GPR-18MS / 18 / 28
Explosion Proof
Oxygen Analyzer

Owner's Manual

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Table of Contents

The appendices referenced above are an integral part of the documentation, installation and maintenance of this oxygen analyzer. It is important that users review these documents before proceeding.

1 Introduction

Your new Explosion Proof Oxygen Analyzer is a precision device designed to give you years of use. It has been designed to incorporate several types of oxygen sensors enabling user's to select an analysis range appropriate for their application with the confidence of an ATEX certified analyzer system. Analysis ranges available with selected oxygen sensors:

GPR-18MS analyzes oxygen levels from 10 ppb (parts per billion) to 1,000 ppm (parts per million) and features the new "Pico-Ion" Sensor Technology developed exclusively by Advanced Instruments Inc.

GPR-18 analyzes oxygen levels from 100 ppb to 1% (10,000 ppm) and features the advanced galvanic type ppm oxygen sensor.

GPR-28 analyzes oxygen levels from 0.05% (500 ppm) to 95% and features the advanced galvanic type percent oxygen sensor.

Specifications of the individual analyzers and discussion of the sensors can be found in sections 4 and 5 .

These analyzers is designed to measure the oxygen concentration in inert gases, gaseous hydrocarbons, hydrogen and a variety of gas mixtures. The galvanic sensors can be configured for measuring 0-100% oxygen concentration in CO2 and acid gases. To obtain maximum performance from your new oxygen analyzer, please read and follow the guidelines provided in this Owner's Manual.

Every effort has been made to select the most reliable state of the art materials and components; and, to design the analyzer for superior performance and minimal cost of ownership. This analyzer was tested thoroughly by the manufacturer prior to shipment for best performance.

However, modern electronic devices do require service from time to time. The warranty included herein plus a staff of trained professional technicians to quickly service your analyzer is your assurance that we stand behind every analyzer sold.

The serial number of this analyzer may be found on the inside the analyzer. You should note the serial number in the space provided and retains this Owner's Manual as a permanent record of your purchase, for future reference and for warranty considerations.

Serial Number: _______________________

Advanced Instruments Inc. appreciates your business and pledges to make every effort to maintain the highest possible quality standards with respect to product design, manufacturing and service.

2 Quality Control Certification

Date:	Customer:	Order No.:	Pass
Model:	( ) GPR-18MS Explosion Proof ppm O2 Analyzer	S/N ______________________	
	( ) GPR-18 Explosion Proof ppm O2 Analyzer	S/N ______________________	
	( ) GPR-28 Explosion Proof O2 Analyzer	S/N ______________________	_______
Sensor:	( ) GPR-12-2000MS ppm Oxygen Sensor	S/N ______________________	
	( ) GPR or ( ) XLT-12-333 ppm Oxygen Sensor	S/N ______________________	
	( ) GPR-11-32 or ( ) XLT-11-24 Oxygen Sensor	S/N ______________________	_______
Approvals:	EN 61326 Minimum Immunity Test EN 61010-1:2001 Low Voltage Directive		_______
Accessories:	Owner's Manual		_______
	5/16 Open end wrench		_______
Configuration:	A-1107-M PCB Assembly Main / Display		_______
	A-1106-M PCB Assembly Power / Relay		_______
	Range: ( ) GPR-18MS 0-1 ppm, 0-10 ppm, 0-100 ppm, 0-1000 ppm ( ) GPR-18 0-10 ppm, 0-100 ppm, 0-1000 ppm, 0-25% (air calibration only) ( ) GPR-28 0-1%, 0-5%, 0-10%, 0-25%		_______
	Wetted parts: stainless steel ( ) Manual flow and bypass valves, flow indicator ( ) Manual flow meter (with integral metering valve)		_______
	Standard power: ( ) 100/110 VAC or ( ) 220/240 VAC		_______
	Heater system: ( ) 100/110 VAC or ( ) 220/240 VAC; controller set at 85° F		_______
			_______
Test – Electronics:	LED indicators: range, alarms		_______
	4-20mA offset		_______
	Alarm relays activate/deactivate with changes in O_2 concentration		_______
	Analog signal output 0-1V and 4-20mA		_______
	Range ID contacts (optional)		_______
Test – Gas:	Baseline drift on zero gas < ± 2% F.S. over 24 hour period		_______
	Noise level < ± 1.0% F.S.		_______
	Span adjustment within 10-50% F.S.		_______
	Peak to peak over / under shoot < 0.5% F.S.		_______
Final:	Overall inspection for physical defects; place SAMPLE/BYPASS valve in BYPASS position		_______
Options:			_______
Notes:			_______

Declaration of Conformity

Directives:	2006/95/EC Low Voltage 2004/108/EC Electromagnetic Compatibility
Standards:	EN 61010-1 Safety EN 61326-1 Minimum Immunity Test ISO 9001:2000
Compliance:	All applicable standards

Products:

General purpose online oxygen analyzers:

GPR-1600UHP series	
GPR-1600MS series	GPR-16MS series
GPR-1600 series	GPR-16 series
GPR-1900 series	GPR-19 series
GPR-2600 series	GPR-26 series
GPR-2900 series	GPR-29 series
GPR-3100 series	GPR-31 series
GPR-1500 series	GPR-15 series
GPR-2500 series	GPR-25 series
GPR-1500AIS	GPR-15A series
GPR-1800AIS	GPR-18MS/18/28
GPR-2500AIS	GPR-980 series
GPR-2800AIS	GPR-35

General purpose portable oxygen analyzers:

GPR-1200MS series	GPR-12MS series
GPR-1200 series	GPR-12 series
GPR-1100 series	GPR-11 series
GPR-1000	
GPR-2000 series	GPR-20 series
GPR-3000 series	GPR-30 series
GPR-3500MO	GPR-35MO

Intended Use:	Analyze the oxygen concentration in a gas mixture in a non-explosive atmosphere.
Manufacturer:	Analytical Industries Inc. 2855 Metropolitan Place Pomona, California 91767 USA Tel: 909-392-6900, Fax: 909-392-3665 e-mail: info@aii1.com
Date:	September 15, 2001
Place:	Pomona, California 91767 USA

We hereby declare the above product meets the provisions of the directives and standards specified. All supporting documents are retained on the premises of the manufacturer and the notified body above.

Patrick Prindible
Vice President & QA Manager

3 General Safety & Installation

Safety

This section summarizes the basic precautions applicable to all analyzers. Additional precautions specific to individual analyzer are contained in the following sections of this manual. To operate the analyzer safely and obtain maximum performance follow the basic guidelines outlined in this Owner's Manual.

Caution: This symbol is used throughout the Owner's Manual to **Caution** and alert the user to recommended safety and/or operating guidelines.

Danger: This symbol is used throughout the Owner's Manual to identify sources of immediate **Danger** such as the presence of hazardous voltages.

Read Instructions: Before operating the analyzer read the instructions. **Retain Instructions:** The safety precautions and operating instructions found in the Owner's Manual should be retained for future reference. **Heed Warnings Follow Instructions:** Follow all warnings on the analyzer, accessories (if any) and in this Owner's Manual. Observe all precautions and operating instructions. Failure to do so may result in personal injury or damage to the analyzer.

Heat: Situate and store the analyzer away from sources of heat.

Liquid and Object Entry: The analyzer should not be immersed in any liquid. Care should be taken so that liquids are not spilled into and objects do not fall into the inside of the analyzer.

Handling: Do not use force when using the switches and knobs. Before moving your analyzer be sure to disconnect the wiring/power cord and any cables connected to the output terminals located on the analyzer.

Maintenance

Serviceability: Except for replacing the oxygen sensor, there are no parts inside the analyzer for the operator to service.
Only trained personnel with the authorization of their supervisor should conduct maintenance.

Oxygen Sensor: DO NOT open the sensor. The sensor contains a corrosive liquid electrolyte that could be harmful if touched or ingested, refer to the Material Safety Data Sheet contained in this Owner's Manual. Avoid contact with any liquid or crystal type powder in or around the sensor or sensor housing, as either could be a form of electrolyte. Leaking sensors should be disposed of in accordance with local regulations.

Troubleshooting: Consult the guidelines in section 8 for advice on the common operating errors before concluding that your analyzer is faulty. Do not attempt to service the analyzer beyond those means described in this Owner's Manual. Do not attempt to make repairs by yourself as this will void the warranty, as detailed by section 9, and may result in electrical shock, injury or damage. All other servicing should be referred to qualified service personnel.

Cleaning: The analyzer should be cleaned only as recommended by the manufacturer. Wipe off dust and dirt from the outside of the unit with a soft damp cloth then dry immediately. Do not use solvents or chemicals. **Nonuse Periods:** Disconnect the power when the analyzer is left unused for a long period of time.

Installation

Gas Sample Stream: Ensure the gas stream composition of the application is consistent with the specifications and review the application conditions before initiating the installation. Consult the factory to ensure the sample is suitable for analysis.
Contaminant Gases: A gas scrubber and flow indicator with integral metering valve are required upstream of the of the analyzer to remove interfering gases such as oxides of sulfur and nitrogen or hydrogen sulfide that can produce false readings, reduce the expected life of the sensor and void the sensor warranty if not identified at time of order placement. Installation of a suitable scrubber is required to remove the contaminant from the sample gas to prevent erroneous analysis readings and damage to the sensor or optional components. Consult the factory for recommendations concerning the proper selection and installation of components.

Expected Sensor Life: With reference to the publish specification located in section 4 of this manual, the expected life of all oxygen sensors is predicated on oxygen concentration (< 1000 ppm or air), temperature (77°F/25°C) and pressure (1 atmosphere) in "normal" applications. As a rule of thumb sensor life is inversely proportional to changes in the parameters. Deviations are outside the specifications and will affect the life of the sensor, with respect to Pico-Ion sensors avoid exposure to oxygen levels above 1000 ppm. Failure to do will result in damage to the sensor.

Accuracy & Calibration: Refer to section 5 Operation, Calibration. Analyzers equipped with Pico-Ion oxygen sensors have a maximum range of 0-1000 ppm reflecting its high signal output capability, DO NOT CALIBRATE THE GPR-18MS WITH AIR.

Materials: Assemble the necessary zero, purge and span gases and optional components such as valves, coalescing or particulate filters, and, pumps as dictated by the application; stainless steel tubing is essential for maintaining the integrity of the gas stream for ppm and percentage range (above or below ambient air) analysis; hardware for mounting.

Operating Temperature: The sample must be sufficiently cooled before it enters the analyzer and any optional components. A coiled 10 foot length of ¼" stainless steel tubing is sufficient for cooling sample gases as high as 1,800ºF to ambient. The maximum operating temperature is 45º C on an intermittent basis unless the user is willing to accept a reduction in expected sensor life – refer to analyzer specification - where expected sensor life is specified at an oxygen concentration less than 1000 ppm oxygen for ppm analyzers and air (20.9% oxygen) for percent analyzers, but in all instances at 25°C and 1 atmosphere of pressure. Expected sensor varies inversely with changes in these parameters.

Pressure & Flow

All electrochemical oxygen sensors respond to partial pressure changes in oxygen. The sensors are equally capable of analyzing the oxygen content of a flowing sample gas stream or monitoring the oxygen concentration in ambient air (such as a confined space such in a control room or an open area such as a landfill or bio-pond). **The following is applicable to analyzers equipped with galvanic oxygen sensors, GPR-18 and GPR-28. With respect to analyzers equipped with Pico-Ion oxygen sensors, GPR-18MS refer to the analyzer's specifications in section 4.**

Analyzers designed for in-situ ambient or area monitoring have no real inlet and vent pressure because the sensor is exposed directly to the sample gas and intended to operate at atmospheric pressure, however, slightly positive pressure has minimal effect on accuracy.

Inlet Pressure: Analyzers designed for flowing samples under positive pressure or pump vacuum (for samples at atmospheric or slightly negative atmospheres) that does not exceed 14" water column are equipped with bulkhead tube fitting connections on the side of the unit (unless otherwise indicated, either fitting can serve as inlet or vent) and are intended to operate at positive pressure regulated to between 5-30 psig although the rating of the fitting itself is considerably higher. **Caution:** If the analyzer is equipped with an optional H2S scrubber, inlet pressure must not exceed 30 psig.

