance Log Abbreviations

8.6.4.1 Maintenance Logs

From the Maintenance Log Screen in Figure 35, Maintenance Logs, such as the Replenishment Solution Addition Log, the OverRange Sensor Log and the Over Temperature Log can be displayed.

The **Replenish Addition** log reports on any issues pertaining to solution additions. Three symbols may appear in this log. They are **A** if solution has been added (the user must enter that solution has been added). **C** if the replenishment solution addition flag has been cleared (this is also entered by the user, if the user enters a replenishment solution addition, the flag is automatically cleared). **E** will be displayed if the electrolyte condition flag has been displayed for more than two hours. The analyzer will remain operable, however an upward drift in the zero baseline may be observed. The date and time for any of these occurrences will also be displayed.

The Replenish Log Screen in Figure 36 shows the date, time and notes.

Data Display ⇒ Main Menu ⇒ Maintenance ⇒ Maintenance Log Display ⇒ Replenishment Solution Log

REPLENISH LOG		
<u>Date</u>	<u>Time</u>	<u>Notes</u>
7/15/98	10:27	C
NO MORE		
More Data		

Figure 36: Replenishment Log Screen

The **Sensor Over-range** log reports sensor shutdowns via the sensor on/off relay due to high oxygen conditions. Two such conditions exist. If the sensor is exposed to over 20 ppm O₂ for 20 minutes a shutdown occurs. This shutdown is reported as **DA**. If the sensor is exposed to over 100 ppm O₂ for ten minutes a shutdown occurs. This shutdown is reported as **DB**. The date and time of these conditions are reported.

The **Temperature Overrange** log reports the sensor's temperature probe measuring high temperature (>45 C) for two hours. This will be reported as **DT**. The date and time when this took place is also recorded.

8.6.4.2 Calibration Logs

From the Maintenance Log Screen, Calibration Logs for Zero adjustment and Span Check/Adjust can be displayed.

These logs are similar and report on adjustments made to the analyzer zero or span. A user can perform either an Auto or a Manual calibration. For an Auto calibration, an **A** will be reported. For a Manual calibration, an **M** will be reported. A user calibration can be aborted. If this is the case, an **X** will appear after the Auto or Manual designation. The analyzer could also fail the calibration. In this case an **F** will appear after the Auto or Manual designation. The analyzer can perform scheduled Auto calibrations. For those cases an **S** is displayed. Finally, for the case of Auto Span, the analyzer can recalibrate itself or just perform a check of its calibration. If the analyzer is set for recalibration an **R** will be displayed. For a span check, a **C** is displayed. In the case of a checked Auto Span, if the span falls outside the set criteria limits, the log will display **F** for failure. The log will display date and time of calibration as well as the time required for the calibration and the zero or span reference value following the calibration.

The Zero Adjust Log Screen in Figure 37 gives the date, time, zero value and type of calibration of each stored calibration.

Data Display ⇒ Main Menu ⇒ Maintenance ⇒ Maintenance Log Display ⇒ Zero Adjust Log

ZERO LOG				
Date	Time	Min	ZRef	Nte
S				
01/21/98	16:57	6	14.0	M
01/21/98	16:57	10	12.2	M
01/21/98	16:55	7	21.1	M
01/21/98	16:54	9	2.25	AF
01/16/98	15:51	6	2.25	M
NO MORE				

Figure 37: Zero Adjust Log Screen

8.6.5 Diagnostics Menu

The Diagnostics Menu is used to test different functions of the analyzer. When this Menu is selected, Figure 38 is displayed.

Data Display ⇒ Main Menu ⇒ Maintenance ⇒ Diagnostics Menu

DIAGNOSTICS	
Sensor Voltage:	1.30 VDC
Sensor Temperature:	21.80 C
*Temperature Compensation..	.
Active Zero Offset:	ON
Test Anl Outputs:	100.0%
Test Relays...	
Memory Test...	
Screen Test...	

Figure 38: Diagnostics Menu

8.6.5.1 Sensor Voltage

The **Sensor Voltage** factor is a Diagnostic read-only feature.

8.6.5.2 Sensor Temperature

The display indicates the present sensor temperature. There is no user action with this selection. The temperature value is updated at intervals of 15 to 45 seconds while in the Diagnostics Menu.

8.6.5.3 Temperature Compensation

Temperature changes can be automatically compensated for by using the Automatic Adjust setting. Under this setting, the analyzer determines the optimum

temperature compensation. However, if the analyzer output appears to be drifting unacceptably, and this drift correlates with ambient temperature change, the **Temp. Comp** feature is useful to manually correct for the temperature related drifts. A recorded output that shows oxygen and ambient temperature readings over time clearly illustrates the correlation, if any. The factory setting and current setting are shown. First change the **Automatic Adjust** to OFF. Then use ▲ and ▼ to adjust the **Temp. Comp** setting for different compensation, between 1 and 19. If the analyzer reading increases with increased temperature (under-compensation), then increase the set point (closer to 19). If the analyzer reading decreases with increased temperature (over-compensation), decrease the set point.

Data Display ⇒ **Main Menu** ⇒ **Maintenance** ⇒ **Diagnostics** ⇒ **Temp. Comp**

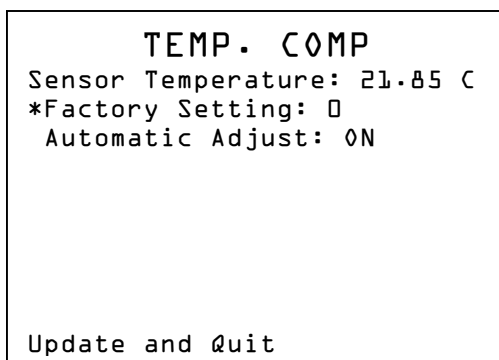


Figure 39: Temperature Compensation Screen

Because it is possible that processes can have real oxygen changes occurring with temperature changes, such as surface adsorption/desorption within a bulk gas delivery system, it is important to judge if the analyzer's response is temperature dependent only while the sample is oxygen free zero gas. A point-of-use purifier at the inlet to the analyzer (as supplied with the Automated and Manual Calibration System options) is suggested.

Once the desired compensation has been entered, select Update and Quit. Observe the readings over an extended period (24-to-72 hours) during which temperature changes occur. Refine the compensation adjustment as necessary.

NOTE



***Temp. Comp** is designed to correct temperature drift at oxygen levels close to zero (<10 ppb). At higher levels, changing **Temp. Comp** is not very effective. A **Temp. Comp** set point is best selected while the analyzer is on zero gas.*

8.6.5.4 Active Zero Offset

The **Active Zero Offset** feature is designed to automatically compensate for the analyzer's gradual zero baseline cleanup. This gradual cleanup is natural and occurs after a fresh startup or after a prolonged or abnormally high oxygen exposure. This feature ensures that accurate low ppb O₂ readings can be made as

soon as possible after initial startup, or after a high O₂ upset event. It is similar to the User Zero Offset feature in that a small positive offset is added to the analyzer O₂ readings (display and output) to compensate for the long term downward trending in the readings during cleanup. The Active Zero Offset provides an automatic addition of offset that occurs in miniscule steps, and within set guidelines, corresponding to the predictable behavior of a DF-560E during cleanup.

When Active Zero Offset is enabled through the Diagnostics Menu, the User Zero Offset feature is disabled and vice versa. While the User Zero Offset feature requires the user to enter a fixed positive offset value to accommodate the baseline cleanup, the Active Zero Offset does so automatically, and only when necessary.

The current Active Zero Offset value is shown in the CHECK/ADJUST ZERO menu. It starts at a value of 0.00 ppb when the analyzer is first turned on, and then increments automatically as the analyzer applies offset to the readings. After each User Zero Calibration, the Active Zero Offset value is reset to 0.00 ppb and then automatically increments again as needed.

The Active Zero Offset is designed to operate when the zero baseline is falling at a rate less than 0.1 ppb/hr as would be the case after 1-2 weeks of initial operation. If user calibrations are performed sooner, the O₂ readings may be decreasing too rapidly for the Active Zero Offset feature to operate properly and negative O₂ readings may result.

If the Active Zero Offset value reaches 2 ppb a warning message CAL ZERO will flash in the system status block on the display instructing the user that a zero calibration should be performed. The maximum amount of offset that can be applied by this feature is 3 ppb. Any further downward trend (baseline cleanup) will result in negative readings until the next user calibration is performed resetting the Active Zero Offset value to zero.





If the Active Zero Offset feature is turned off, the User Zero Offset value will appear in its' place in the CHECK/ADJUST ZERO menu. The previous user Zero Offset value (if any) will reappear and immediately be applied to the live display readings. Likewise, if the Active Zero Offset feature is on, then its' value (if any) will appear and immediately be applied to the live readings.

NOTE



If the Active Zero Offset feature is turned off, the Cal Zero message will still appear if the 3ppb criteria are met.

8.6.5.5 Test Analog Outputs

The Test Output entry is used to calibrate the recorder output. When the Test Output option is selected, use the  and the  and  key to set the desired output level in percent of full scale. After setting the percent full scale level, press . The analog output response should match the value that was entered. For

example, if 80 percent is entered for the percent full scale level, and the analog output is set for 0 to 10 VDC, the analog output is 8.000 VDC.

8.6.5.6 Test Relays

The **Test Relays** selection Figure 38 is used to assure that the relay outputs are functioning. When the Test Relays option is selected, the user is prompted to select the relay number to be tested, using the ▲ and ▼ keys.

NOTE



This test is used to verify that relays 1 through 4 are functioning. To test relay 5 (Sample/Calibration Relay) and relay 6 (Zero/Span Relay), use the Control Menu.

Select the relay to be tested, then press ←. The relays can be toggled with subsequent ←. An audible click occurs. The condition of the relays before the test is restored when the test is concluded.

8.6.5.7 Memory Test

The Memory Test Screen is used to test the internal memory of the analyzer. When the Memory test option is selected from the Diagnostics Menu, Figure 40 is displayed. Testing takes place automatically.