Outlet Pressure: In positive pressure applications the vent pressure must be less than the inlet, preferably atmospheric.

Sample systems and flowing gas samples are generally required for applications involving oxygen measurements at a pressure other than ambient air. In these situations, the use of stainless steel tubing and fittings is critical to maintaining the integrity of the gas stream to be sampled and the inlet pressure must always be higher than the pressure at the outlet vent which is normally at atmospheric pressure. Flow Through Configuration: The sensor is exposed to sample gas that must flow or be drawn through metal tubing inside the analyzer. The internal sample system includes 1/8" compression inlet and vent fittings, a stainless steel sensor housing with an o-ring seal to prevent the leakage of air and stainless steel tubing.

Flow rates of 1-5 SCFH cause no appreciable change in the oxygen reading. However, flow rates above 5 SCFH generate backpressure and erroneous oxygen readings because the diameter of the integral tubing cannot evacuate the sample gas at the higher flow rate. The direction the sample gas flows is not important, thus either tube fitting can serve as the inlet or vent – just not simultaneously.

A flow indicator with an integral metering valve upstream of the sensor is recommended as a means of controlling the flow rate of the sample gas. A flow rate of 2 SCFH or 1 liter per minute is recommended for optimum performance.

Application Pressure - Positive: A flow indicator with integral metering valve positioned upstream of the sensor is recommended for controlling the sample flow rate between 1-5 SCFH. To reduce the possibility of leakage for low ppm measurements, position a metering needle valve upstream of the sensor to control the flow rate and position a flow indicator downstream of the sensor. If necessary, a pressure regulator (with a metallic diaphragm is recommended for optimum accuracy, the use of diaphragms of more permeable materials may result in erroneous readings) upstream of the flow control valve should be used to regulate the inlet pressure between 5-30 psig.

Caution: If the analyzer is equipped with a H2S scrubber as part of an optional sample conditioning system, inlet pressure must not exceed 30 psig.

Application Pressure - Atmospheric or Slightly Negative: For accurate ppm range oxygen measurements, an optional external sampling pump should be positioned downstream of the sensor to draw the sample from the process, by the sensor and out to atmosphere. A flow meter is generally not necessary to obtain the recommended flow rate with most sampling pumps.

Caution: If the analyzer is equipped with an optional flow indicator with integral metering valve or a metering flow control valve upstream of the sensor - open the metering valve completely to avoid drawing a vacuum on the sensor and placing an undue burden on the pump. If pump loading is a consideration, a second throttle valve on the pump's inlet side may be necessary to provide a bypass path so the sample flow rate is within the above parameters.

Recommendations to avoid erroneous oxygen readings and damaging the sensor:

- Do not place your finger over the vent (it pressurizes the sensor) to test the flow indicator when gas is flowing to the sensor. Removing your finger (the restriction) generates a vacuum on the sensor and may damage the sensor (thus voiding the sensor warranty).
- Assure there are no restrictions in the sample or vent lines
- Avoid drawing a vacuum that exceeds 14" of water column pressure – unless done gradually
- Avoid excessive flow rates above 5 SCFH which generate backpressure on the sensor.
- Avoid sudden releases of backpressure that can severely damage the sensor.
- Avoid the collection of liquids or particulates on the sensor, <u>they block the diffusion of oxygen into the sensor</u> - wipe away.
- If the analyzer is equipped with an optional integral sampling pump (positioned downstream of the sensor) and a flow control metering valve (positioned upstream of the sensor), completely open the flow control metering valve to avoid drawing a vacuum on the sensor and placing an undue burden on the pump.

Moisture & Particulates: Installation of a suitable coalescing or particulate filter is required to remove condensation, moisture and/or particulates from the sample gas to prevent erroneous analysis readings and damage to the sensor or optional components. Moisture and/or particulates do not necessarily damage the sensor, however, collection on the sensing surface can block or inhibit the diffusion of sample gas into the sensor resulting in a reduction of sensor signal output – and the appearance of a sensor failure when in fact the problem is easily remedied by blowing on the front of the sensor. Consult the factory for recommendations concerning the proper selection and installation of components.

Moisture and/or particulates generally can be removed from the sensor by opening the sensor housing and either blowing on the sensing surface or gently wiping or brushing the sensing surface with damp cloth. **Caution:** Minimize the exposure of ppm sensors to air during this cleaning process. Air calibration followed by purging with zero or a gas with a low ppm oxygen concentration is recommended following the cleaning process. Moisture and/or particulates generally can be removed from the sample system by flowing the purge gas through the analyzer at a flow rate of 4.5-5 SCFH for an hour.

Mounting: The analyzer is approved for indoor use, outdoor use requires optional enclosures, consult factory. Mount as recommended by the manufacturer.

Gas Connections: Inlet and outlet vent gas lines for ppm analysis require 1/8" or ¼" stainless steel compression fittings; hard plastic tubing with a low permeability factor can be used percentage range measurements.

Power: Supply power to the analyzer only as rated by the specification or markings on the analyzer enclosure. The wiring that connects the analyzer to the power source should be installed in accordance with recognized electrical standards. Ensure that is properly grounded and meets the requirements for area classification. Never yank wiring to remove it from a terminal connection. AC powered analog analyzers consume 5 watts. Optional 110V and 220V heaters AC powered heaters consume an additional 100-150 watts.

4 Features & Specifications

Explosion Proof Oxygen Analyzers

- Common Platform
- Accuracy < ±1% FS
- Sensitivity 0.5% FS
- Linearity .995
- 4-5 Standard Ranges
- Temperature Control
- SS Wetted Parts
- Flame Arrestors Standard
- 4-20mA Signal Output
- 2 Adjustable Alarms
- Long Life Sensors
- CO2 Compatible Sensor
- ISO 9001 QA System

Advanced Sensor Technology
ppb, ppm, % Oxygen Analysis

GPR-18MS / GPR-18 / GPR-28 O_2 Analyzers
Meet UL standards for use in Class 1, Division 1, Groups C,D hazardous areas

Applications

1 to 10 ppm O2 Contamination:
Steam cracking of HC feedstocks
Purification of olefin feedstocks - ethylene, propylene, butadiene
Catalyst for polyethylene, polypropy-Lene, polyesters and other plastics
Vent Gas - styrene (CO2 in stream), VCM, acetic acid
LNG - gas treatment, liquid extract

1% to 5% Oxygen Levels:
Polyolefins - CO2 background
Vinyl Chloride - H2 compressor feed
HC Vapors - barges, centrifuges
Chlorine - H2 from electrolysis
H2 Generators
N2 Blanketing - polypropylene, buta-diene, HMD, acetone, phenol, PTA
LNG - wet gas flare

Technical Specifications

	GPR-18 MS	GPR-18	GPR-28
Accuracy:	< 1% of FS range under constant conditions	< 1% of FS range under constant conditions	< 1% of FS range under constant conditions
Analysis:	0-1 ppm, 0-10, 0-100, 0-1000 ppm FS ranges	0-10 ppm, 0-100, 0-1000 ppm, 0-1%, 0-25% FS	0-1%, 0-5%, 0-10%, 0-25% FS ranges
Application:	Oxygen analysis from 10 ppb to 1000 ppm in inert, He, H2, mixed gas streams	Oxygen analysis from 100 ppb to 1% in inert, He, H_2, mixed, and acid (CO_2) gas streams (a)	Oxygen analysis from 0.05% to 100% in inert, He, H_2, mixed and acid (CO_2) gas streams (a)
Approvals:	Meets UL standards for Cl 1, Div 1, Groups C,D	Meets UL standards for Cl 1, Div 1, Groups C,D	Meets UL standards for Cl 1, Div 1, Groups C,D
Area Class:	Enclosure Class 1, Division 1, Groups B, C, D NEMA4/7	Enclosure Class 1, Division 1, Groups B, C, D NEMA4/7	Enclosure Class 1, Division 1, Groups B, C, D NEMA4/7
Alarms:	2 adjustable form C relay contacts non-latching; sensor and power failure	2 adjustable form C relay contacts non-latching; sensor and power failure	2 adjustable form C relay contacts non-latching; sensor and power failure
Calibration:	Certified gas of O_2 balance N_2 approximating 80% of range above analysis range recom-mended for optimum results	Certified gas of O_2 balance N_2 approximating 80% of range above analysis range recom-mended for optimum results	Certified gas of O_2 balance N_2 approximating 80% of range above analysis range recom-mended for optimum results
Compensation:	Temperature	Temperature	Temperature
Connections:	1/8" compression tube fittings	1/8" compression tube fittings	1/8" compression tube fittings
Controls:	Explosion proof actuators for range selection, zero and span calibration adjustments	Explosion proof actuators for range selection, zero and span calibration adjustments	Explosion proof actuators for range selection, zero and span calibration adjustments
Display:	3-1/2 digit bright red LCD; resolution .001 ppm	3-1/2 digit bright red LCD; resolution .01 ppm	3-1/2 digit bright red LCD; resolution .001%
Enclosure:	Painted aluminum 16x18x11" wall mt., 70 lbs.	Painted aluminum 16x18x11" wall mt., 70 lbs.	Painted aluminum 16x18x11" wall mt., 70 lbs.
Flow Sensitivity:	None between 1-3 SCFH, 1 SCFH recom-	None between 1-5 SCFH, 2 SCFH recom-	None between 1-5 SCFH, 2 SCFH recom-
Linearity:	> .995 over all ranges	> .995 over all ranges	> .995 over all ranges
Pressure:	Inlet - regulate to 20-50 psig, max 150 psig; vent - atmospheric not to exceed ±5" water column	Inlet - regulate to 5-30 psig, max 150 psig; vent - atmospheric not to exceed ±14" water column	Inlet - regulate to 5-30 psig, max 150 psig; vent - atmospheric not to exceed ±14" water column
Power:	Specify 100/120 or 220/240 VAC	Specify 100/120 or 220/240 VAC	Specify 100/120 or 220/240 VAC
Recovery Time:	O_2 Level Duration O_2 Target Recovery	O_2 Level Duration O_2 Target Recovery	O_2 Level Duration O_2 Target Recovery
	Air 30 sec 1 ppm 45 min	Air 2 min 10 ppm 60 min *	Air 2 min 0.1% ppm < 30 sec
	9 ppm 2 min 10 ppb 10 min	Air 2 min 1 ppm 20 min **	
	1 ppm 5 min 10 ppb 15 min	* Installation ** In service for 2 weeks at 1 ppm	
Response Time:	90% of final FS reading < 20 seconds	90% of final FS reading < 10 seconds	90% of final FS reading < 10 seconds
Sample System:	Flow control and shut off valves; flow indicator	Flow control and shut off valves; flow indicator	Flow meter with integral valve
Sensitivity:	< 0.5% of FS range	< 0.5% of FS range	< 0.5% of FS range
Sensor Model:	GPR-12-2000MS	GPR-12-333	GPR-11-32-4
Sensor Life:	36 mos at 25ºC, 1 atm; average O_2 < 100 ppm	24 mos at 25ºC, 1 atm; average O_2 < 1000 ppm	36 months in air at 25ºC, 1 atm
Signal Output:	4-20mA isolated and 0-1V	4-20mA isolated and 0-1V	4-20mA isolated and 0-1V
Temp. Range:	5º to 45ºC	5º to 45ºC (GPR), -20º to 45ºC (XLT sensor)	-10º to 45ºC (GPR), -20º to 45ºC (XLT sensor)
Warranty:	12 months analyzer; 12 months sensor	12 months analyzer; 12 months sensor	12 months analyzer; 12 months sensor
Wetted Parts:	Stainless steel	Stainless steel	Stainless steel
	Optional Equipment	**Optional Equipment**	**Optional Equipment**
	No sensor option with > 0.5% CO_2 present	(a) XLT-12-333 sensor with > 0.5% CO_2 pre-sent; 24 month sensor life	(a) XLT-11-24-4 sensor with > 0.5% CO_2 pre-sent; 24 month sensor life
	Temperature controlled heater system	Temperature controlled heater system	Temperature controlled heater system
	Sample conditioning systems - contact factory	Sample conditioning systems - contact factory	Sample conditioning systems - contact factory

5 Operation

Principle of Operation

This ATEX Certified Explosion Proof Oxygen Analyzer is a precision device designed to give you years of use. It has been designed to incorporate several types of oxygen sensors enabling user's to select an analysis range appropriate for their application with the confidence of an ATEX certified analyzer system. Analysis ranges available with selected oxygen sensors:

GPR-18MS analyzes oxygen levels from 10 ppb (parts per billion) to 1,000 ppm (parts per million) and features the new "Pico-Ion" Sensor Technology developed exclusively by Advanced Instruments Inc.
GPR-18 analyzes oxygen levels from 100 ppb to 1% (10,000 ppm) and features the advanced galvanic type ppm oxygen sensor.
GPR-28 analyzes oxygen levels from 0.05% (500 ppm) to 95% and features the advanced galvanic type percent oxygen sensor.

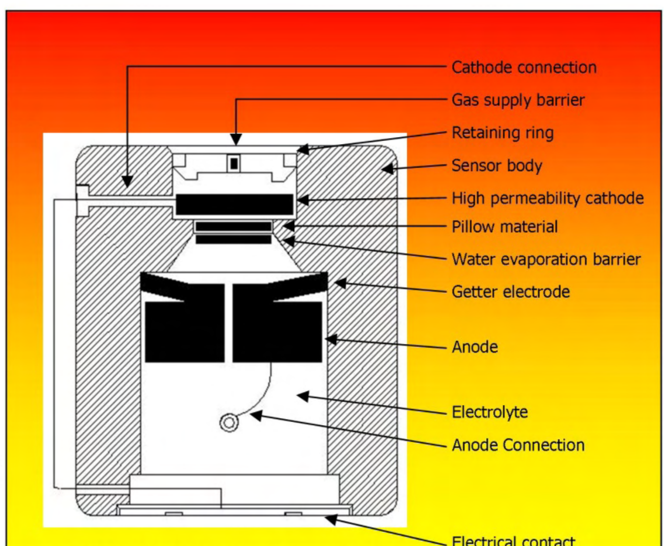
Breakthrough Sensor Technology:
A breakthrough sensor technology measures the partial pressure of oxygen from less than 10 ppb to 1000 ppm level in inert gases, gaseous hydrocarbons, helium, hydrogen and mixed gas streams. The "Pico-Ion" sensor design and chemistry have been combined to produce a significant advancement in oxygen sensor technology.

Pico-Ion 'MS' Oxygen Sensor

Design Criteria
The evolution of electronics influences virtually every aspect of our personal and business lives. The world of industrial gas analyzers is no exception. However, often overlooked is the fact that the heart of any analyzer is the sensor. Thus advancing the sensor technology is a critical element in the development of analyzers.

- Proprietary metal catalyzed cathode . . .
  - High signal output 10x greater than galvanic sensors
  - High signal to noise ratio
  - Fast response time
- Maximize the rate oxygen is reacted . . . Minimize oxygen dissolving into electrolyte
- Fast recovery from exposure to oxygen

O_2 Exposure	Duration	O_2 Target	Recovery
Air	30 sec	10 ppm	15 min
Air	30 sec	1 ppm	45 min
9 ppm	2 min	100 ppb	3 min
9 ppm	2 min	10 ppb	10 min
1 ppm	5 min	10 ppb	15 min



GPR-12-2000MS ppb/ppm Oxygen Sensor

- Lower detectable limit < 10 ppb
- High accuracy and repeatability < $\pm$1%
- Employ a water evaporation limiting barrier
- Employ a barrier to limit the amount of oxygen dissolving into electrolyte
- Operating life minimum 36 month target
- No sensor maintenance
- Compact disposable design
- Long term stability less than 5% drift from span over 6 months
- Extended intervals between calibration minimum 3 months to 6 month target
- Readily transportable and insensitive to minor mechanical shock
- Low cost of ownership

Oxygen, the fuel for these electrochemical transducers, reacts chemically at the sensing electrode to produce an electrical current output proportional to the oxygen concentration in the gas phase. The sensor's signal output is linear over all four ranges and remains virtually constant over its useful life. The sensor requires no maintenance or electrolyte addition and is easily and safely replaced at the end of its useful life.

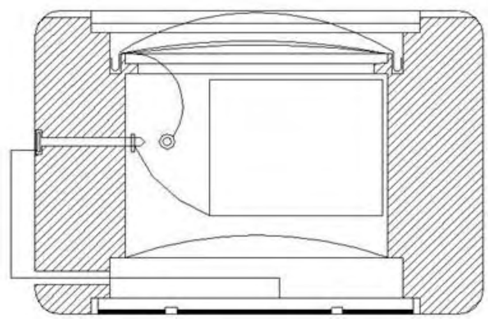
Advanced Galvanic ppm Sensor Technology
The sensors function on the same principle and are specific for oxygen. They measure the partial pressure of oxygen from low ppm to 1% levels in inert gases, gaseous hydrocarbons, helium, hydrogen, mixed gases, acid gas streams and ambient air.
Proprietary advancements in design and chemistry add significant advantages to an extremely versatile oxygen sensing technology. Sensors for low ppm analysis recover from air to ppm levels in minutes, exhibit longer life, excellent compatibility with CO_2 and acid gases (XLT series) and reliable quality giving them a significant advantage over the competition.

Design Objectives

- Improve quality and reliability through a proprietary controlled manufacturing process . . .
- Comply with domestic and international quality standards
- Compact disposable dimensions
- No sensor maintenance
- Improve performance over replacement sensors - sensitivity, stability, response, recovery
- Longer operating and shelf life - translate into longer warranty period
- Low cost of ownership

ppm Oxygen Sensors

- Shorten manufacturing cycle from 4-6 weeks to 3-4 days
- Recovery to 10 ppm from oxygen shock or air . . .
  in less than 1 hour on nitrogen purge
- Higher signal output to achieve . . .
  50 ppb sensitivity
  Enhanced stability, less temperature dependent
- Superior compatibility with 0.5 to 100% CO_2 gas streams
  ppm O_2 contamination in natural gas
  ppm O_2 contamination in beverage grade pure CO_2
- Operating life of 24 months in ppm O_2 concentrations
- Extended operating range –20ºF to 50º F
- Develop special sensor for high ppm/low % applications



GPR/XLT 12 Series ppm Oxygen Sensor

Advanced Galvanic Percent Sensor Technology
The sensors function on the same principle and are specific for oxygen. They measure the partial pressure of oxygen from low percent levels (0.05%) to 100% levels in inert gases, gaseous hydrocarbons, helium, hydrogen, mixed gases, acid gas streams and ambient air.

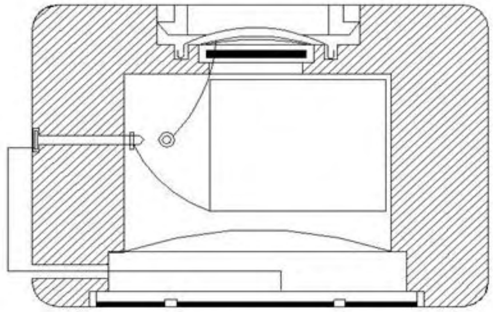
Proprietary advancements in design and chemistry add significant advantages to an extremely versatile oxygen sensing technology. Extending the expected life of our new generation of percentage range sensors now range to five and ten years with faster response times and greater stability. Another significant development involves the first galvanic oxygen sensor capability of continuous oxygen purity measurements and expanding the operating temperature range from -40°C to 50°C, excellent compatibility with CO_2 and acid gases (XLT series) and reliable quality giving them a significant advantage over the competition.

Design Objectives

- Improve quality and reliability through a proprietary controlled manufacturing process . . .
- Comply with domestic and international quality standards
- Compact disposable dimensions
- No sensor maintenance
- Improve performance over replacement sensors - sensitivity, stability, response, recovery
- Longer operating and shelf life - translate into longer warranty period
- Low cost of ownership

% Oxygen Sensors

- Extend operating life to 10 years in air (20.9% O_2) . . .
  24 months in continuous 100% O_2
- Extended operating range to –40° C/F to 50° C
- Excellent stability at elevated pressure . . .
  Up to 10 atmospheres in hyperbaric chambers
- Superior compatibility with 0.5 - 100% CO_2 gas streams
  24 month operating life in traditional dimensions
- Develop special sensor for fast response and long life
  Large cathode with proprietary electrolytes and anodes



GPR/XLT 11 Series % Oxygen Sensor

Electronics

The signal generated by the sensor is processed by state of the art low design and integrated circuits. The first stage amplifies the signal. The second stage eliminates the low frequency noise. The third stage employs a high frequency filter and compensates for signal output variations caused by ambient temperature changes. The result is a very stable signal. Sample oxygen is analyzed very accurately. Response time of 90% of full scale is less than 10 seconds (actual experience may vary due to the integrity of sample line connections, dead volume and flow rate selected) on all ranges under ambient monitoring conditions. Sensitivity is typically 0.5% of full scale low range. Oxygen readings may be recorded by an external device via an isolated 4-20mA and 0-1V signal output jack.

Sample oxygen is analyzed very accurately. Overall performance is enhanced by an optional temperature controlled heater system that controls the temperature around the sensor. Response time of 90% of full scale is less than 20 seconds on the 0-1 ppm range and on higher ranges (actual experience may vary due to the integrity of sample line connections, dead volume and flow rate selected).

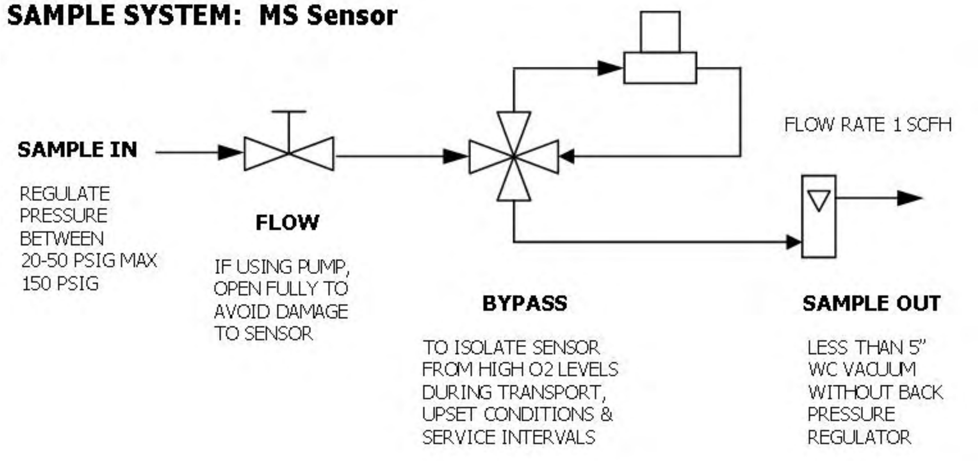
Power for the on-line analyzers is supplied by an integral power supply. Connections of the appropriate AC line voltage are hard wired to screw type terminal blocks. Power requirements related to 100/110VAC and 220/230VAC heaters must be specified at order placement.

Sample Systems

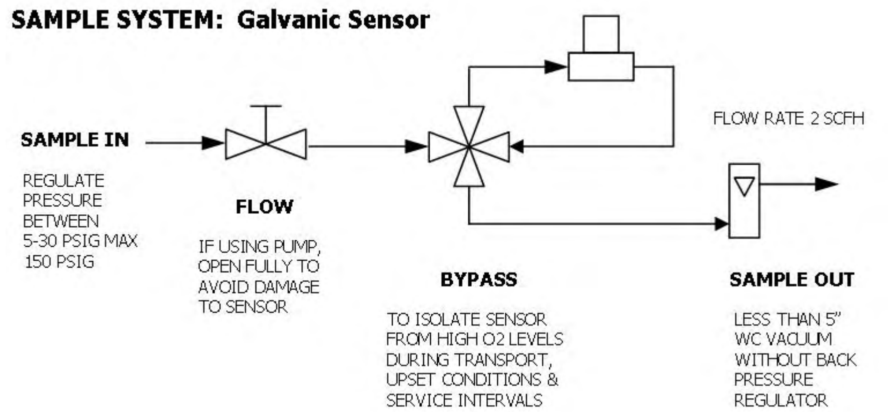
The sample must be properly presented to the sensor to ensure an accurate measurement. The GPR-18MS and GPR-18 are designed with a sample system consisting of stainless steel and glass wetted parts,a uniquely designed leak tight sensor housing that has been proven capable of less than 1 ppb oxygen measurements (using the Pico-Ion sensor) and a bypass sample system that complements the performance (fast recovery from exposure to high oxygen levels) capabilities of the sensor and enables the user to isolate the sensor from exposure to high oxygen concentrations which results is a substantial increase is user productivity.