Data Display ⇒ Main Menu ⇒ Diagnostics Menu ⇒ Memory Test

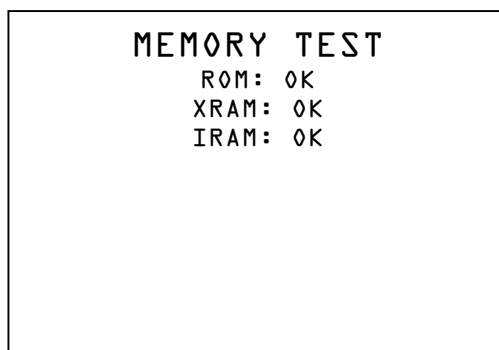


Figure 40: Memory Test Screen

After the test is complete, the display should indicate **ROM:OK**, **IRAM:OK**, and **XRAM: OK**.

If any memory test fails, repeat the test. If a failure repeats, contact your local Servomex Business Center.


8.6.5.8 Screen Test

When the screen test option is selected from Figure 38, each pixel in the display is tested. A series of horizontal lines appears on the display followed by a series of vertical lines. After the test has been completed, the display returns to Figure 38.

If an error message appears or a pixel is inactive, contact your local Servomex Business Center.

8.7 Setup Analyzer Menu

The Setup Analyzer Menu is used to set a variety of Analyzer parameters. Some of these parameters are set when initially configuring the analyzer. When this selection is made (and the appropriate password is entered if required), Figure 41 is displayed.

Each entry in Figure 41 leads to a submenu as shown in Figure 42. Select the desired submenu, by placing the asterisk next to it and then press . A new display is shown as indicated below.

Data Display ⇨ Main Menu ⇨ Setup

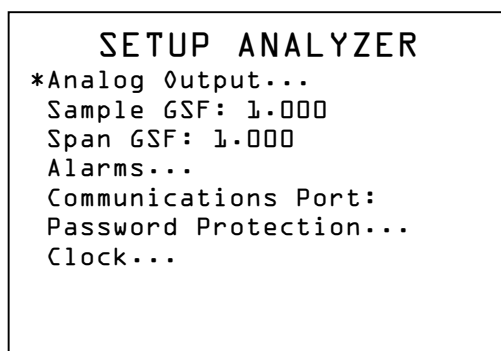


Figure 41: Setup Analyzer Menu

8.7.1 Analog Output

Data Display ⇨ Main Menu ⇨ Setup ⇨ Analog Outputs

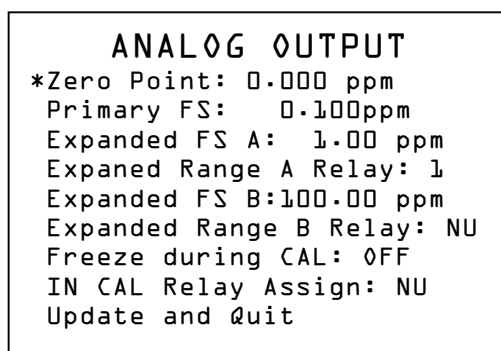


Figure 42: Analog Outputs Screen

The **Analog Output** entry in the Setup Analyzer Menu scales the full range of analog output (voltage and current) over a partial or full range of oxygen concentration.

The Analog Outputs Screen is shown in Figure 42.

8.7.1.1 Zero Point

The **Zero Point** input corresponds to the lowest voltage or current output (0 VDC, 4 mA) that is sent to a recorder, while the **FS** (Full Scale) input corresponds up to the maximum voltage or current output (0.1/1/5/10 VDC and 20 mA) is sent. The full scale point is set from 0.000 ppm to 9.999 ppm.

NOTE



The voltage or current output accurately tracks up to -5% of the full scale range selected. For example: F.S.=0.100 ppm, Zero=0.0 ppm, Analyzer output tracks down as low as -5 ppb.

8.7.1.2 Output Ranges

Often in pure gas monitoring applications, the 0-10 VDC and/or 4-20 mA analog outputs are set to scale over a low range (normal scale) of concentrations for example 0.0 – 0.02 ppm. As a result small changes can easily be detected on a chart recorder or external data acquisition system. On the other hand, a process upset would quickly exceed full scale. As a result, by use of the Expanded Range Scale, the upset can still be monitored as the analyzer automatically switches to the higher scale. And conversely, when the oxygen reading has dropped back to 95% of the normal scale the analyzer will switch back down.

Both analog output ranges can be selected from Figure 42. The range of the Primary Full Scale (FS) must be less than that of the Expanded Full Scale (Expand FS). Both output ranges are available through pins A Out + and A Out – on the J10 connector on the rear of the analyzer. The analyzer auto-ranges between the two outputs depending on the current analyzer reading.

A window as narrow as 10 percent of the analyzer's decades (0 to 10 ppm, 0 to 1 ppm, 0 to 100 ppb) can be set for the full-scale analog output. Analyzers are shipped with a factory setting of 0 to .100 ppm on the primary scale, 0-1 ppm on FSA, and 0-10 ppm on FSB. This range changes if a new Zero Point or Full Scale is entered. The analog output range is displayed under the oxygen reading on the Data Display Screen. The units are always expressed in ppm.

8.7.1.3 Expanded Range Relays

Both expanded ranges for the analog output can be assigned to relays. When the analyzer's reading causes a change to the analog output scale, the assigned relay trips indicating that the analyzer has auto-ranged to a different analog output scale.

8.7.1.4 Cal Freeze

When **CAL FREEZE** is ON, the system holds the oxygen analog output at the last reading prior to entering a calibration sequence. When this option is OFF, the oxygen analog output follows the calibration measurement. Using ↵ toggles this

feature **ON** and **OFF**. This selection allows the user to perform a calibration without tripping alarms in external data collection and control systems. It also eliminates off-range voltage or current conditions during calibrations.

CAL FREEZE only activates when entering a calibration sequence. Selecting **CAL FREEZE ON** does not freeze the output in real time.

8.7.1.4.1 IN CAL Relay Assign

IN CAL RELAY ASSIGN is used to assign one of four optional relays to signal an external device that the analyzer is in the calibration mode. Sequentially pressing \downarrow toggles among **NU**, **1**, **2**, **3** and **4**.

The assigned relay trips when the analyzer is performing a zero or span calibration. Following a successful completion of either a Manual or Automatic calibration process, the relay releases after about a two minute delay which allows the electronics to stabilize.

After entering the **CHECK/ADJ SPAN** menu, and initiating a Manual or Auto Span calibration, the In-Cal Relay operates as follows after a span process has been completed (or initiated and aborted):

If the oxygen reading is above the Lowest Active High Alarm Set Point (minus its deadband), the instrument releases the In-Cal Relay after the oxygen reading has stabilized or increased. The interval used to judge stability depends on the level of the current reading, and how close the current reading is to the Lowest Active High Alarm Set Point. The lower and/or the closer the reading is to the set point, the longer the period.

When the oxygen reading falls below the Lowest Active High Alarm Set Point (minus its deadband), or when no High Alarm Set Points are active, the instrument releases the in-Cal Relay upon the completion of an AutoSpan/AutoZero or entering Update and Quit after a manual span or zero.

NOTE



*The Lowest Active High Alarm Set Point, and the deadband which applies to that alarm set point, is the lowest numerical High Oxygen Alarm Value programmed in the **ALARMS SETUP** menu that is also switched ON. This alarm can be configured as just a visual alarm. No audible annunciation or relay action is needed for this alarm.*

The user can control the length of time following a span calibration that the analyzer is given before reporting data, to ensure the reliability of the data. By choosing a high alarm set point, which is below the maximum allowable oxygen concentration for the specific gas stream (i.e. high alarm levels set for warning and shut-down), the In-Cal Relay can be used to minimize downtime following a span calibration without risk of false alarms triggered in external devices by the analog output level.

For example, if the maximum oxygen concentration specification is 10 ppb, simply set an oxygen alarm at 8 or 9 ppb. Even if the analyzer is not responsible for alarming functions, this insures that the host control system is informed not to use oxygen data until the oxygen readings are safely below the alarm level.

Choose the highest level that is safely below the maximum contamination level to minimize the amount of time that the analyzer is signaling that it is off-line.

Following a Span Calibration at approximately 7 ppm, and assuming the process gas normally reads below 1.0 ppb, the analyzer typically requires 1 to 3 hours to be safely below 10 ppb. The lower the Lowest Active High Alarm Set Point (minus deadband) is set, the longer it takes to release the In-Cal relay. It is recommended that the Lowest Active High Alarm Set Point (minus deadband) value be 2.0 ppb or higher. If none of the judgment criteria to release the relay is met within 12 hours, the relay is released.

8.7.2 Sample GSF

The optional **GSF** (Gas Scale Factor) is used to correct for changes in the rate of oxygen diffusion when background gases other than nitrogen are present in the span calibration gas. Enter the Sample GSF Menu through the Setup Analyzer Menu (Figure 41).

The software in the analyzer supports the following gases in the GSF calculation:

Gas		GSF Value
Nitrogen	N ₂	1.00
Argon	Ar	1.03
Hydrogen	H ₂	0.61
Helium	He	0.69
Carbon Monoxide	CO	1.01
Ammonia	NH ₃	0.90
Nitrous Oxide	N ₂ O	1.11
Sulfur Hexafluoride	SF ₆	1.84
Trifluoro-methane	CHF ₃	1.24
Tetrafluoro-methane	CF ₄	1.61
Hexafluoroethane	C ₂ F ₆	1.97
Octafluoropropane	C ₃ F ₈	2.30
Methane	CH ₄	0.94
Ethylene	C ₂ H ₄	1.10
Ethane	C ₂ H ₆	1.15
Propylene	C ₃ H ₆	1.22
Butane	C ₄ H ₁₀	1.48
Hexane	C ₆ H ₁₄	1.75

Table 14: Gas Scale Factor Values

In many applications, the sample GSF does not need to be altered from the default value of 1.00. However, if the sample gas has a significantly different diffusivity

compared with nitrogen (such as helium or hydrogen), the GSF should be applied. To use the GSF feature, enter the volumetric percentages of the sample gas as described below. The GSF is automatically calculated. Alternately, the GSF factor can be entered manually.

Contact your local Servomex Business Center for assistance with gases not listed above.

Select **Sample GSF** to see the first, second and third pages of the Sample GSF Menu (Figures 40, 41, and 42).

The Sample Gas Scale Factor allows the user to enter the composition of the sample gas, from which the correct GSF is calculated. Entries for additional gases can be accessed by using the ▲ or ▼ key to scroll through the list. The entries spread across three screens. Selecting **More Gases...** gives access to the additional choices, shown in Figure 44. By moving the asterisk to the appropriate line and pressing ←, the volume percentage of the sample gas can be adjusted.

Data Display ⇌ Main Menu ⇌ Setup ⇌ Sample GSF

SAMPLE GSF	
*N2:	0.00%
AR:	0.00%
H2:	0.00%
He:	0.00%
CO:	0.00%
NH3:	0.00%
More Gases...	
GSF:	1.000
Update and Quit	

Figure 43: First Page of Sample GSF Menu

After the volumetric percent of the selected gas is entered, continue to press ← until the number is no longer in reverse video. Repeat the process for the other gases in the sample gas composition. Entries to the second page of the Sample Gas Scale Factor Menu are added to entries on the first page to calculate the correct GSF.





NOTE



An error message appears if the sum of gases does not equal 100 percent. If that occurs, adjust one (or more) value(s) and press ← again.

Entries to the third page of the Sample Gas Scale Factor Menu are added to entries on the first and second pages to calculate the correct GSF. When the composition of the gas has been entered, move the asterisk to **Update and Quit** and press ←. The GSF is calculated and displayed.

If the GSF of the gas used to calibrate the system is already known, it can be entered directly. To enter the GSF directly, move the asterisk to the **GSF** line and

press . If the GSF menu is being used to reset all gases to 0 percent, just manually enter a GSF of 1.00. Using the ,  and  keys to enter the value.

```

      SAMPLE GSF
*N2O:  0.00%
SF6:  0.00%
CHF3: 0.00%
CF4:  0.00%
C2F6: 0.00%
C3F8: 0.00%
More Gases...
GSF: 1.000
Update and Quit

```

Figure 44: Second Page of Sample GSF Menu

```

      SAMPLE GSF
*CH4:  0.00%
C2H4: 0.00%
C2H6: 0.00%
C3H8: 0.00%
C4H10: 0.00%
C6H14: 0.00%
More Gases...
GSF: 1.000
Update and Quit

```

Figure 45: Third Page of Sample GSF Menu

8.7.2.1 Disclaimer

The method used to correct the calibration of the Platinum Series DF-560E 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 95 percent accurate. In addition, there is further error introduced when correcting for a "multi" component background gas. This may result in up to an additional 3 percent 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 for spanning is to obtain a certified Calibration standard that has been prepared in a background gas that models the average process sample. For example, if the average process sample background gas is composed of 50 percent hydrogen and 50 percent nitrogen, and a safer gas mixture can be used for calibrating such as 45 percent helium and 55 percent nitrogen. Both mixtures have approximately the same diffusivity of oxygen. In this case, any possible error introduced in using the

theoretically derived correction factor is eliminated. Care must still be used; however, as certified standards may also have an inaccuracy associated with them.

Questions regarding the calculation of a background gas correction factor for a specific application should be directed to your local Servomex Business Center.

8.7.3 Span GSF

The **Span GSF** (Gas Scale Factor) is used to correct for changes in the rate of oxygen diffusion when background gases other than nitrogen are present in the span calibration gas. The Span GSF menu can be entered through the Calibration Menu (Figure 21) or through the Setup Analyzer Menu (Figure 41).

In many applications, the span GSF does not need to be altered from the default value of 1.00. However, if the sample gas has a significantly different diffusivity compared with nitrogen (such as helium or hydrogen), a span gas with diffusivity similar to the sample gas increases the accuracy of measurements. In this case, the GSF should be applied. To use the GSF feature, enter the volumetric percentages of the sample gas as described below. The GSF is automatically calculated. Alternately, the GSF can be entered manually.

8.7.4 Alarms

The analyzer comes with the following six alarms as standard equipment: four oxygen alarms, one sensor temperature alarm, and one electrolyte condition alarm. These alarms can be user-controlled to activate up to four optional relays. High and low setpoints as well as deadbands are user-set.

The temperature alarm indicates an out of specification temperature condition for the sensor. The maximum temperature is limited to 45° C.

The electrolyte alarm indicates a fault condition of the electrolyte. The alarm sounds if the electrolyte level is low, or if the electrolyte is contaminated.

The Alarms screen is used to set or determine the status of alarms. **NU** (not used) indicates that an alarm is not currently assigned. When the Alarms entry is selected Figure 46 is displayed.

Data Display ⇒ Main Menu ⇒ Setup ⇒ Alarms

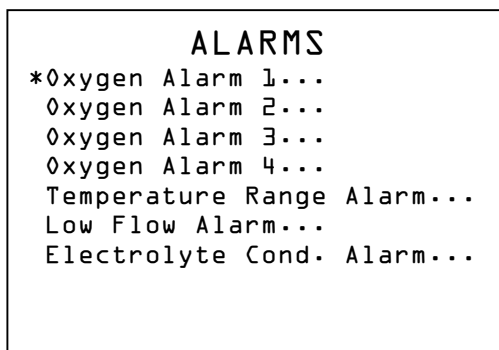


Figure 46: Alarms Screen

To select an alarm for editing, use the ▲ and ▼ keys to move the asterisk and press ↵.

8.7.4.1 Oxygen Alarms

If one of the O₂ alarms has been selected, the display is show in Figure 47.

Data Display ⇒ Main Menu ⇒ Setup ⇒ Alarms ⇒ Oxygen Alarm 1

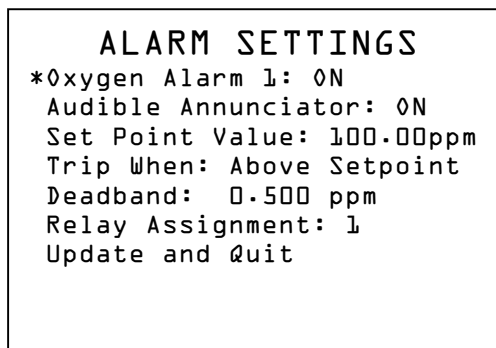


Figure 47: Settings for Oxygen Alarms

To indicate that the alarm is to be used, move the asterisk to **Oxygen Alarm 1 (2, 3 or 4):** and press ↵. The display toggles between ON and OFF.

The **SetPoint Value** refers to the limit above or below which the alarm is triggered. Using the Trip When command, the user can set whether the oxygen concentration is above or below the set point before the alarm is triggered.

Deadband refers to the value from the nominal set point that an output value must exceed before an alarm is reset. For example, for set point value of 0.050 ppm, with the Trip When set to Above Set Point, and the deadband set at 0.0050 ppm, the alarm is triggered at 0.050 ppm. The alarm continues to report until the oxygen concentration falls below 0.045 ppm. At 0.045 ppm, the alarm is reset.

With the Trip When set to Below Set Point, the alarm would trigger at 0.050 ppm and continue to report until the O₂ concentration increased to 0.055 ppm. At 0.055 ppm the alarm would reset.

NOTE



*For very low alarm levels where a **Deadband** setting of less than 1.0 ppb is desirable, be certain to set **Deadband** greater than the peak-to-peak noise of the oxygen readings. The peak-to-peak noise is determined by the Average Filter Settings.*

Relay Assignment indicates the relay to which the alarm is assigned. The options are NU (not used), 1, 2, 3 or 4. Each relay can be assigned up to seven alarms. If more than one alarm is assigned to a relay, any assigned alarm trips the relay, and the relay remains tripped until ALL alarms assigned to it are cleared.

8.7.4.2 Temperature Range Alarm

The temperature alarm is used to indicate an out of range temperature condition for the sensor. From Figure 46, selecting the **Temperature Range Alarm** will bring the display shown in Figure 48. The temperature has both a high trigger value (the alarm activates above this temperature) and a low trigger value (the alarm activates below this value). The alarm can be assigned to any optional relay(s).

Data Display ⇨ Main Menu ⇨ Setup ⇨ Alarms ⇨ Temperature Range Alarm

ALARM SETTINGS

*Temperature Alarm: OFF
Audible Annunciator: OFF
High Trip Value: 30.00 C
Low Trip Value: 15.00 C
DeadBand: 0.50 C
Relay Assignment: NU
Update and Quit

Figure 48: Temperature Range Alarm Screen

The temperature alarm is programmed in the same way as an O₂ alarm. The temperature alarm cannot be set to a value greater than 45° C; 40° C is recommended for the high trigger value.

8.7.4.3 Low Flow Alarm

The optional low flow alarm is used to indicate a low sample gas flow condition. The flow alarm is provided with a low flow switch that trips if the flow rate drops below the value listed in Table 15.

From Figure 46, selecting the **Low Flow Alarm** brings up the display shown in Figure 49. The alarm can be assigned to any optional relay(s).

Data Display ⇨ Main Menu ⇨ Setup ⇨ Alarms ⇨ Low Flow Alarm

ALARM SETTINGS

*Low Flow Alarm: OFF
Audible Annunciator: OFF
Relay Assignment: NU
Update and Quit

Figure 49: Low Flow Alarm Screen

Gas	Trip Point (scfh)
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 15: Flow Switch Trip Points

8.7.4.4 Electrolyte Condition Alarm

The electrolyte condition alarm is used to indicate an electrolyte fault condition, such as low electrolyte level or electrolyte contamination if the level is above the MIN indicator line on the sensor tank (change electrolyte.) See the Section on *Sensor Maintenance*.

From Figure 46, selecting the **Electrolyte Cond. Alarm** brings the display shown in Figure 50. The alarm can be assigned to any optional relay(s).

Data Display ⇒ Main Menu ⇒ Setup ⇒ Alarms ⇒ Electrolyte Cond. Alarm

ALARM SETTINGS

*Electrolyte Alarm: OFF

Audible Annunciator: OFF

Relay Assignment: NU

Update and Quit

Figure 50: Electrolyte Condition Alarm Screen

8.7.5 Communications Port

Select Communications Port from the Setup Analyzer Menu (Figure 41). This COMM SETUP Screen (Figure 48) is used to edit information about the external communications port.

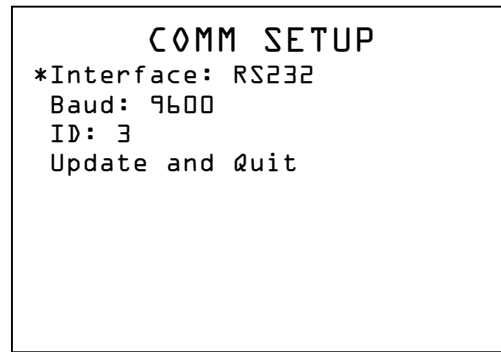



Figure 51: COMM SETUP Screen

Interface - Used to indicate if the data is in the format of RS-232C (**232**), the RS-485 (**485**) or no communication port (**OFF**). Hardware must be factory installed to support either port option.