This bypass feature has two important features: one, the sensor can be isolated from exposure to high oxygen levels when changing sample lines, during transport and during standby intervals; and, two, it enables the user to purge newly connected gas lines of the oxygen trapped inside. The result is an analyzer that comes on-line at ppb or ppm levels in a matter of minutes and provides users with a significant increase in productivity.

GPR-18MS



GPR-18



The advantages of the bypass sample system include:

- Supplying the analyzer with the sensor it was qualified with.
- Isolating the sensor during transport, calibration and maintenance intervals when changing gas line connections.
- Isolating the sensor from exposure to high oxygen levels during upset conditions which extends sensor life.
- Purging the air (or high oxygen levels above 1,000 ppm) trapped in the gas lines following a process upset.

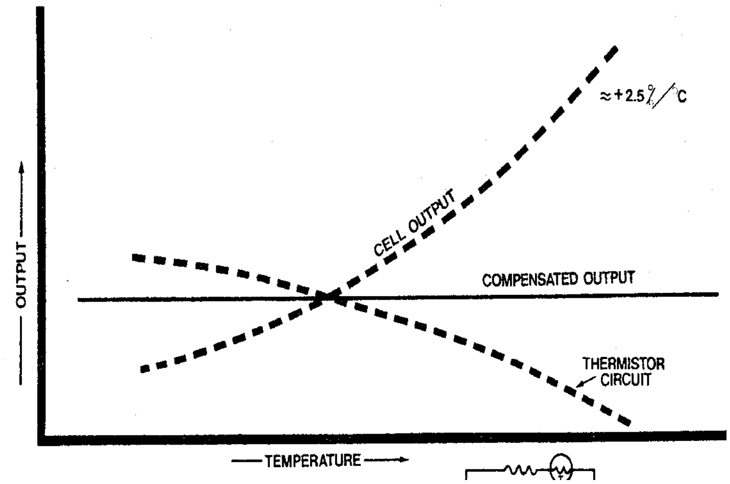
GPR-28 is designed with a sample system that enables the user to control the flow rate via a flow meter positioned upstream of the sensor. The sample must be properly presented to the sensor to ensure an accurate measurement. The sensor is exposed to sample gas that must flow or be drawn through the analyzer's internal sample system.

Advanced Instruments Inc. offers a full line of sample handling, conditioning and expertise to meet your application requirements. Contact us at 909-392-6900 or e-mail us at info@aii1.com

Accuracy & Calibration

Single Point Calibration: As previously described the galvanic oxygen sensor generates an electrical current proportional to the oxygen concentration in the sample gas.

Absolute Zero: In the absence of oxygen the sensor exhibits an absolute zero, e.g. the sensor does not generate a current output in the absence of oxygen. Given these linearity and absolute zero properties, single point calibration is possible.

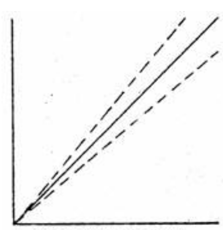


Pressure: Because sensors are sensitive to the partial pressure of oxygen in the sample gas their output is a function of the number of molecules of oxygen 'per unit volume'. Readouts in percent are permissible only when the total pressure of the sample gas being analyzed remains constant. The pressure of the sample gas and that of the calibration gas(es) must be the same (reality < 1-2 psi).

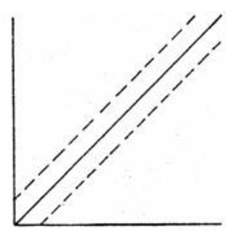
Temperature: The rate oxygen molecules diffuse into the sensor is controlled by a Teflon membrane otherwise known as an 'oxygen diffusion limiting barrier' and all diffusion processes are temperature sensitive, the fact the sensor's electrical output will vary with temperature is normal. This variation is relatively constant 2.5% per °C.

A temperature compensation circuit employing a thermistor offsets this effect with an accuracy of better than ±5% (over the entire Operating Range of the analyzer) and generates an output function that is independent of temperature. There is no error if the calibration and sampling are performed at the same temperature or if the measurement is made immediately after calibration. Lastly, small temperature variations of 10-15° produce < 1% error.

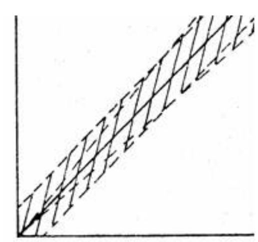
Accuracy: In light of the above parameters, the overall accuracy of an analyzer is affected by two types of errors: 1) those producing 'percent of reading errors', illustrated by Graph A below, such as ±5% temperature compensation circuit, tolerances of range resistors and the 'play' in the potentiometer used to make span adjustments and 2) those producing 'percent of full scale errors', illustrated by Graph B, such as ±1-2% linearity errors in readout devices, which are really minimal due to today's technology and the fact that other errors are 'spanned out' during calibration. Graph C illustrates these 'worse case' specifications that are typically used to develop an transmitter's overall accuracy statement of < 1% of full scale at constant temperature or < 5% over the operating temperature range. QC testing is typically < 0.5% prior to shipment.



A. PERCENT OF READING ERRORS



B. PERCENT OF FULL SCALE ERRORS



C. OVERALL ACCURACY

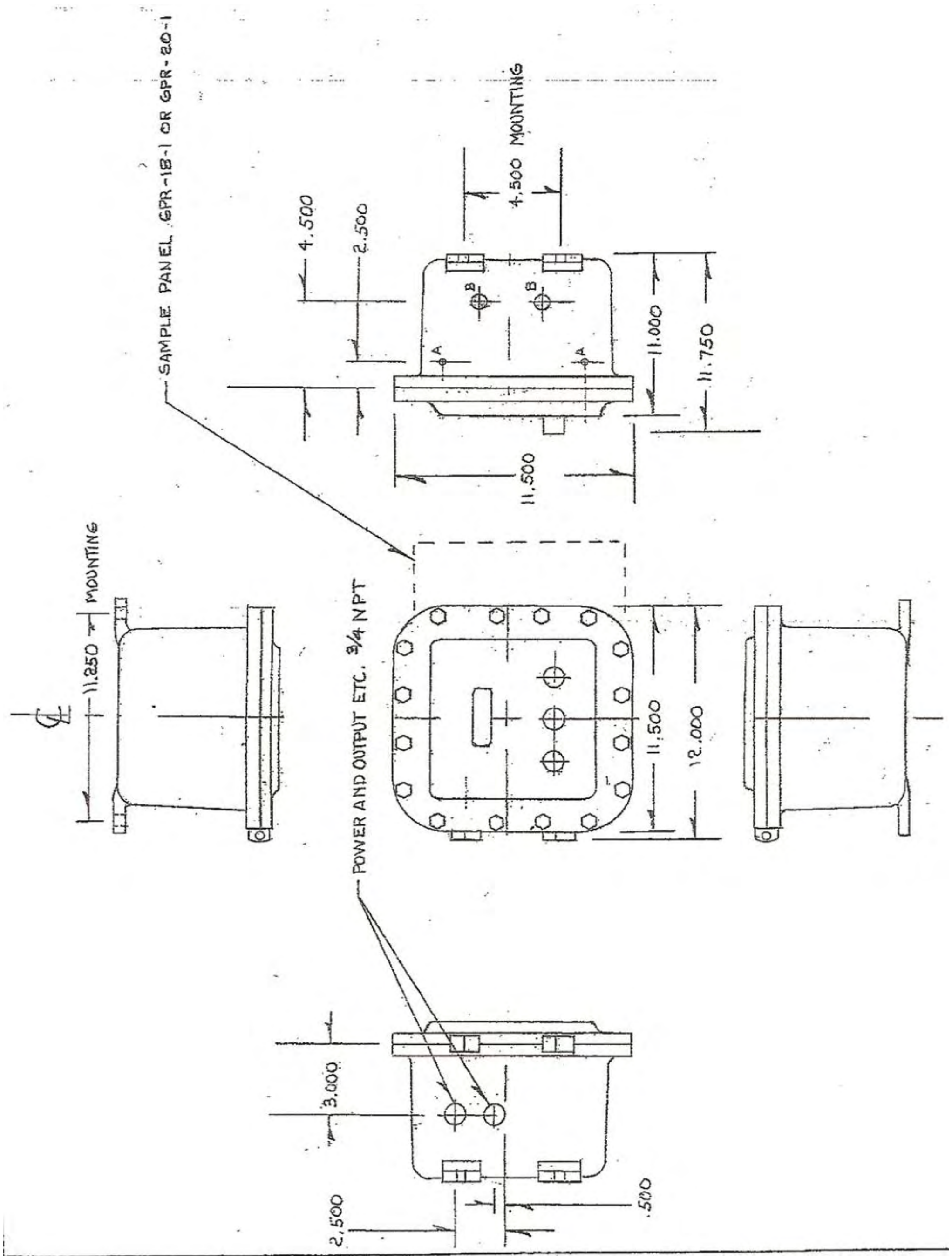
Example: As illustrated by Graph A any error, play in the multi-turn span pot or the temperature compensation circuit, during a span adjustment at 20.9% (air) of full scale range would be multiplied by a factor of 4.78 (100/20.9) if used for measurements of 95-100% oxygen concentrations. Conversely, an error during a span adjustment at 100% of full scale range is reduced proportionately for measurements of lower oxygen concentrations.

Refer to the Calibration section for additional information.

Mounting the Analyzer

The oxygen analyzer consists of two PCB assemblies, sensor housing and sample system valves. An optional temperature controlled heater system enhances stability during low ppm measurements. In standard configuration the alarm controls are integral to prevent tampering, however, as illustrated below the alarm controls can be accessed externally with approved actuators.

These components are packaged in a compact 8" x 8" x 8" wall mount enclosure. Designed for mounting on a flat vertical surface approximately 5 feet above the floor by bolting the mounting feet attached to the rear of the enclosure. The user is responsible for selecting the appropriate bolts to support at least 80 pounds.



Gas Connections

The analyzers flow through configuration is designed for positive pressure samples and requires connection to 1/8" diameter tube fittings, see illustration, of the FLOW control valve (SAMPLE IN), SAMPLE/BYPASS valve (ppm analyzers only and flow indicator (SAMPLE OUT or VENT).

The user is responsible for making provision for calibration gases, regulating the pressure and flow as described below in the Span Gas Preparation section.

Recommendation: When installing analyzer, consider installing an optional 3-way valve before the FLOW valve to provide a permanent connection for span gas and means of switching from SAMPLE to SPAN gas and vise versa without breaking gas line connections. This arrangement would eliminate the possibility of exposing the sensor to air (if the sample line is disconnected) and shorten the calibration time. However, before changing gas lines allow the gas to flow for 1-2 minutes to purge the stagnant gas which has accumulated air through leakage of the connections.

Caution: Do not place your finger over the vent (it pressurizes the sensor) to test the flow indicator when gas is flowing to the sensor. Removing your finger (the restriction) generates a vacuum on the sensor and may damage the sensor (voiding the sensor warranty).

Procedure:

1. **Caution:** Do not change the factory setting until instructed, the SAMPLE/BYPASS valve should be in BYPASS position.
2. Locate the sample inlet and outlet fittings respectively at the rear of the gas panel of the analyzer, refer to the illustration above under the Mounting the Analyzer section.
3. Regulate the pressure to as described in section 4.
4. Assure there are no restrictions in the vent line.
5. Connect the 1/8" dia. metal vent line to the fitting designated SAMPLE OUT or VENT.
6. Connect the 1/8" dia. metal sample gas line to the fitting designated SAMPLE IN.
7. Allow the gas flow for 1-2 minutes to purge the air trapped inside the gas lines.
8. Adjust the FLOW valve until the recommended flow rate of is reached.
   Note: Open the flow control valve completely if using an external sampling pump positioned downstream of the sensor.
9. Switch the SAMPLE/BYPASS valve to the SAMPLE position.
10. If the sensor is shipped separately, continue following these instructions which include Installing the Oxygen Sensor below.

Electrical Connections

Power must be supplied through a separate conduit on the left side of the enclosure, see above #1. Use a shielded power cord with minimum of 18 gauge wires. If equipped with the optional temperature controlled heater system, the required internal wiring has been installed at the factory. The user simply connects an appropriate source of AC power (determined by the requirements specified for the heater) to the terminal strip as illustrated below.

Caution: Additional penetrations to the enclosure may only be made by ATEX certified personnel. The output and alarm connections are supplied through the right side of the enclosure. To prevent external fire or explosion user must must observe the manufacturer's installation and maintenance instruction found in the appendices which are an integral part of this Owner's Manual.

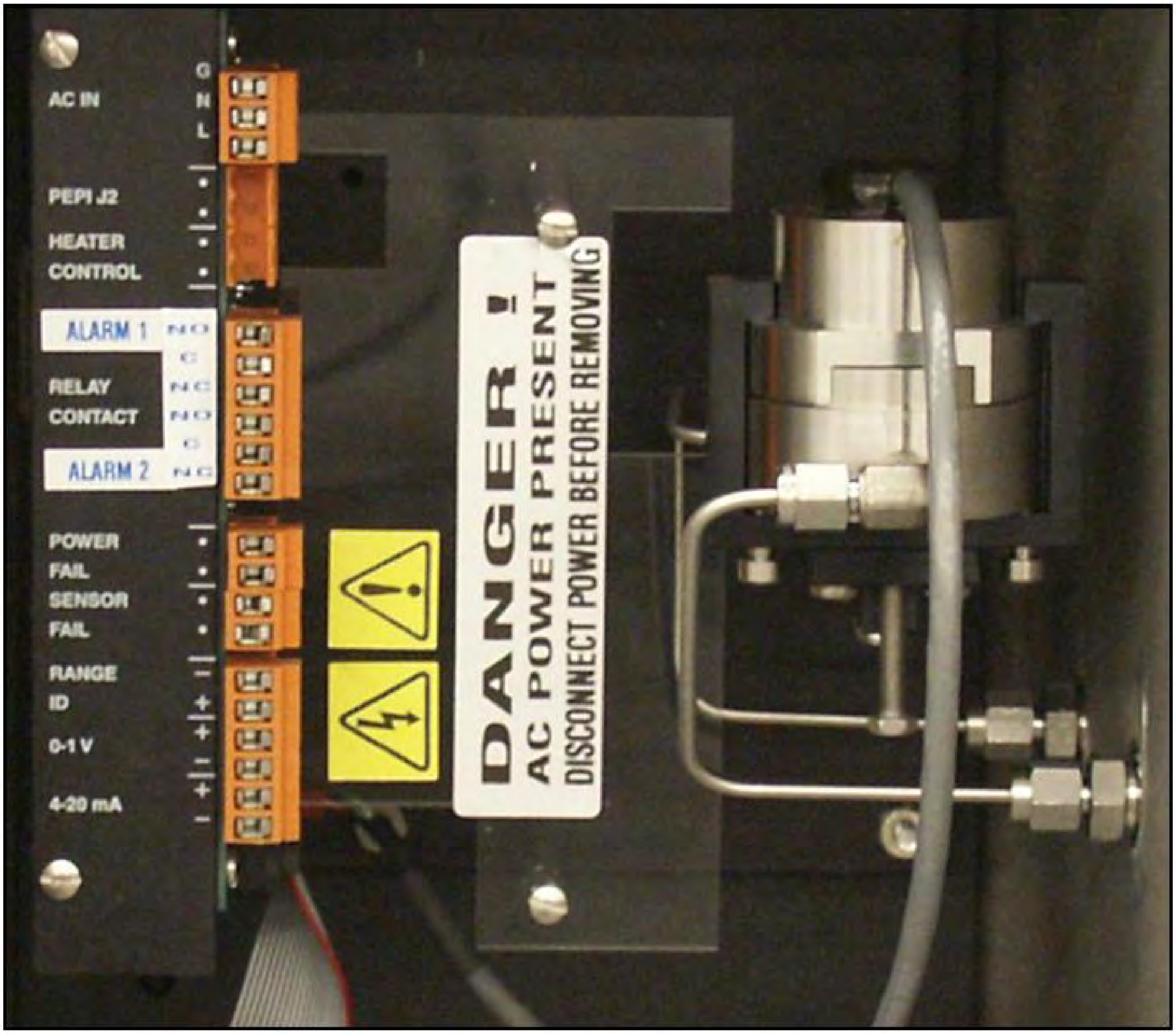
Note: The heater system is rated for 100/110 VAC or 220/230 VAC not both. Note the rating of the power requirement for the heater. An improper voltage could permanently damage the heating system.

Danger: Avoid electric shock, exercise extreme caution when servicing the analyzer.

- Disconnect the AC power source before removing the protective plexiglas panel that covers the terminal block. If the AC power source is connected to the terminal block, touching any terminal connections where AC power is present such as transformer pins and AC connector on the PCB Assembly would result in an electric shock.

- Replace the protective plexiglas panel before establishing power to AND after servicing the analyzer electronics.

- **Note:** There is no AC power present on the circuit board assemblies found on the door of the analyzer.



Procedure:

1. Disconnect the AC power source before servicing the analyzer.
2. Insert the power cable through the user supplied approved conduit fitting on the left side of the analyzer.
3. Insert the output cable(s) through the user supplied approved conduit fittings on the right side of the analyzer.
4. Strip the ends of the wires approximately ¼ inch.
5. Remove the safety cover plate.
6. Loosen the terminal screws, insert the bare wire into the appropriate terminals and re-tighten with a small bladed screwdriver.
7. **Note:** If equipped with the optional temperature controlled heater system, the necessary wiring has been installed at the factory and no additional connections are required. The power connection services both the analyzer electronics and temperature controlled heater system.
8. **Caution:** Connect the power ground directly to the ground terminal on the inside of the analyzer case.
9. Replace the safety cover plate.
10. Pack and seal the power and interconnection wiring as described in Appendix A.
11. Establish power as directed below.

Alarms
The analyzer is equipped with two user adjustable alarms located on the interior panel attached to the front door. When activated the alarms trigger SPDT Form C, normally closed, non-latching relays @ 5A, 30VDC or 240VAC resistive. The alarms are fully adjustable by the two potentiometers accessible from the auxiliary panel on the inside of the door with a small bladed screwdriver. Optionally, alarm control actuators can be mounted externally as illustrated in the Mounting the Analyzer section above.

Note: Fail safe alarm configuration - connect positive lead to NO and negative to the C, common or neutral. To connect to an active relay, connect the live cable to the common terminal C and the secondary cable to the normally open NO terminal. To break the connection upon relay activation, connect the secondary cable to the normally closed NC terminal.

Power Fail Alarm
A dry contact rated at 30VDC @ 1A is provided as a power failure alarm. The contact is normally closed but opens when the power to the analyzer is switched off or interrupted. Connect the lead wires from the external recording device to the male phone plug supplied with analyzer.

Sensor Fail Alarm
A 5V output with negative ground is provided when the sensor is operational. The output is 0V when the sensor fails and its output goes to zero. **Note:** Adjusting the ZERO OFFSET to .000 activates the Sensor Failure Alarm characterized by a momentary spike in the trend analysis. To avoid the spike set the ZERO OFFSET to .001

Caution: The sensor failure alarm becomes active when the display indicates '000' on any range of the analyzer. To verify the 'sensor failure' condition, advance the range switch to the lowest (most sensitive) range available. If the display continues to indicate '000' or a negative number, replace the sensor.

Range ID Output
A voltage output corresponding to each range is provided. The output of the highest range (normally CAL) is 5V and the remaining three ranges 4V, 3V and 2V for the low range.

Signal Outputs
The analyzer provides an isolated 4-20mA signal output and a 0-1V full scale signal output for external recording devices. The integral IC on the main PCB converts the 0-1V signal with negative ground to a 4-20mA fully isolated signal. A finer adjustment of the zero offset of the 4-20mA converter can be provided by a potentiometer, R99, mounted on the main PCB Assembly. Consult factory for instructions. **Caution:** The integral 4-20mA converter is internally powered and does not require external power. DO NOT supply any voltage to either of the two terminals of the 4-20mA converter.

Temperature Controller

If the optional the temperature controlled heater system is installed, access it by opening the front door. This unit is a PID controller that operates between 0-99°F. The controller is programmed to maintain the temperature at 75-85°F. C**aution:** Do not change this setting. A higher temperature setting may drastically reduce sensor life and possibly cause damage to the electronic circuitry of both the controller and the analyzer.

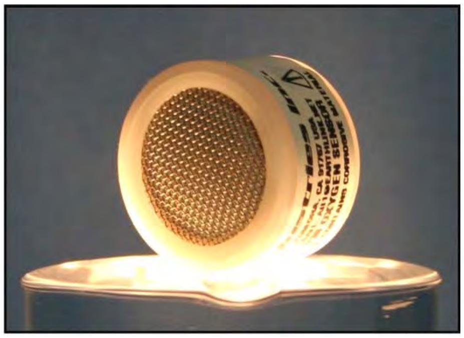
When power is applied to the temperature controller, the controller tunes itself to eliminate and/or minimize the over/under shoot of temperature from the setpoint. It is recommended that at initial start-up, when replacing the oxygen sensor or when trouble shooting; turn the power to the heater off or set the temperature set point at 60°F to turn the heater off to prevent overheating the analyzer. **Caution:** Keep the analyzer front door closed and securely fastened when the temperature controller is ON.

Heater Runaway Protection

As part of the optional temperature controlled heater system, the analyzer is protected in the event the temperature controller should fail and thereby allowing the heater to runaway damaging the interior of the analysis unit. The runaway protection is provided by a J2 type device positioned between the temperature controller and the heater. This device cuts of power to the heater if the temperature inside the analysis unit exceeds 70°C. Correct the problem and reset the runaway protector device by exposing it to 0°C for a few minutes (a refrigerator freezer will do).

Additional electrical diagrams are provided for reference purposes in Appendix I.

Installing the Oxygen Sensor



Analyzers are equipped with an integral oxygen sensor that is tested and calibrated by the manufacturer prior to shipment and is fully operational from the shipping container. Analyzers must be calibrated once the installation has been completed and periodically thereafter as described below. Should it be necessary to install the oxygen sensor – refer to section 6 Maintenance which covers replacing the oxygen sensor.

Caution: DO NOT open the oxygen sensor. The sensor contains a corrosive liquid electrolyte that could be harmful if touched or ingested, refer to the Material Safety Data Sheet in section 10. Avoid contact with any liquid or crystal type powder in or around the sensor or sensor housing, as either could be a form of electrolyte. Leaking sensors should be disposed of in accordance with local regulations.

Span Gas Preparation

Caution: Do not contaminate the span gas cylinder when connecting the regulator. Bleed the air filled regulator (faster and more reliable than simply flowing the span gas) before attempting the initial calibration of the instrument.

Required components:

- Certified span gas cylinder with an oxygen concentration, balance nitrogen, approximating 80% of the full scale range above the intended measuring range.
- Regulator to reduce pressure to between 5 and 30 psig, recommended 30 psig.
- Flow meter to set the flow to 2 SCFH.
- 2 lengths of 1/8" dia. metal tubing measuring 4-6 ft. in length.
- Suitable fittings and 1/8" dia. metal tubing to connect the regulator to the flow meter inlet
- Suitable fitting and 1/8" dia. metal tubing to connect from the flow meter vent to tube fitting designated SAMPLE IN on the GPR-18 gas panel.

Procedure:

1. With the span gas cylinder valve closed, install the regulator on the cylinder.
2. Open the regulator's exit valve and partially open the pressure regulator's control knob.
3. Open slightly the cylinder valve.
4. Loosen the nut connecting the regulator to the cylinder and bleed the pressure regulator.
5. Retighten the nut connecting the regulator to the cylinder
6. Adjust the regulator exit valve and slowly bleed the pressure regulator.
7. Open the cylinder valve completely.
8. Set the pressure between 5-30 psig using the pressure regulator's control knob.