Baud - Used to set the Baud rate for data transmission. Pressing  toggles among **19200**, **9600**, **4800**, **2400** or **1200**.

ID:xxx - Used to indicate the device to which the data is sent. The device number can be edited. **ID:** must be set even if the RS-232 mode is used.

Update and Quit - Used to accept the values set on this screen.

8.7.6 Password Protection

The Platinum Series DF-560E Oxygen Analyzer includes password protection that can be used to limit access to the menus.

The password operates on two levels, a Master Password for a higher level control of the system, and a Operator Password to allow partial access to the system. If the selected level requires a password, the display presents a password prompt.

The Password Menu is displayed in Figure 52.

NOTE




If a master password has previously been entered, the Password Menu can only be accessed by using the previously entered master password.

The **Master Password** (shown as ↑↑↑) is required for all levels marked M under **Setup** (see below).

The **Operator Password** (shown as ↓↓↓) is required for all levels marked O under **Setup**.

When **Password Required** is set **OFF**, no passwords are required. When it is set **ON**, Password protection is activated.

Setup allows access to all the DF-560E menus. Pressing  at any editable point toggles the option through M (Master password required for access), O (Master or Operator password required for access) and * (no password required for access).

Data Display ⇒ Main Menu ⇒ Setup Analyzer ⇒ Password Menu

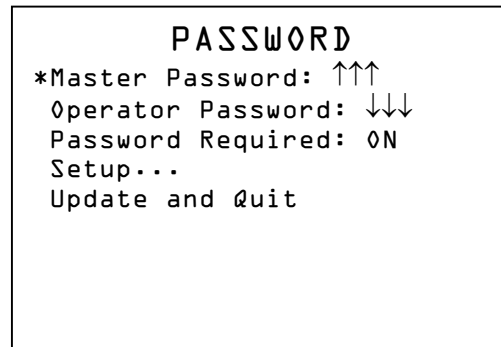










Figure 52: Password Menu Screen

NOTE



When an Analyzer is shipped from the factory, no password is installed.

To set an Operator Password or Master Password, select the desired level. A password consists of a series of one to eight keystrokes using the , , and  keys. Any combination of these keystrokes is acceptable. A typical password is , , , . After the eighth key is pressed for setting the Operator Password, the display automatically skips to the next menu line. If fewer than eight keys are used to set the Operator Password,  must be pressed to enter the password.

After the Password options have been set, select Update and Quit to save the information and return to Figure 41.

NOTE



Once the Master password has been entered on this screen, the system enters into password protection mode, as if that password had been entered after the “Main Menu” selection. Password access remains at the master level until the Main menu is re-selected and a new password is entered.

NOTE



The master password should be recorded in a secure location. If the master password is misplaced, contact your local Servomex Business Center.

The Master Password and Operator Password can be changed as desired after the present Master Password has been entered. The new password is activated by pressing ↵ when the asterisk is at **Update and Quit**.

NOTE



A Master Password must be set before an Operator Password is recognized by the analyzer.

8.7.7 Clock Setup

Access the time and date setting from the Clock selection in the Setup Analyzer Menu (Figure 41). The Clock Setup screen is shown in Figure 53. Set the time and date using the ▲, ▼ and ← keys.

Data Display ⇒ Main Menu ⇒ Setup Analyzer ⇒ Clock Setup

```
CLOCK SETUP
      16:32:25
    January 21, 1998
*Set Time: 00:00:00
  Set Date: 01Sep98
  Update and Quit
```

Figure 53: Clock Setup Screen

8.8 Data Logging/Viewing Menu

Select **Data Logging/Viewing** from the Main menu (Figure 18) for the screen shown in Figure 54. Changes can be made to the rate of data collection.

Data Display ⇒ Main Menu ⇒ Data Logging/Viewing

```
OXYGEN DATA


*Long Term Log (2 pts/hr)
-----|-----
Short Term Log (1 pt/min)
-----|-----
View Long Term Data...
View Short Term Data...
Clear ST Log
ST Mode: Continuous
Update and Quit
```

Figure 54: Data Logging/Viewing Screen







The DF-560E stores data in two buffers: a short term buffer and a long term buffer. Data is stored at a rate of one point per minute in the short term buffer for a maximum of four days, and at one point every 30 minutes in the long term buffer for a maximum of thirty days. The long term buffer is constantly acquiring data. The short term buffer can be set to acquire data in different modes which are described in the ST Mode section.





8.8.1 View Data

When viewing data in either the short or long term mode, one can adjust the axis scales or units, and zoom in on one particular portion of the graph.

The units of time (horizontal) axis are represented as date/time. If the cursor is moved to this line and  is pressed, the axis units will change to hours for the short term graph and days for the long term graph. In all cases, the data on the far right of the graph represents the most recent data.

8.8.2 Scale Data


The scale of the O2 concentration axis (vertical), is set automatically, depending upon what concentration the analyzer has been exposed to. By moving the cursor to **Scale** and pressing  one can highlight portions of the presented range and adjust it to zoom in. This is accomplished by moving the  or  arrows to the number that is highlighted by reverse video. In cases when data is near zero, a negative limit can be entered on the concentration axis by pressing  until the low limit of the axis is in reverse video and then pressing **ESC**. This action highlights the space next to the low limit. By pressing the  key, a negative sign appears. To change back to positive values, press the  key.

The bottom line on the screen allows the axis time scale to be adjusted. By pressing  at **BEG**, the downward arrow is highlighted in reverse video. By pressing the  key the arrow is moved across the page in time increments of five days for the long term graph and 12 hours for the short term graph. By pressing the  key, one can scroll back at increments of one day for the long term graph and two hours for the short term graph. Similarly, one can adjust the time scale from the opposite end by going to **END** and pressing .

NOTE



The downward arrow represents the oldest data (leftmost on the graph). The upward arrow represents the most recent data (rightmost on the graph). They can not be forced to overlap each other.

The increments of movement along the time axis were chosen to allow the user great flexibility and ease for making adjustments so that one can zoom in on certain data ranges. If an arrow is highlighted on either the **BEG** or **END** bar, it can be brought back to default position by pressing **ESC**. To leave the time adjust bar with an arrow in a moved position, hit .

8.9 Data Logging/Graphing Menu

8.9.1 Short-Term Log

Selecting **Short-Term Log** brings up a graphic display of the oxygen concentration over a maximum of four days. The user can adjust the scale, and the start and end points shown. The Start and End dates are adjusted by using the ▲ or ▼ arrows to move the arrows on the screen forward and back.

Data Display ⇌ Main Menu ⇌ Data

Logging/Graphing ⇌ View Short-Term Data

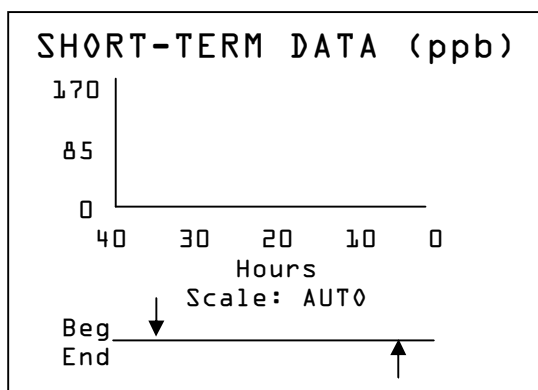
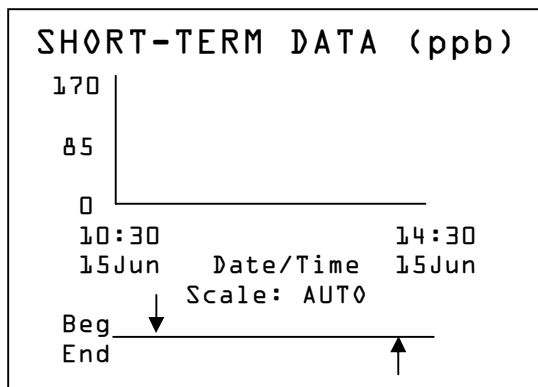


Figure 55: Short-Term Data Logs

8.9.2 Long-Term Log

Selecting **Long-Term Log** brings up a graphic display of the oxygen concentration over a maximum of thirty days. The user can adjust the scale, and the start and end points shown. The Start and End dates are adjusted using the up and down arrows to move the arrows on the screen forward and back.

Data Display ⇒ Main Menu ⇒ Data
Logging/Graphing ⇒ View Long-Term Data

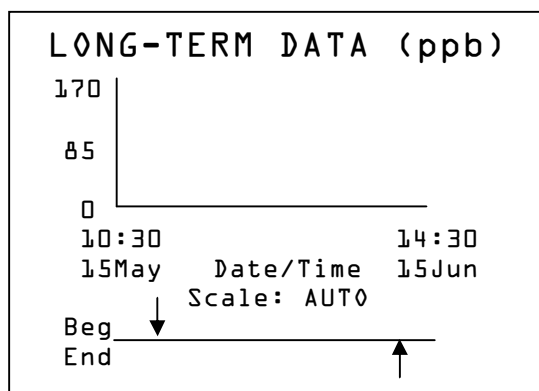


Figure 56: Long-Term Data Log

8.9.3 Clear ST Log

When Clear ST Log is selected, the system purges all information from the Short-Term Log.

8.9.4 ST Mode

The ST Mode determines how the memory stores the oxygen data. Selecting Continuous causes the system to overwrite the oldest information once the buffer is full. Run till full causes the system to stop collecting data once the buffer is full. Delayed start causes the system to refrain from data collection until the set time is reached. Data is collected until the buffer is full.

9 Service

9.1 Return Material Authorization number

If an analyzer has to be returned to the factory, the shipper will have to obtain a Return Material Authorization number from your local Servomex Business Center. See the *Shipping* section for more details.

9.2 Maintenance

9.2.1 Calibration

All DF-560E Oxygen Analyzers are calibrated with certified gas standards at the factory prior to shipment. If the analyzer is operated within its specified conditions, no initial calibration is required upon receipt from the factory.