Caution: Do not exceed the recommended flow rate. Excessive flow rate could cause the backpressure on the sensor and may result in erroneous readings and permanent damage to the sensor.

Establishing Power to the Electronics

Establish power to the electronics by connecting the power cable to an appropriate source of AC power. The electronics are rated for a universal power input of 100-230 +/-10% VAC 50-60 Hz, unless the analyzer is equipped with the optional temperature controlled heater system. Ensure the voltage provided is appropriate for the heater.

The LCD display along with range LED on the side of the display should light up when power is applied to the analyzer. Assuming the analyzer has been installed as directed above, the reading displayed when the analyzer is turned on reflects the oxygen value under static condition (i.e. the axiom that all valves leak) indicating the integrity of the internal sample system or the equilibrium point of oxygen diffusing into the sample system and oxygen consumed by the sensor.

Display Mode

The DISPLAY SELECT slide switch is located inside the front door on the A-1107 PCB Assembly Main/Display has been factory set to the O2 position, refer to the illustration above under the Mounting the Analyzer section. Advance this switch to change or one of the available DISPLAY modes:

- OXYGEN to display the oxygen reading
- ALARM 1 set point
- ALARM 2 set point

Setting Alarm Values

The analyzer is equipped with one high and one low fully adjustable alarms. When activated the alarms trigger SPDT Form C non-latching relays @ 5A, 30VDC or 240VAC resistive. The alarms are fully adjustable by the two potentiometers accessible from the auxiliary panel on the inside of the door. Optionally, alarm control actuators can be mounted externally as illustrated in the Mounting the Analyzer section above.

The alarm setpoint represents a value. When the oxygen reading exceeds ALARM 2 (high alarm) or falls below ALARM 1 (low alarm) the alarm setpoint, the relay is activated and the corresponding LED indicator located on the front door is turned on.

To prevent chattering of the relays, a 2% hysteresis is added to the alarm setpoint. This means that the alarm will remain active until the oxygen reading has fallen 2% below the alarm setpoint (high alarm) or risen 2% above the alarm setpoint (low alarm) after the alarm was activated.

Procedure:
1. Open the front door to access the DISPLAY SELECT slide switch located on the A-1107 PCB Assembly Main/Display.
2. Advance the selector switch to the ALM1 (high alarm) or ALM2 (low alarm).
3. The digital LED display will indicate the current alarm set point.
4. The alarm setpoint is expressed as a value.
5. Adjust the potentiometer a ½ a turn at a time to allow the electronic processing to catch up . . . until the display reads the desired alarm setpoint value. **Note:** External alarm control actuators are optional and would be located on the outside of the analyzer's front door.
6. **Caution:** Use a small bladed screwdriver. No wrenches please!
7. Repeat to set the other alarm.
8. Once the alarm values are set, advance the DISPLAY SELECT slide switch back to OXYGEN position.

Note: Before concluding the sensor is not "coming down to expected ppb or ppm levels" or "is not responding to sample gas", please check and confirm the analyzer in the proper OXYGEN DISPLAY mode before contacting the factory.

Range Selection

The ppm analyzers are equipped with five (5) and the percent analyzer four (4) standard measuring ranges (see specification) and provides users with a choice of sampling modes. The ranges available are indicated around the RANGE selector switch (actuator) located in the center of the control panel under the digital LED display on the front of the analyzer, refer to the illustration above under the Mounting the Analyzer section. Simply turn the RANGE selector switch to the desired range.

Installation is complete . . .

Calibration

The electrochemical oxygen sensors manufactured by Analytical Industries Inc. (dba Advanced Instruments) generate an electrical current that is **linear** or proportional to the oxygen concentration in the sample gas. In the absence of oxygen the sensor exhibits an **absolute zero**, e.g. the sensor does not generate a current output in the absence of oxygen. Given the properties of linearity and an absolute zero, single point calibration is possible.

As described below, zero calibration is recommended only when the application (or user) demands optimum accuracy for analysis below 5% of the most sensitive or lowest range available on the analyzer. Span calibration in one of the forms described below is sufficient for all other measurements. When employed zero calibration should precede span calibration.

Zero Calibration
Despite the absolute zero inherent in electrochemical oxygen sensors, the reality is that analyzers display an oxygen reading when sampling a zero gas due to:

- Contamination or quality of the zero gas
- Minor leakage in the sample line connections
- Residual oxygen dissolved in the sensor's electrolyte
- Tolerances of the electronic components

The zero capability (low end sensitivity) of every analyzer is qualified prior to shipment. However, because the factory sample system conditions differ from that of the user, no ZERO OFFSET adjustment is made to the analyzer by the factory

Span Calibration
Involves periodically, see Intervals section below, checking and/or adjusting the electronics to the sensor's signal output at a given oxygen standard or span. Maximum drift from calibration temperature is approximately 0.11% of reading per °C. The frequency of calibration varies with the application conditions (potential for contamination), the degree of accuracy required by the application and the quality requirements of the user. However, the interval between span calibrations should not exceed three (3) months.

Note: Regardless of the oxygen concentration of the standard used, the span calibration process takes approximately 10 minutes, however, the time required to bring a ppm analyzer back on-line can vary, see Online Recovery Time below.

Considerations
When it comes to the calibration of oxygen analyzers utilizing an electrochemical oxygen sensor circumstances vary widely from the ideal conditions that exist at the factory to a variety of differing circumstances users encounter in the field. The following describes the most common factors and reasons that they influence the calibration procedures.

Factor	Reasons
Intervals:	All electrochemical sensor based analyzers require periodic, e.g. weekly intervals to a 3 month maximum, calibration to ensure accuracy and ascertain whether the sensor has been contaminated or otherwise damaged while in service.
Conditions:	Calibrate at the temperature and pressure of the sample.
Analysis Level Required:	Continuous analysis below 5% of the most sensitive or lowest range available: ZERO CALIBRATION followed by SPAN CALIBRATION with good quality gases is recommended (for optimum accuracy) when: - the analyzer and/or O2 sensor is initially installed, - the sample system connections are modified, - the O2 sensor is replaced. Note: It is not necessary to repeat the ZERO CALIBRATION with subsequent periodic SPAN CALIBRATION unless desired or one of the above events occurs. All other analysis: SPAN CALIBRATION is sufficient. Procedure varies with factors.

Zero Calibration Offset Adjustment Capability:	Designed to facilitate precise analysis below 5% of the most sensitive or lowest range available on the analyzer, this feature enables users' to compensate for background offsets, as defined above, of up to 50% of the most sensitive or lowest full scale range available on the analyzer and bring analyzers online faster.

As described below, accomplishing either objective places a degree of responsibility on the user. Determining the true offset requires the user to wait, see Online Recovery Time section, until the analyzer reading is no longer trending downward (best evidenced by a constant horizontal trend on an external recording device). Bringing the analyzer online faster, basically the same as choosing not to wait for the stable horizontal trend reading, requires the user to repeat the ZERO CALIBRATION function. The frequency of which is at the user's discretion, hourly is recommended but at least when the reading goes negative.

Advanced Instruments' oxygen analyzers are capable of zero offset adjustments of 50% of the most sensitive or lowest range available on the analyzer. Since every analyzer is QC tested to 1% of the most sensitive or lowest range available, exercise CAUTION when initiating the ZERO CALIBRATION function at 50% (prematurely) of the most sensitive or lowest range available on the analyzer. If the anticipated O2 analysis level is less than the offset value or if adequate time is not allowed for the analyzer to establish the true offset, the analyzer will in all probability display a negative reading.

Note: From the SYSTEM menu option "Display Negative (Reading)" users can toggle between ON and OFF choose by pressing the ENTER key and control whether analyzer displays negative readings.

Type of Analyzer:

Online ppb or ppm process analyzers: Analysis below 5% of the most sensitive or lowest range is normally limited to these analyzers. However, such analysis is possible with portable analyzers from Advanced Instruments due to their 60 day duty cycle and/or ability to operate during battery charging.

Portable analyzers: Typically used intermittently moving between different sample points/systems for trend analysis above 5% of the most sensitive range and, therefore, they fall into the "all other analysis" category requiring only span calibration.

Percentage analyzers: Generally used above 5% of the most sensitive range and, therefore, fall into the "all other analysis" category requiring only span calibration.

Online Recovery Time:

The priority users place on getting or keeping an analyzer online is "the" most significant factor involved in calibration and troubleshooting issues. The time it takes an analyzer to come down to a specific level after exposure to high O2 concentrations or air is significantly different if a sensor is being installed than if the sensor had been in-service at low ppm levels for more than 1 week as illustrated below:

Sensor	Calibration at Install	In-service Calibration
MS Pico-Ion	Air to 1 ppm < 45 min Air to .1 ppm < 6 hrs Air to .02 ppm < 8 hrs	80 ppm to .02 ppm < 10 min 9 ppm to .02 ppm < 5 min
ppm Fuel Cell	Air to 100 ppm < 10 min Air to 10 ppm < 1 hr Air to 1 ppm < 6 hrs Air to .1 ppm < 16 hrs	Air to 1 ppm < 30 min 80 ppm to .1 ppm < 10 min 8 ppm to .05 ppm < 5 min
% Fuel Cell	Air to .1% < 1 min Air to .05% < 3 min	

The above times assume the introduction of a purge gas, the lower of the available zero or sample (if known and constant) gas, with a ppm level O2 concentration less than 0.5 ppm is introduced to the analyzer following span calibration to purge (accelerate the reaction of) the O2 that has dissolved into the electrolyte inside the sensor. If zero gas is not available, substitute the sample gas and expect slightly longer recovery time.

Span Gas Selection:

The O2 concentration of a span gas should approximate 70-90% of the full scale range dictated by the span gas, e.g. 80 ppm O2 on the 0-100 ppm range. For optimum accuracy, the full scale range dictated by the span gas should be at least one range higher than the intended analysis range. Both of the aforementioned recommendations reduce the error induced by the tolerance of the electronic components; also, span gases with higher O2 concentrations are more reliable and less expensive.

Conversely, if the recommended span gas is not available and air calibration is not an option, a span gas of the same full scale range and near the anticipated analysis level (approximately 10% of full scale) is acceptable with the understanding the accuracy will suffer slightly.

Use of span gas near 10% of the same full scale range for measurements at the higher end of the range has the effect of “expanding the error” by moving upscale as illustrated by Graph A and Example 1 in the Accuracy section above and is not recommended. Of course the user can always elect at his discretion to accept an accuracy error of $\pm$2-3% of full scale range if no other span gas is available.

Type of Sensor:

Pico-Ion MS Oxygen Sensors: Analyzers utilizing these sensors require span gas(es) and cannot be calibrated with air (20.9% or 209,000 ppm O2) due to their high signal output. Calibrate with a span gas containing less than 1000 ppm O2; a span gas containing 70-90 ppm O2 is recommended.

Galvanic Fuel Cell Sensors: Analyzers utilizing these sensors can be calibrated with ambient air (20.9% or 209,000 ppm O2) and have been proven capable of precise analysis below 0.5 ppm (500 ppb).

Note: As described above, these oxygen sensors are capable of one point calibration.

Span Gas vs. Air (Fuel Cell Sensors only):

Span gas calibration: Recommended for calibration of in-service analyzers, if the priority is the fastest online recovery time.

Air calibration: Recommended for calibration an analyzer if a new oxygen sensor is being installed or if the availability of span gas, the cost of span gas or the accuracy of a span gas is an issue. An air calibrated analyzer can be used to reliably verify a “certified” span gas, which has frequently been found to be inaccurate. For best results, select a recognized name supplier.

Note: Galvanic Fuel Cell sensors can be calibrated (using air) and brought online (using sample gas) without “purchased calibration gases” and without sacrificing accuracy - provided the analyzer is given enough time to come down to the O2 concentration of the sample gas.

Span Calibration Adjustments:

Prematurely initiating the SPAN CALIBRATION function (when ZERO CALIBRATION has not been performed) before the analyzer reading has stabilized can result in erroneous readings as follows:

When purging an analyzer to lower ranges for span gas calibration: If the oxygen reading reaches less than 2% of the intended calibration range, enter the value of the span gas. If the oxygen reading is greater than 2% of the calibration range, add the O2 reading to the value of the span gas (the impact of the offset on accuracy is minor but the addition allows the oxygen sensor to continue to purge down and avoid negative readings).