Depending upon the nature of the application, Servomex suggests verifying the span calibration of the analyzer approximately every 12 months using a gas with a known level of oxygen. Span checks can be performed with gases in the range of 0 to 10 ppm. However, reliable standard gas mixtures are readily available in the 4-7 ppm range. Refer to page 42 for information on using calibration standards with background gases that differ from the process background gas.

The zero calibration is most important for applications requiring accuracy below 10 ppb. For use in applications that are above 10 ppb, the zero calibration is not recommended for newly installed instruments.

By far the zero calibration is the most important calibration for the Platinum DF-560E Oxygen Analyzer. From a stable zero calibration baseline, oxygen readings below 1 ppb can be made accurately. In many measurement cases, the accuracy of the oxygen reading are determined by the quality of the zero calibration. It is important to check the zero periodically and make appropriate calibration adjustments.

From an initial start-up, the analyzer may take 7 to 14 days to reach a stable zero. After achieving a stable zero baseline, the analyzer requires periodic zero checks and possibly adjustments to ensure accuracy. For applications where the process is continuously monitored, the zero check frequency guidelines in the table below should be used.

Experience with a particular application determines the optimum frequency of zero checking.

Accurate oxygen readings can be made even though the zero is not completely stabilized, such as after a start-up or after exposure to high oxygen concentrations. Simply calculate the difference in concentration between the analyzer output on

zero gas and the sample gas. This comparison should be made over a short time span to avoid errors introduced by a stabilizing zero.

Zero Check Frequency Guidelines		
Typical Reading	Maximum O ₂ Impurity	Zero Check Frequency
1.0 ppb and greater	10 ppb	Once every month
0.2 to 1.0 ppb	5 ppb	Twice per month
0 to 0.2 ppb	1 ppb	Once per week

Table 16: Zero Check Frequency

NOTE



If the Active Zero Offset feature is in use, and the “Cal Zero” message appears on the display, it is mandatory to do a zero calibration.

NOTE



If the analyzer is used in a portable mode, the optional isolation valves should be used during transport to preserve the stability of the zero calibration.

9.2.2 Storage Conditions

If the analyzer is to be stored for extended periods of time, be sure that the temperature of storage location does not exceed 50° C (122° F). Storage in direct sunlight can cause temperatures to exceed the recommended limits even though ambient temperatures may be below the maximum temperature.

Store the analyzer with the electrolyte removed from the sensor.

9.2.3 Sensor Maintenance

The analyzer does not require routine maintenance other than the addition of Replenishment Solution to the sensor. Exposure to dry gas for an extended time gradually extracts water from the sensor. The electrolyte needs to be replenished occasionally.

CAUTION



If the electrolyte level is low, add only Hummingbird Brand Replenishment Solution to the sensor. **Do not add electrolyte solution to restore the electrolyte level.** Do not overfill.

The Sensor Assembly consists of two connected chambers. The operation of the sensor is satisfactory as long as the level of electrolyte is above the minimum indicator line on the reservoir label.

One bottle of electrolyte contains 100 cc. This quantity is sufficient for satisfactory operation. It is not necessary to add Replenishment Solution.

Typically, bone dry sample gas can extract approximately 10 to 20 cc of water per month. The electrolyte level should be checked every 1 to 2 months. **If needed**, add Hummingbird Brand Replenishment Solution to bring the electrolyte level between the minimum and maximum indicator lines on the reservoir label.

Operation with sample gases with very low dew points increases the frequency of replenishing the electrolyte.

The Oxygen Analyzer is equipped with an Electrolyte Condition alarm to indicate that the electrolyte level is low. The operation of this alarm is described in the *Alarms* section.

9.2.4 Procedure for Adding Replenishment Solution to the Sensor

1. Open the front door.
2. Unscrew the gold sensor cover. Remember, the electrolyte is caustic; be careful of drips of electrolyte from the cover.
3. Slide the cover to one side. It will not fall off, nor can it be removed while the sensor is in the enclosure.
4. Add Hummingbird Brand Replenishment Solution to the electrolyte solution using the supplied squeeze bottle. Fill to the max level indicator line on the reservoir label. **Do not overfill.**
5. Replace the cover securely.
6. Close the front door.

NOTE



When an Analyzer is operating at low ppb levels, adding replenishment solution to the electrolyte may result in a temporary increase in the oxygen reading due to the presence of dissolved oxygen in the liquid and the introduction of oxygen due to agitation. More frequent additions (using smaller quantities of solution), and adding it with minimal disturbance to the electrolyte in the reservoir minimizes this effect, and potential interruptions in service.

9.2.5 Gas Purifier Maintenance

9.2.5.1 Optional Gas Purifier provides a low oxygen calibration gas (Zero Gas)

The Gas Purifier removes oxygen from typical trace level sample gas stream to provide sub-ppb oxygen concentrations for use as a zero reference gas during Analyzer calibration. Calibration systems are supplied from Servomex with a 100 ppm-hr installed standard or an optional 3000 ppm-hr purifier can be selected. Replacement purifiers can be ordered from your local Servomex Business Center.

NOTE



The gas purifier supplied by Servomex Corporation has a finite life that is greatly affected by the source gas oxygen level, flow rate, and duration of sampling. Always minimize the time sampling from the purifier and ensure that the source gas is below 50 ppb for optimal life expectancy..

9.2.5.2 Determining When to Change the Purifier

In time the active component in the purifier becomes depleted and oxygen breakthrough occurs.

There are two observable signs of breakthrough:

1. When no decrease in the oxygen reading is noted after switching to zero gas. (This assumes that the process gas contains some low level of oxygen.)
2. When the zero reference value increases after each successive zero calibration, see the *Troubleshooting* section in this manual.

The following verification test lets you know if breakthrough is occurring, and that the purifier needs to be replaced:

1. Establish a stable oxygen reading by diverting the low ppb process gas through the gas purifier at a flow rate of 1.0 scfh.
2. Increase the flow rate to 2.0 scfh. If after several minutes, there is an increase in the analyzer's reading, replace the purifier.

9.2.5.3 Preparation for Gas Purifier Removal and Installation

NOTE



*Read the installation instruction and prepare all tools and parts for a **quick** installation. The new purifier must be installed rapidly to minimize exposing the purifier to ambient oxygen levels. Tools and supplies must be readily available and all preparations to the calibration system must be done **before** removing the new purifier from its packaging.*

Removal and installation requires the following tools and parts:

- 7/8 -inch open end wrench
- 3/4 -inch open end wrench
- Two VCR-type gaskets and retainers Servomex P/N 210431

9.2.5.4 Gas Purifier Change in the Manual and Automated Calibration Systems

The analyzer should be in the process measurement mode when installing a new gas purifier on a Manual or Automated Calibration System. Unless the process gas is hazardous, process gas should be flowing during this procedure.

9.2.6 Gas Purifier Removal/Installation Procedure

The procedure to remove the gas purifier is as follows:

1. The analyzer must be in the process measurement mode by placing the valve handles in the positions as shown in Figure 57: Valve Handle Positions When Changing the Gas Purifier
2. Using the 7/8-inch wrench to backup the fittings, loosen both VCR-type end fittings on the expended purifier with the 3/4-inch wrench.
3. Fully unscrew both VCR-type fittings. If necessary, spring the tubing slightly to remove the purifier.
4. Remove the gaskets with their retainers.

9.2.6.1 The procedure to install the gas purifier is as follows:

Use reasonable precautions when installing the purifier. Contamination can adversely affect performance. Use new gaskets and retainers in the fittings.

NOTE



The gas purifier is designed to operate with low ppb (<50 ppb) inlet gas. Exposure to ambient air can seriously reduce the useful life of the purifier.

1. After the expended purifier has been removed, install new gaskets and retainers on the calibration system plumbing.
2. Open the sealed packing bag containing the new purifier.
3. Write the installation date on the gas purifier label.
4. Quickly remove both VCR-type cap nuts from the new purifier.

NOTE



When installing a gas purifier, be very careful. During installation slightly spring the plumbing apart to provide ample clearance to insert the gas purifier. The gas purifier sealing surfaces must not be dragged across the gaskets or their retainers.

5. Install the purifier with the flow direction arrow as shown in Figure 57. It may be necessary to slightly spring the calibration system plumbing to insert the gas purifier.
6. Screw the fitting nuts at both ends finger-tight.
7. Using a backup wrench at each end of the purifier. Tighten the gas nut 1/4 turn beyond finger-tight.

After installation is complete, allow low ppb process gas to flow through the gas purifier for 15 minutes to purge ambient gas from the gas lines. To accomplish the purging open the valves surrounding the purifier, and then close the process valve.

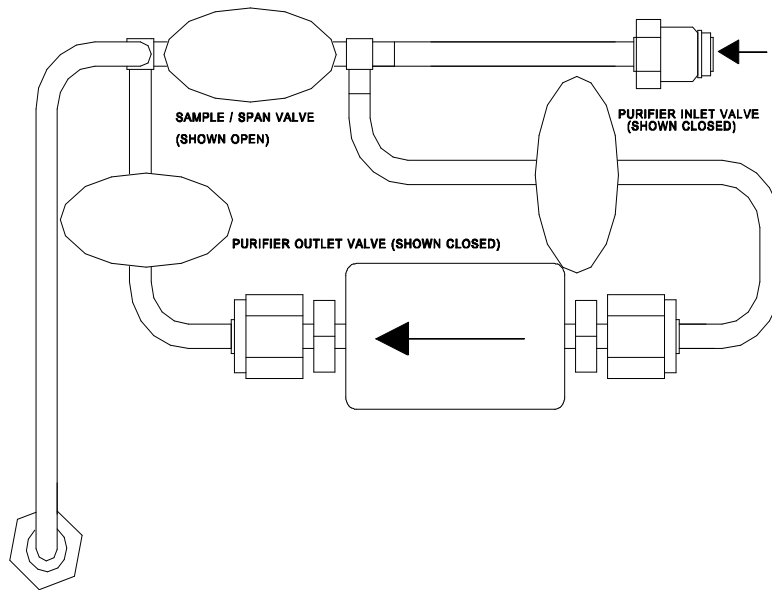


Figure 57: Valve Handle Positions When Changing the Gas Purifier

9.3 Replaceable Parts List

When ordering spare parts, please be certain to supply the model number and serial number of your analyzer.

PART NO.	PART DESCRIPTION
<u>Printed Circuit Boards</u>	
210483	PCB, Main
210775	PCB, Display
210492	PCB, Power Supply
210991	PCB, Backplane
210489	PCB, NICAD Battery (Optional)
210468	PCB, Auxiliary Electrodes Power
210785	Assembly, LCD Display
<u>Cable Harnesses And Connectors</u>	
210846	Cable, Sensor Harness
210384	Cable, Display to Backplane, 26 pin ribbon
210379	Cable, Battery PCB to Backplane (Optional)
210378	Cable, Auxiliary Power Module to Sensor & Backplane
210389	Cable, RS232 and RS485 to 9 Pin D-Sub Serial Port Adapter
210408	Power Cord, 110 VAC
210409	Power Cord, 220 VAC
210407	Terminal Block, Plug-In I/O, 8 Pin
210519	Terminal Block, Connector Key
<u>Optional Electrical / Electronic Assemblies</u>	
210437	Module, RS-232 Interface
210438	Module, RS-485 Interface (2)
210512	Relay, Alarm (SPDT, 5 Amp)
210603	Battery Pack, NiMH, Spare
210926	Probe, Temperature Sensor
<u>Hardware Items</u>	
210462	Sensor Cell
210354	0.010 Orifice
210989	0.0056 Orifice
210431	Gasket, VCR
210432	Gasket, VCR w/filter
210411	Feet, Rubber
210518	Switch, Low Flow, 0.5 scfh (Optional)
211282	Rotometer Without Valve (0-5 scfh)
210614	Rotometer Without Valve (0-2 scfh)
210523	Valve, Downstream Sensor Isolation (Optional)
210398	Cap, Sensor Tank, Gold
210418	Fitting, Outlet Bulkhead, (1/8" Comp)

210779	Assembly, Welded 1/4" VCR Male Inlet
210372	Bracket, Sensor Mounting
210531	Assembly, Handle (Portable Units Only)
<u>Optional Automated or Manual Calibration System</u>	
210510	Regulator, Pressure
210370	Bracket, Pressure Regulator
210508	Purifier, Zero Gas, 1/4" VCR Male
210507	Purifier, Zero Gas, High Capacity, 1/4" VCR Male
210414	Fitting, Elbow, Pneumatic, 1/8" NPT X 1/8" Barb
210419	Fitting, Tee, Pneumatic, 1/8" Barb
210522	Tubing, Pneumatic, 1/8" OD (4 foot length)
<u>Miscellaneous / Service Aids</u>	
ELECTROLYTE_GOLD	Hummingbird Brand Electrolyte Solution, (100 mL Bottle)
210515	Hummingbird Brand Replenishment Solution – 100ml
210514	Hummingbird Brand Replenishment Solution – 0.5l
210513	Hummingbird Brand Replenishment Solution – 1.0l
210516	Hummingbird Brand Replenishment Solution – 2.0l
210426	Fuse, 250 mA (5 X 20 mm) (Main & Cal)
210428	Fuse, 500 mA (5 X 20 mm) (Main)
210423	Fuse, 125 mA (5 X 20 mm) (Cal)
211597	Operator Manual

Table 17: Replaceable Parts List

9.4 Troubleshooting

The following *Troubleshooting Guide* helps the user resolve many of the common operational situations that occur with the analyzer. Investigate possible remedies in the listed order.

Troubleshooting Guide for the DF-560E Analyzer

Observation	Possible Remedy (see Key below)
Analyzer reads Over-Range	Y,C,Q,I
Analyzer spikes excessively when moved using portable feature	B,K,I
Analyzer output has unacceptable peak-to-peak noise	K,H,X,U,I, AC
Zero baseline gradually drifting positive	G,A,B,C,D,F,Q,H,AB,I, AC
Zero baseline gradually drifting negative	P
Zero baseline high, but stable (> 15 ppb above factory zero)	G, A, B, C, D, F, E, Q, AB,I
Very slow analyzer purge down (doesn't drop below 10 ppb in 7 days)	G, A, B, C, D, F, E, Q, H, AB,I
Zero baseline drifting up and down (exclusive of temperature)	H,Q,I
Repetitive negative spiking	J,X,Z,A,B,C,D,E,Q,H,I, AA, U, AC
Repetitive positive spiking	J,X,Z, U
O ₂ reading is drifting excessively with ambient temperature (> 0.3 ppb/C)	E,G,P,R,AB,I
Occasional positive oxygen excursions	M, U
Electrolyte Condition Alarm ON	A,N,C,D,H,I
O ₂ reading does not decrease upon switch to on-board Servomex purifier(Assumes sample gas contains some O ₂)	O
Span reading is unacceptably high (> 50% high)	T,V,S,I
Span reading is unacceptably low (> 50% low)	T,S,I,H
Unacceptably Slow Speed of Response	L,G,H,I
Analyzer indicates high temperature	AB, I
Analyzer reads a high ppm value while on zero gas	W

Key:

A	Add Hummingbird Brand Replenishment Solution if level is near or below "MIN" mark
B	Remove some electrolyte if level is near or above "MAX" mark
C	Measure applied voltages on electrode pairs:
	Sensor Electrodes (wht/yel* and wht/red/blk) 1.300 ± 0.005 VDC
	Secondary Electrodes (wht/blue* and wht/red) 2.1 ± 0.3 VDC
	Stablex Electrodes (white* and blue) 1.55 ± 0.005 VDC
	* is the common lead of the voltmeter.
D	Measure the DC currents on electrode pairs:
	Secondary Electrodes 2.0 ± 0.2 mADC (disconnect wht/red wire at reservoir terminal, and insert ammeter between wht/red wire and reservoir terminal)
	Stablex Electrodes < 13 uADC (disconnect white wire at reservoir terminal, and insert ammeter between white wire and reservoir terminal)
E	Check sensor temperature in Diagnostics Menu. It should be 1-3° C higher than current ambient temperature when the

	door is closed.
F	Check to see if AEPM board is unplugged.
G	Perform the low flow leak test: Obtain stable oxygen readings at flow = 2.0 scfh and flow = 1.0 scfh. The reading at flow = 1.0 scfh should be no more than 2 ppb higher than that at 2.0 scfh. Locate and fix any ambient leaks upstream of the analyzer. See page 38.
H	Empty electrolyte, rinse sensor thoroughly with DEIONIZED water, and refill sensor with fresh electrolyte. Restart analyzer on zero gas and allow a minimum of 4 days for the analyzer to purge down.
I	Contact your local Servomex Business Center for additional assistance with the results of the troubleshooting.
J	Adjust Filter Settings to Ultra Low LDL. Transient Rejection ON.
K	Adjust Filter Settings to ULTROX Mode, Ultra Low LDL. Transient Rejection ON.
L	Adjust Filter Settings to Weight ≥ 50 , Threshold ≥ 0.1 , RESP: Faster. See page 67.
M	Contact Servomex with your observation, you may require replacement of the upstream pressure regulator.
N	Make sure sensor cap is secure.
O	Check for purifier breakthrough. With the Servomex Corporation on-board purifier in-line, obtain stable oxygen readings at a flow rate of 2.0 scfh and at a flow rate of 0.5 scfh. The reading at 2.0 scfh should not be higher than the reading at 0.5 scfh. If it is, replace the purifier.
P	This is typical Analyzer behavior following a dry start-up. Perform a Manual or Auto (if applicable) Zero Calibration.
Q	Examine outside of sensor for evidence of electrolyte residue.
R	Quantify the drift effect with temperature changes (identify a \pm correlation). Appropriately adjust the temperature compensation set point.
S	Make sure the span background gas is properly accounted for using SPAN GSF in the menu.
T	Check the accuracy and age of the calibration reference cylinder.
U	If serial communications are being used, connect a jumper between the Serial Comms connector (J15) pin labeled "GND" with the ground stud on the rear panel of the analyzer.
V	Perform a low flow leak test while the span gas cylinder is connected. Obtain a stable reading at a flow rate of 2.0 scfh and at a flow rate of 0.5 scfh. Reading should be lower at 0.5 scfh. If not, investigate for leakage and fix.
W	Verify that the span valve is not mistakenly left open.
X	Remove any devices being driven by the analyzer output, i.e. chart recorders or Data Acquisition Systems. Also disconnect anything controlled by the analyzer alarm relays. Verify proper operation with these devices removed.
Y	Verify that a flow rate of 1.0 scfh of zero gas has been established. Allow 10 minutes time after zero gas connection to come on scale.
Z	Assure that spiking is not due to EMI (i.e. radio communications).
AA	Remove any devices downstream of the analyzer which may cause back pressure.
AB	Make sure the fan is operating and proper ventilation exists.
AC	It is possible for a sensor that is filled to, or above, the MAX line to exhibit this symptom. Remove some electrolyte from the sensor.

9.5 Shipping

If it comes necessary to return the analyzer to the factory or ship it to another location, please follow the packaging and shipping procedure below in order to prevent damage to the analyzer during shipment.

CAUTION



Do not ship the analyzer with electrolyte in the sensor - thoroughly drain and rinse sensor before shipping



9.5.1 Shipment Procedure

Note: If you are shipping the analyzer to another location, follow the procedure below. If you are returning the analyzer to the factory, first call Servomex to obtain a **Return Material Authorization number** (see complete details below), then proceed as follows:

1. Turn off the power switch. Disconnect any source of AC power from the analyzer.
2. Disconnect all external electrical connections (for instance, alarms, data output, and so forth).
3. Mark each for reattachment later.
4. Remove the sensor as described in the Adding Electrolyte Procedure on page 10. Be sure to protect the inlet fitting sealing surface by using the supplied green cap or a gasket retainer assembly.
5. Drain the electrolyte into a receptacle suitable for proper disposal.
6. Rinse the sensor with distilled or de-ionized water at least three times. Drain the water into the receptacle.
7. Securely hand tighten the cover.
8. Reinstall the sensor using the two sensor mounting screws.
9. Install the bulkhead lock nut. Cap the inlet fitting to prevent debris from entering.

Put the analyzer in its original container. Ensure that all internal components are adequately secured. It is recommended that bubble packing or similar protective material be added inside the container for added protection.