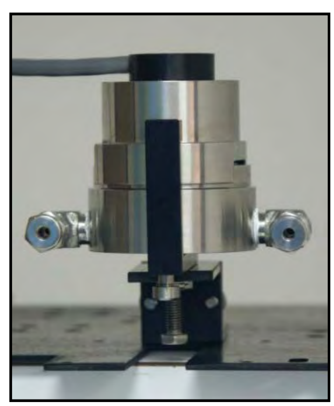
Note: If ZERO CALIBRATION has been performed or the analyzer has been in service, the analyzer reading should already be stable and below 2% of the calibration range.

When installing a new oxygen sensor and calibrating with air: Allow 5-10 minutes for the sensor to equilibrate in ambient air from storage packaging. Failure to do so can introduce a positive offset (electronic gain) that prevents the analyzer from displaying low ppm O2 readings.

Required components: Refer to Installing Span Gas section above.

Procedure Calibration with Span Gas or Instrument Air :

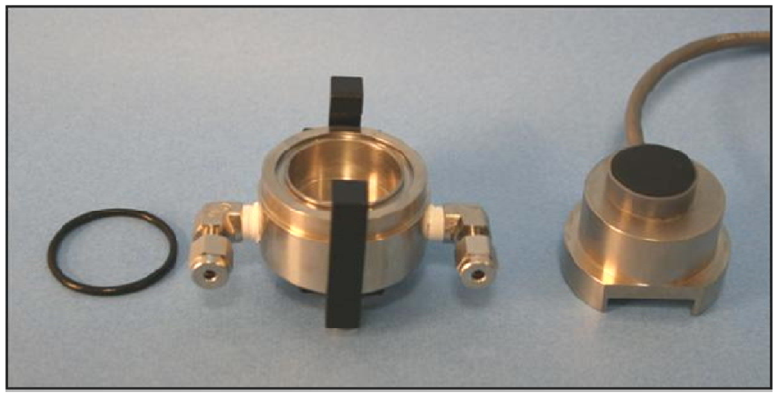
1. Refer to Display Mode and Range Selection and place the analyzer in the OXYGEN mode on the range dictated by the value of the span gas.
2. If SPAN CALIBRATION follows ZERO CALIBRATION above, skip the next step.
3. Refer to the Gas Connections section above.
4. Refer to the Span Gas Selection and Span Gas vs. Air sections above.
5. Slowly open the FLOW control valve until the recommended flow rate is reached.
6. Allow the span gas to flow until the reading stabilizes before adjusting the SPAN actuator/potentiometer.
7. The analyzer should stabilize in 5-10 minutes.
8. If after 30 minutes the oxygen value displayed is not stable perform a complete check of all external sample system connections before concluding the sensor is defective and notifying the factory.
9. After the reading stabilizes, turn the SPAN actuator/potentiometer ½ turn at a time until the LED display reads the desired span gas value. **Caution:** Turning the potentiometer more the ½ turn recommended does not allow the electronics sufficient time to keep pace with the adjustment. And since adjustments are rarely made in one consecutive turn – there is a real possibility that the 2nd and 3rd part of the adjustment could unknowingly be based on "values that have not stabilized" thereby resulting in an inaccurate calibration.
10. Close the FLOW control valve, disconnect the span gas line and connect the sample gas line (after purging as described above).
11. Proceed to SAMPLING.



Procedure Ambient Air Calibration (Galvanic Sensors only):

1. Review the above Span Calibration procedure and the following instructions before proceeding.
2. Refer to Display Mode and Range Selection and place the analyzer in the OXYGEN mode on the 0-25% range dictated by the value of the span gas.
3. Access the interior of the analyzer by removing the bolts securing the front door.
4. Using the 5/16 wrench supplied loosen but do not remove the clamp bolt located in the center of the bracket attached to bottom section with the elbow fittings.
5. Rotate the upper section of the sensor housing 90º to disengage from the clamp.
6. Remove the upper section by pulling it straight up and let it rest on your 1st and 2nd fingers.

7. With your other hand remove the oxygen sensor, place it in the upper section of the sensor housing ensuring the PCB contacts the two gold pins and use your thumb to hold the sensor and upper section of the sensor housing together.
8. The sensor is now exposed to ambient air, connected to the analyzer electronics and ready for calibration.
9. With the sensor exposed to ambient air – allow the reading to stabilize before adjusting the SPAN actuator/potentiometer.
10. After the reading stabilizes, turn the SPAN actuator/potentiometer ½ turn at a time until the LED display reads the 20.9 oxygen content of ambient air.
11. **Caution:** Turning the actuator/potentiometer more the ½ turn recommended does not allow the electronics sufficient time to keep pace with the adjustment. And since adjustments are rarely made in one consecutive turn – there is a real possibility that the 2nd and 3rd part of the adjustment could unknowingly be based on "values that have not stabilized" thereby resulting in an inaccurate calibration.



12. Reinstall the sensor as follows:
13. Place the sensor in the bottom section of the sensor housing with the PCB facing up.
14. Place the upper section of the sensor housing over the sensor.
15. Gently push the upper section downward and rotate 90º to engage the clamp.
16. Finger tighten the clamp bolt and one full turn with the 5/16 wrench to compressed the o-ring seal.
17. **Note:** Manually turn the RANGE selector switch to follow the progress of the sensor's recovery from exposure to air during installation.
18. Begin sampling once the analyzer has reached the value of the purge gas.

Sampling

The sensor is exposed to sample gas that must flow or be drawn through the analyzer's internal sample system. To ensure your applications and gas sample are consistent with your expectations, review the Installation considerations in section 3.

Pico-Ion MS sensor: Slightly more sensitive to changes in flow rates but changes of 1-3 SCFH cause no appreciable change in the oxygen reading. However, higher flow rates and/or sudden changes in flow rates can cause erratic readings or even damage the sensor. A FLOW valve upstream of the sensor controls the flow rate of the sample gas which is displayed by the flow indicator downstream of the sensor. A flow rate of 1 SCFH is recommended for optimum performance.

Galvanic ppm sensor: Flow rates of 1-5 SCFH cause no appreciable change in the oxygen reading. However, flow rates above 5 SCFH can generate erroneous oxygen readings. A FLOW valve upstream of the sensor controls the flow rate of the sample gas which is displayed by the flow indicator downstream of the sensor. A flow rate of 2 SCFH is recommended for optimum performance.

Galvanic percent sensors: Flow rates of 1-5 SCFH cause no appreciable change in the oxygen reading. However, flow rates above 5 SCFH can generate erroneous oxygen readings. A FLOW METER with integral metering valve upstream of the sensor controls the flow rate of the sample gas and displays the flow rate. A flow rate of 2 SCFH is recommended for optimum performance.

Application Pressure - Positive:
A FLOW valve positioned upstream of the sensor controls the sample flow rate to the recommended flow rate. If necessary, a pressure regulator (with a metallic diaphragm is recommended for optimum accuracy, the use of diaphragms of more permeable materials may result in erroneous readings) upstream of the flow control valve should be used to regulate the inlet pressure as specified in section 4.

Application Pressure - Atmospheric or Slightly Negative:
For accurate ppm range oxygen measurements, an optional integral sampling pump is positioned downstream of the sensor to draw the sample from the process, by the sensor and out to atmosphere.

Caution: If the analyzer is equipped with an optional integral sampling pump (positioned downstream of the sensor), completely open the FLOW valve (positioned upstream of the sensor) to avoid drawing a vacuum on the sensor and placing an undue burden on the pump.

Review the Sample System discussion found in the Principle of Operation section at the beginning of section 5.

Procedure:
1. Select the desired sampling range that provides maximum resolution.
2. Use metal tubing to transport the sample gas to the analyzer. The main consideration is to eliminate air leaks which can affect oxygen measurements.
3. Ensure the upper and bottom sections of the sensor housing are secured tightly by the U-shaped clamp and bolt in the center of the bottom section of the sensor housing.
4. Ensure the sample gas tube fittings are properly installed with both ferrules, finger tightened and ¾ of a turn for 1/8" tubing and 1-1/4 of a turn for ¼" tubing.
5. Assure there are no restrictions in the sample gas lines – inlet or vent.
6. For sample gases under positive pressure the user must provide a means of regulating the inlet pressure between 5-30 psig, the analyzer is equipped with a FLOW VALVE to set the flow rate at the recommended 2 SCHF.
7. For sample gases under atmospheric or slightly negative pressure an optional sampling pump is recommended to draw the sample into the analyzer. Generally, no pressure regulation or flow control device is involved.
8. **Caution:** If the analyzer is equipped with both a FLOW valve upstream of the sensor and an integral SAMPLING PUMP downstream of the sensor, always open the FLOW valve completely before operating the pump (avoid drawing a vacuum on the sensor).
9. Assure the sample is adequately vented for optimum response and recovery – and safety.

To avoid erroneous oxygen readings and damaging the sensor:
1. Do not place your finger over the vent (it pressurizes the sensor) to test the flow indicator when gas is flowing to the sensor. Removing your finger (the restriction) generates a vacuum on the sensor and may damage the sensor (voiding the sensor warranty).
2. If the analyzer is equipped with an optional integral sampling pump (positioned downstream of the sensor), completely open the flow control metering valve (positioned upstream of the sensor) to avoid drawing a vacuum on the sensor and placing an undue burden on the pump.
3. Assure there are no restrictions in the sample or vent lines
4. Avoid drawing a vacuum that exceeds 14" of water column pressure – unless done gradually
5. Avoid changes in flow rate and excessive flow rates which generate backpressure on the sensor.
6. Avoid sudden releases of backpressure that can severely damage the sensor.
7. Avoid the collection of particulates, liquids or condensation collect on the sensor that could block the diffusion of oxygen into the sensor.

Standby
The analyzer has no special storage requirements.
- The sensor should remain connected during storage periods – place the SAMPLE/BYPASS valve in the BYPASS position and close the SHUT OFF completely.
- Store the analyzer with the power OFF.
- If storing for an extended period of time, charge before operating.

6 Maintenance

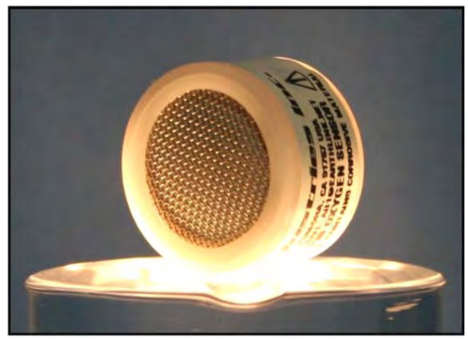
With exception of components related to optional equipment and charging the battery of portable analyzers, cleaning the electrical contacts when replacing the sensor is the extent of the maintenance requirements of this analyzer as there are no serviceable parts in the analyzer given the nature of the solid state electronics and sensor.

Serviceability: Except for replacing the oxygen sensor, there are no parts inside the analyzer for the operator to service. Only trained personnel with the authorization of their supervisor should conduct maintenance.

Sensor Replacement

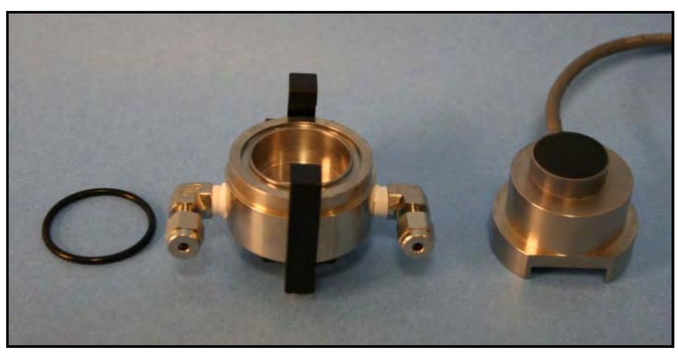
Periodically, the oxygen sensor will require replacement. The operating life is determined by a number of factors that are influenced by the user and therefore difficult to predict. The Specifications found in section 4 define the normal operating conditions and expected life of the oxygen sensors utilized by the analyzer. Expected sensor life is inversely proportional to changes in oxygen concentration, pressure and temperature.