If you are returning the analyzer to the factory, contact your local Servomex Business Center to obtain a **Return Material Authorization number**. Clearly mark the Return Material Authorization number on the outside of the shipping container and on the packing list. The analyzer should be returned (freight

prepaid) to Servomex Corporation, 4 Constitution Way, Woburn, MA 01801-1087.

10 Theory of Operation

10.1 The Sensor

The sensor in the DF-560 Analyzer operates on a Coulometric principle. Oxygen in the sample gas is reduced in an electrochemical reaction that results in a measurable current flow. The use of this technique is widely recognized for its ability to provide a precise oxygen measurement. A schematic of the sensor configuration is shown in Figure 58.

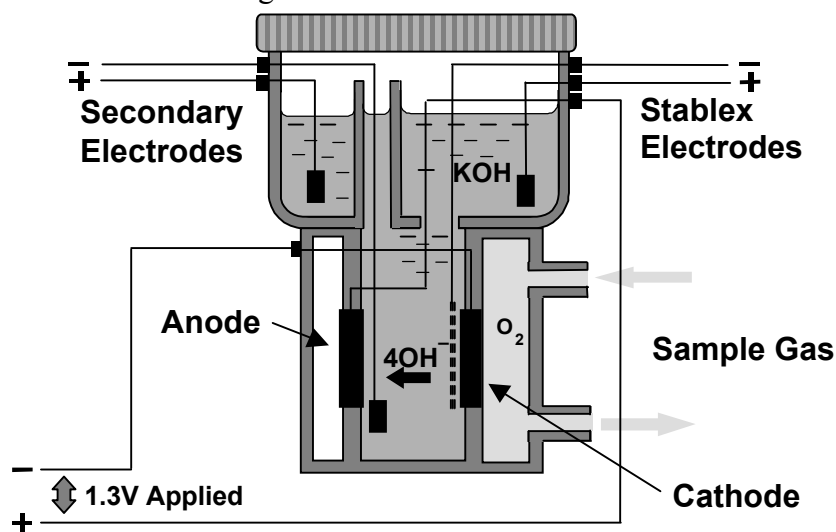


Figure 58: Schematic of DF-560E Oxygen Sensor

The sample gas is in direct contact with the sensor cathode. Oxygen in the sample gas is reduced electrochemically at the cathode to hydroxyl ions (OH^-). The electrolyte solution contains potassium hydroxide (KOH) which assists in the migration of hydroxyl ions (OH^-) to the anode where they are oxidized to complete the reaction. A voltage of approximately 1.3 VDC, applied to the sensor electrodes, drives the reduction and oxidation reactions. The current flow resulting from the reaction is proportional to the oxygen content in the sample gas. The processed signal is then displayed on the front panel in ppm or ppb units of oxygen.

10.2 The Electrolyte Conditioning System

The DF-560E Analyzer is equipped with Servomex's patented electrolyte conditioning system and is composed of two specialized electrode pairs.

The patented secondary electrode pair protects the sensing electrodes from the deleterious effects of trace impurities inevitably found in the electrolyte. The secondary electrodes attract and trap trace ionic impurities present in the electrolyte, providing a scavenging function that results in long-term zero and span stability.

The Stablex electrode pair effectively isolates the sensor cathode from the interference caused by oxygen that is dissolved in the electrolyte. The Stablex cathode, located directly in front of the sensor cathode, removes dissolved oxygen. Stablex provides an active dissolved oxygen barrier and removes the need to sparge the electrolyte. (Sparging involves bubbling pure nitrogen through the electrolyte and it causes significant levels of electrochemical interference to the oxygen measurement process)

11 Safety

11.1 Symbols and Explanations

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



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



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.

11.2 Terms and Definitions

- DANGER:** Indicates that the information is provided to alert the user to a potential personal hazard, or the potential of damage to the product.
- CAUTION:** Indicates that the information is provided to alert the user to the potential of damage to the instrument, or an incorrect result if the procedures are not followed.
- NOTE:** Indicates that the information is provided to increase the efficiency, accuracy, or reliability of the analyzer.

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 setup or operate the 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.

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.

DANGER



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

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

CAUTION



Over-pressurizing the sensor can result in permanent damage to the sensor. Limit the backpressure to the analyzer to ± 1 psig.

*Be sure the downstream isolation valve (if so equipped) is toggled open **before** gas flow is started.*

CAUTION



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

EMI DISCLAIMER



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

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

11.3 Electrolyte Solution Material Safety Data Sheet (MSDS)

1. IDENTIFICATION OF THE SUBSTANCE

Trade Name	Electrolyte Solution, <i>E-lectrolyte Gold</i> , <i>E-lectrolyte Blue</i> , <i>E-lectrolyte Black</i> , DF-E05, DF-E06, DF-E07, DF-E09
Manufacturer	Servomex 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. Toxicological 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.
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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 depleters

Does not contain any Class 2 Ozone depleters

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

Canada – DSL/ NDSL

CAS# 1310-58-3

1

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.

11.4 Replenishment Solution Material Safety Data Sheet (MSDS)

1. IDENTIFICATION OF THE SUBSTANCE

Trade Name Replenishment Solution, RS-A

Manufacturer Servomex 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	H ₂ O containing trace salts
Physical State	Colorless, odorless liquid
pH	6.0-8.0
Solubility	Complete (100%)
Boiling Point	100 ⁰ C
Melting Point	0 ⁰ C
Flash Point	Not applicable
Flammability	Not flammable
Explosion Limits	Not applicable
Specific Gravity	1.00
Vapor Pressure	17.5 mm Hg @ 20 ⁰ C

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. Toxicological Information

Toxicity (water)

CAS# 7732-18-5: Oral, rat: LD50 >90 mL/kg

Carcinogen Status

Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA

12. Ecological Information

Mobility

Completely soluble in water

Degradability

Not applicable.

Accumulation

Not applicable.

Ecotoxicity

Applicable.

13. Disposal Considerations

Waste Disposal

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

14. Transportation Information

Not regulated.

15. Regulatory Information

16. Other Information

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

MSDS Creation Date: 09/30/94

MSDS Revised: December 7, 2006

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

11.5 Material Safety Data Sheet (MSDS) for Gas Purifier Packing



The Source for Gas Purification

*AERONEX, INC. • 6975 Flanders Drive • San Diego, CA 92121 TEL 858
452 0124 • FAX 858 452 0229*

Servomex Part Number: 16233870

Patent: U.S. 6,059,859

SECTION 1 - PRODUCT IDENTIFICATION

Trade name and Synonyms: Hydrogen (H) Gas Purifier media

Chemical name: Titanium Dioxide and Nickel

Formula: TiO₂, Ni, NiO

Product CAS No.: Chemical mixture

Product use: Hydrogen Purifier, removes oxygen, moisture and other molecular impurities from H₂ gas and Hydrogen-Inert gas mixtures.

SECTION 2 – COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous components in the solid mixture inside the purifier body

<u>COMPONENT</u>	<u>CAS No.</u>	<u>%</u>	<u>Shipping Hazard</u>
Titanium Dioxide	13463-67-7	20-50	No
Sodium Oxide	1313-59-3	1-3	No
Graphite, Synthetic	7782-42-5	1-3	No
Nickel	7440-02-0	10-30	Yes
Nickel Oxide	1313-99-1	10-30	Yes
Silica, Amorphous	7631-86-9	10-20	No
Magnesium Oxide	1309-48-4	10-20	No

Note: See Section 8 for Exposure Limits and Section 11 for Toxicological Information

SECTION 3 – HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:

Black extrusions and Gray Pellets

Odorless

Flash Point: Not Determined

Suspected Cancer Hazard: Risk of cancer depends on route, duration and level of exposure.

Causes eye, skin and respiratory tract irritation. May cause allergic skin and respiratory reaction. Harmful if swallowed. May cause gastrointestinal irritation, headache, nausea, vomiting and diarrhea.

This product will remain stable when housed in the purifier body. When nickel is exposed air at temperatures below 175°F (79°C) will remain stable. At temperature above 175°F (79°C), oxidation will occur. Nickel when exposed to excess air and moisture, the oxidation process may generate temperatures high enough to cause combustion. Exposing this product to atmospheres containing hydrogen and temperatures above 300°F (150°C) will render this product pyrophoric. Exposure of the pyrophoric product to air at room temperature will cause ignition.

Routes of Entry:

Eyes? YES Skin? YES Inhalation? YES Ingestion? YES

Potential Health Effects:

EYE CONTACT causes irritation.

SKIN CONTACT causes irritation and may cause sensitization or allergic reactions which may be accentuated by heat and humidity. The symptoms of this NICKEL dermatitis, referred to as "nickel itch," may include an itching or burning sensation followed by the eruption of sores.

INHALATION causes upper respiratory irritation. Individuals hypersensitive to NICKEL may develop asthma, bronchitis, shortness of breath or wheezing. Prolonged or repeated overexposure to TITANIUM may cause lung damage.

INGESTION is harmful. May cause nausea, abdominal discomfort, vomiting and diarrhea.

Carcinogenicity: Nickel

NTP? YES IARC? YES OSHA? NO

NICKEL has been classified by both the International Agency for Research on Cancer (IARC) and the National Toxicology Program (NTP) as having sufficient evidence of carcinogenicity in experimental animals. In addition, IARC has determined that there is inadequate evidence of carcinogenicity in humans (Class 2B). The American Conference of Governmental Industrial Hygienists (ACGIH) has categorized nickel as A5 (not suspected as a human carcinogen). In evaluating NICKEL COMPOUNDS, the International Agency for Research on Cancer (IARC) has determined that there is sufficient evidence of carcinogenicity to humans (Group 1). The National Toxicology Program (NTP) lists only certain nickel compounds as substances which may reasonably be anticipated to be carcinogenic. This product contains one of those nickel compounds specifically identified by NTP.

Carcinogenicity: Titanium Dioxide

NTP? NO IARC? NO OSHA? NO

Chronic Health Hazards:

Refer to Potential Health Effects and Carcinogenicity.

Medical Conditions Generally Aggravated by Exposure:

May aggravate existing medical conditions such as allergies, dermatitis, asthma, bronchitis or any other respiratory ailment.

NOTE: See Section 8 for Exposure Limits, Section 11 for Toxicological Information and Section 12 for Ecological Information.

SECTION 4 – FIRST AID MEASURES

In the unlikely event that the purifier media is liberated from the purifier body these health hazards may arise from inhalation, ingestion, and or/contact with the skin and/or eyes

Eye Contact: Immediately flush eyes with plenty of water for at least 15min. Call a physician.

Skin Contact: Immediately wash skin with soap and plenty of water. If irritation persists, call a physician.

Inhalation: Remove to fresh air. If breathing is difficult, oxygen should be administered by qualified personnel. Call a physician.

Ingestion: Get medical attention! If vomiting occurs, keep head lower than hips to prevent aspiration.

SECTION 5 – FIRE-FIGHTING MEASURES

Flash Point: Not Determined

Auto-Ignition: Not Applicable

LEL: Not Applicable

UEL: Not Applicable

NFPA Hazard Classification: Nickel

Health: 1 Flammable: 2 Reactivity: 0

HMIS Hazard Classification: Nickel

Health: 2* Flammable: 2 Reactivity: 0

* Indicates the possibility of chronic health effects. See Chronic Health Hazards in Section 3 for more information.

NFPA Hazard Classification: Titanium Dioxide

Health: 0 Flammable: 0 Reactivity: 0

HMIS Hazard Classification: Titanium Dioxide

Health: 1* Flammable: 0 Reactivity: 0

* Indicates the possibility of chronic health effects. See Chronic Health Hazards in Section 3 for more information

Extinguishing Media: Use water, carbon dioxide or foam.

Special Fire-Fighting Procedures: Wear NIOSH/MSHA approved positive-pressure self-contained breathing apparatus and protective clothing as specified in 29 CFR 1910.156.

Unusual Fire and Explosion Hazards: This product will remain stable when housed in the purifier body. When nickel is exposed air at temperatures below 175°F (79°C) will remain stable. At temperature above 175°F (79°C), oxidation will occur. Nickel when exposed to excess air and moisture, the oxidation process may generate temperatures high enough to cause combustion. Exposing this product to atmospheres containing hydrogen and temperatures above 300°F (150°C) will render this product pyrophoric. Exposure of the pyrophoric product to air at room temperature will cause ignition.

SECTION 6 – ACCIDENTAL RELEASE MEASURES

Allow media to cool before taking any action.

Contain spillage and scoop up or vacuum. Avoid dusting. Notification of the National Response Center (800-424-8802) may be required. Refer to EPA, DOT and applicable state and local regulations for current response information.

It is recommended that each user establish a spill prevention, control and countermeasure plan (SPCC). Such plan should include procedures applicable to proper storage, control and clean up of spills, including reuse or disposal as appropriate (see Section 13: Disposal Consideration).

****Note**** In the unlikely event that the purifier media is liberated from the purifier body the above procedures should be followed. Additionally, proper exposure controls and personal protection equipment should be used (see Section 8: Exposure Control/Personal Protection), and disposal of the material should be in accordance with Section 13: Disposal Considerations.

SECTION 7 - HANDLING AND STORAGE

****Note**** In the unlikely event that the purifier media is liberated from the purifier body the following procedures should be observed.

Notify Safety personnel. **Allow media to cool before taking any action.** Wash thoroughly after handling media. Keep container closed. Avoid breathing dust. Keep away from sunlight, heat or fire. Store in cool, dry location away from incompatible materials

SECTION 8 – EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Limits Ingredients:	PEL-OSHA	TLV-ACGIH
Titanium Dioxide CAS NO.: 13463-67-7	10mg/m ³ (Total Dust) 5mg/m ³ (Respirable Dust)	10mg/m ³ (Total Dust)
Sodium Oxide CAS NO.: 1313-59-3	Not Established	Not Established
Graphite, Synthetic CAS NO.: 7782-42-5	2.5mg/m ³ (Respirable Dust)	2mg/m ³ (Respirable Dust)
Nickel CAS NO.: 7440-02-0	1 mg/m ³	1. 5 mg/m ³ (Inhalable Fraction)
Nickel Oxide CAS NO.: 1313-99-1	1 mg/m ³ (as Ni, insoluble compounds)	0.2 mg/m ³ (as Ni, Inhalable fraction)
Silica, Amorphous CAS NO.: 7631-86-9	6mg/m ³	10mg/m ³
Magnesium Oxide CAS NO.: 1309-48-4	10mg/m ³ (Fume, total dust) 5mg/m ³ (Fume respirable fraction)	10mg/m ³ (Fume)

Unless otherwise noted, all values are reported as 8-hour Time-Weighted Averages (TWAs) and total dust (particulates only). All ACGIH TLVs refer to the 1998 Standards. All OSHA PELs refer to 29 CFR Part 1910 Air Contaminants: Final Rule. January 19, 1989.

Respiratory Protection: A NIOSH/MSHA-approved respirator recommended for dust if media is liberated from purifier body.

Ventilation: General; local exhaust ventilation as necessary to control any air contaminants to within their PELs or TEVs during exposure to media

Protective Equipment: Chemical goggles as needed to prevent irritation. Rubber or neoprene gloves. Body protection as necessary to prevent skin contact.

SECTION 9 – PHYSICAL AND CHEMICAL PROPERTIES

Appearance: Black extrusions and Grey Pellets

Odor: Odorless

Specific Gravity (H₂O=1): 0.9 g/cc (Bulk Density)

Melting Point: Not Determined

Vapor Pressure (mm Hg): Not Applicable

Vapor Density (Air=1): Not Applicable

Evaporation Rate: Not Applicable

% Solubility in Water: Insoluble

pH: Not Determined

SECTION 10 – STABILITY AND REACTIVITY

Stability: Generally considered stable housed inside purifier body or when properly installed in Inert Gas Systems. Purifier may heat up if used with oxygen or corrosive gases.

Avoid: Heat and humidity.

Incompatibility (Materials to Avoid): Air, strong acids, strong oxidizing agents and mineral acids.

Hazardous Decomposition or By-Products: Toxic emissions may be released in a fire situation. Mineral acids will react with the nickel content to liberate flammable hydrogen gas. Thermal decomposition may produce oxides of Titanium.

Polymerization: Polymerization is not expected to occur.

SECTION 11- TOXICOLOGICAL INFORMATION

Chemical Name	%Wt.	LD50	LC50
Titanium Dioxide CAS NO.: 13463-67-7	20-50	5000mg/kg Rat, Oral	Not Available
Sodium Oxide CAS NO.: 1313-59-3	1-3	Not Available	Not Available
Graphite, Synthetic CAS NO.: 7782-42-5	1-3	Not Available	Not Available
Nickel CAS NO.: 7440-02-0	10-30	Not Available	Not Available
Nickel Oxide CAS NO.: 1313-99-1	10-30	50mg/kg Mouse, subcutaneous	Not Available
Silica, Amorphous CAS NO.: 7631-86-9	10-20	3160mg/kg Rat, Oral	Not Available
Magnesium Oxide CAS NO.: 1309-48-4	10-20	Not Available	Not Available

NOTE: See Section 3, 8 and 12 for additional information.

SECTION 12 – ECOLOGICAL INFORMATION

Ecotoxicity: No data available.

Environmental Fate: No data available.

SECTION 13 – DISPOSAL CONSIDERATIONS

US EPA Waste Number: Not Regulated

Federal, State, and Local disposal laws and regulations will determine the proper waste disposal/recycling/reclamation procedure. All waste materials should be reviewed to determine the applicable hazards (testing may be necessary). Disposal requirements are dependent on the hazard classification and will vary by location and the type of disposal selected.

****NOTE**** Chemical additions, processing or otherwise altering this material may make the waste management information presented above incomplete, inaccurate or otherwise inappropriate.

As local regulations may vary; all waste must be disposed/recycled/reclaimed in accordance with Federal, State, and Local environmental control regulations.

SECTION 14 – TRANSPORT INFORMATION

INTERNATIONAL

UN Number: UN3190

UNITED STATES

EPA Waste Number: Not Regulated

DOT Classification: 4.2 Spontaneously combustible material

DOT Proper Shipping Name: Self Heating Solid, Inorganic, N.O.S. (Nickel mixture)

Packing Group: II

CANADA

PIN Number: UN3190

TDG Class: 4.2 Spontaneously combustible material

EC DGL: Spontaneously combustible substance

SECTION 15 – REGULATORY INFORMATION

US FEDERAL REGULATIONS

TSCA: IN TSCA

SARA 311 and 312 Hazard Categories

Immediate (Acute) Health Hazard: Yes

Delayed (Chronic) Health Hazard: Yes

Fire Hazard: Yes

Reactivity Hazard: No

Sudden Release of Pressure: No

SARA Section 313 Notification:

This product contains a toxic chemical (or chemicals) subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

CHEMICAL NAME	CAS Number	%Wt.
Nickel	7440-02-0	10-30
Nickel Oxide	1313-99-1	10-30

OZONE DEPLETING SUBSTANCES (ODS): This product neither contains nor is manufactured with an ozone depleting substance subject to the labeling requirements of the Clean Air Act Amendments 1990 and 40 CFR Part 82.

VOLATILE ORGANIC COMPOUNDS (VOC): None

US STATE REGULATIONS

CALIFORNIA: The State of California has a regulation (Proposition 65) which identifies specific chemicals known to the State of California to cause cancer or birth defects. Proposition 65 requires a disclosure for products sold within the State of California containing an identified chemical. The following information is required by the State of California for this product:

***WARNING:** This product contains chemicals known to the State of California to cause cancer.

Components: Nickel and Nickel Oxide

VOLATILE ORGANIC COMPOUND (CARB): Not determined

CANADIAN REGULATIONS

DSL/NDL: DSL

WHMIS Classification: Class B Division 6
Class D Division 2 Subdivision A
Class D Division 2 Subdivision B

EUROPEAN REGULATIONS

EINECS: Yes

OTHER REGULATIONS

MITI (Japan): Yes

AICS (AUSTRALIA): Yes

SECTION 16 – OTHER INFORMATION

Prepared by: Aeronex Inc., Research and Development Department

Phone Number: See Header

All information within this document is believed to be accurate and current. Aeronex does not guarantee the information to be all-inclusive and shall not be held accountable for any damage caused from this product.

12 Warranty

Servomex Corporation 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.

Servomex's Sensor Warranty offers extended protection such that, if any Sensor of a Servomex Oxygen Analyzer fails under normal use within five years from the date of purchase, 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 no additional cost. The original warranty expiration date is not extended by this action.

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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