Caution: DO NOT open the oxygen sensor. The sensor contains a corrosive liquid electrolyte that could be harmful if touched or ingested, refer to the Material Safety Data Sheet contained in the Owner's Manual.



Procedure:

1. Regardless of the type of sensor the analyzer is equipped with, the procedure for replacing an oxygen sensor is the same. Note: Pico-Ion MS sensor cannot be calibrated with air.
2. Determine your calibration requirements by reviewing the Calibration discussion in section 5 Operation, pay particular attention to the recovery times and span gas available.
3. Remove the bolts and open the door of the enclosure.
4. Using the 5/16 wrench supplied loosen but do not remove the clamp bolt located in the center of the bracket attached to bottom section with the elbow fittings.
5. Rotate the upper section of the sensor housing 90º to disengage from the clamp.
6. Remove the upper section by pulling it straight up and place it on a smooth surface.
7. Remove the old oxygen sensor and dispose of it as you would a battery.
8. Remove the o-ring from the bottom section of the sensor housing.
9. Wipe the o-ring with a damp lint free cloth.
10. Lightly lubricate the o-ring with vacuum grease for optimal seal.
11. Reinstall the o-ring into the bottom section of the sensor housing.
12. Place the analyzer in the OXYGEN mode.
13. Advance the red LED to the 0-25% RANGE.
14. Connect zero gas or low oxygen content sample gas line to purge the lines and the sensor of oxygen to the appropriate range for zero and/or span calibration.
15. **Caution:** Minimize the time the new sensor is exposed to ambient air.
16. The flow rate should already be set to 2 SCFH.
17. Remove the new oxygen sensor from the shipping bag.
18. Remove the red label and the gold ribbon (shorting device) from the PCB at the rear of the sensor.
19. Place the new sensor in the bottom section of the sensor housing with the PCB facing up.
20. Place the upper section of the sensor housing over the sensor.
21. Gently push the upper section downward and rotate 90º to engage the clamp.
22. Finger tighten the clamp bolt and one full turn with the 5/16 wrench to compressed the o-ring seal.
23. Expect the analyzer reading to recover to ppb levels as described in the analyzer specification.
24. Perform the desired calibration(s). Note: Manually turn the RANGE selector switch to follow the progress of the sensor's recovery from exposure to air during installation. Begin sampling once the analyzer has reached the value of the purge gas.



7 Spare Parts

Recommended spare parts for the GPR-18MS Explosion Proof ppm Oxygen Analyzer:

Item No.	Description
GPR-12-2000MS	ppm Oxygen Sensor

Other spare parts:

Item No.	Description
IC-1007	Amplifier E/I Converter 4-20mA Isolated
CTRL-1004	Controller Temperature Proportional
A-3290	Flow Indicator 1/4” FNPT SS Glass Viton O-rings 2x10”
FUSE-1001	Fuse 3A 240V .25 x 1.25”
FUSE-1002	Fuse Holder 3A 240V .25 x 1.25”
HTR-1002	Heater 110VAC
HTR-1003	Heater 220VAC
MTR-1002	Meter Digital Panel LED 3.5 Digit
ORNG-1007	O-ring 3/32 x 1-3/8 x 1-9/16 Viton
A-1106-MS	PCB Assembly Main / Display
A-1107-MS	PCB Assembly Power Supply / Interconnection
B-2474-4-12	Sensor Housing Assembly Stainless Steel
A-1016-A	Sensor Housing Bottom Assembly Stainless Steel
B-2762-B-4-12	Sensor Housing Upper Assembly Stainless Steel
SNSR-1001	Sensor Temperature RTD
SNSR-1002	Sensor Temperature Runaway Protector J-2
A-2610	Switch Assembly Range
TOOL-1001	Tool 5/16” Combination Wrench
VALV-1004	2-Way SS Flow Metering Valve
VALV-1014	2-Way SS Shut Off Valve 90° Turn

Recommended spare parts for the GPR-18 Explosion Proof ppm Oxygen Analyzer:

Item No.	Description
GPR-12-333	ppm Oxygen Sensor
XLT-12-333	ppm Oxygen Sensor

Other spare parts:

Item No.	Description
IC-1007	Amplifier E/I Converter 4-20mA Isolated
CTRL-1004	Controller Temperature Proportional
A-3290	Flow Indicator 1/4” FNPT SS Glass Viton O-rings 2x10”
FUSE-1001	Fuse 3A 240V .25 x 1.25”
FUSE-1002	Fuse Holder 3A 240V .25 x 1.25”
HTR-1002	Heater 110VAC
HTR-1003	Heater 220VAC
MTR-1002	Meter Digital Panel LED 3.5 Digit
ORNG-1007	O-ring 3/32 x 1-3/8 x 1-9/16 Viton
A-1106-M	PCB Assembly Main / Display
A-1107-M	PCB Assembly Power Supply / Interconnection
A-1004-2-28	Sensor Housing Assembly Stainless Steel
A-1016-A	Sensor Housing Bottom Assembly Sensor Stainless Steel
B-2762-A-2-28	Sensor Housing Upper Assembly Stainless Steel
SNSR-1001	Sensor Temperature RTD
SNSR-1002	Sensor Temperature Runaway Protector J-2
A-2610	Switch Assembly Range
TOOL-1001	Tool 5/16” Combination Wrench
VALV-1004	2-Way SS Flow Metering Valve
VALV-1014	2-Way SS Shut Off Valve 90° Turn

Recommended spare parts for the GPR-28 % O_2 Analyzer include:

Item No.	Description
GPR-11-32	Oxygen Sensor
XLT-11-24	Oxygen Sensor

Other spare parts:

Item No.	Description
IC-1007	Amplifier E/I Converter 4-20mA Isolated
CTRL-1004	Controller Temperature Proportional
FMTR-1002	Flow Meter SS ¼" FNPT Ports Viton O-Rings 5 SCFH Scale
FUSE-1001	Fuse 3A 240V .25 x 1.25"
FUSE-1002	Fuse Holder 3A 240V .25 x 1.25"
HTR-1002	Heater 110VAC
HTR-1003	Heater 220VAC
MTR-1002	Meter Digital Panel LED 3.5 Digit
ORNG-1007	O-ring 3/32 x 1-3/8 x 1-9/16 Viton
A-1106-C	PCB Assembly Main / Display
A-1107-C	PCB Assembly Power Supply / Interconnection
A-1004-2-28	Sensor Housing Assembly Stainless Steel
A-1016-A	Sensor Housing Bottom Assembly Sensor Stainless Steel
B-2762-A-2-28	Sensor Housing Upper Assembly Stainless Steel
SNSR-1001	Sensor Temperature RTD
SNSR-1002	Sensor Temperature Runaway Protector J-2
A-2610	Switch Assembly Range
TOOL-1001	Tool 5/16" Combination Wrench

8 Troubleshooting

Symptom	Possible Cause	Recommended Action
Slow recovery or response time	At installation, defective sensor	Replace sensor if recovery unacceptable or O_2 reading fails to reach 10% of lowest range
	Failure to purge gas lines with Bypass, air leak in connections, dead legs, distance of sample line, low flow rate, volume of optional filters and scrubbers	Leak test the entire sample system: Vary the flow rate, if the O_2 reading changes inversely with the change in flow rate indicates an air leak - correct source of leak
	Abnormality in zero gas	Qualify zero gas (using portable analyzer)
	Damaged in service - prolonged exposure to air, electrolyte leak	Replace sensor
	Sensor nearing end of life	Replace sensor
High O_2 reading after installing or replacing sensor	Analyzer calibrated before sensor stabilized caused by: 1) Prolonged exposure to ambient air, worse if sensor was **unshorted**	Allow O_2 reading to stabilize before making the span/calibration adjustment Continue purge with zero gas
	2) Air leak in sample system connection(s)	Leak test the entire sample system (above)
	3) Abnormality in zero gas	Qualify zero gas (using portable analyzer)
High O_2 reading Sampling	Flow rate exceeds limits	Correct pressure and flow rate
	Pressurized sensor	Remove restriction on vent line, replace sensor
	Improper sensor - CO_2 affects GPR sensor	Use XLT sensor when CO_2 or acid gases are present
	Abnormality in gas	Qualify the gas (use a portable analyzer)
Reading doesn't agree to expected O_2 values	Pressure and temperature of the sample is different than span gas	Calibrate the analyzer (calibrate at pressure and temperature of sample)
	Abnormality in gas	Qualify the gas (use a portable analyzer)
	Failure to allow reading to stabilize before zero and/or span calibration adjustments	Repeat calibration procedure and allow reading (sensor) to stabilize
	Calibration error caused by turning the zero and/or span potentiometer more than ½ turn at a time (electronics need time to keep up	Repeat calibration, allow reading to stabilize and make adjustments ½ turn at a time

Symptom	Possible Cause	Recommended Action
Erratic O_2 reading	Change in sample pressure	Repeat calibration at the temperature and pressure of sample
	Dirty electrical contacts in upper section of sensor housing	Clean contacts with alcohol (minimize exposure time of MS sensor to ambient air to extent possible)
	Corroded solder joints on sensor PCB from corrosive sample or electrolyte leakage from sensor	Replace sensor and return sensor to the factory for warranty determination
	Corroded spring loaded contact in upper section of sensor housing from liquid in sample or electrolyte leakage from sensor	**Upper section of sensor housing:** Clean contacts with alcohol, flow sample or zero gas for 2-3 hours to flush sample system and sensor housing **Sensor:** Replace if leaking and return it to the factory for warranty determination
	Liquid covering sensing area	Wipe with alcohol and lint free towel or flow sample or zero gas for 2-3 hours to flush
	Presence of interference gases	Consult factory
	Presence of sulfur gases and/or CO_2	Replace sensor and install scrubber, contact factory
	Unauthorized maintenance	Replace sensor, obtain authorized service
No O_2 reading Negative O_2 reading	Failure of an electronic component or power surge that sends a charge to the sensor	Service the analyzer, check the power source and THEN replace the sensor
	Pressurizing the sensor by: a) Flowing gas to the sensor with the vent restricted or SHUT OFF valve closed and suddenly removing the restriction draws a vacuum and can damage the sensor and/or cause electrolyte leakage b) Drawing a vacuum on the sensor by partially opening the FLOW valve upstream of the sensor when using a pump downstream to draw sample from a process at atmospheric pressure or a slight vacuum can damage the sensor and cause it to leak electrolyte	Introduce span gas to determine if the sensor responds. If successful calibrate the analyzer and resume sampling If not successful, inspect for electrolyte leakage, check and clean the contacts in the upper section of the sensor housing, flow a little warm water followed by air or clean sample through the analyzer for 2-3 hours to push the electrolyte through the sample system and THEN replace the sensor

Purpose: SPAN CALIBRATION of digital (reference to analog) ppm O_2 analyzer already in-service.
TROUBLESHOOT ppm O_2 analyzer to confirm response and stability <u>under controlled conditions.</u>

Preliminary Test

1.) Confirm metal sample system components - no plastic.
2.) Leak Test: Vary analyzer flow rate up/down and observe reading.

Reading stable?

No →
1.) Tighten and 'Snoop' connections
2.) STOP if reading is not stable and contact factory.

Yes ↓

Set-up

1.) Place analyzer SAMPLE/BYPASS valve(s) in BYPASS mode, see (a) below.
2.) Select AUTO-RANGING mode or MANUALLY select range for span gas
3.) Perform DEFAULT ZERO or MANUALLY eliminate previous zero adjustments
4.) Perform DEFAULT SPAN
Note: Zeroing the analyzer is only recommended for continuous analysis < 1 ppm which normally excludes portable analyzers - constantly changing gas lines.

Connect Gas Line

1.) Connect the span gas line or if equipped with a 3-way SAMPLE/SPAN valve place it in the SPAN mode.
2.) Allow the span gas to flow for 5-10 minutes to purge the air (20.9% O_2) from inside the span gas line - during connection or leaks during standby.

If analyzer is not equipped with BYPASS SAMPLE SYSTEM, see (a) below:
1.) Purge the span gas line before connecting to the analyzer.
2.) Connect the gas lines as quickly as possible - some air will be introduced.
3.) Allow extra time for the reading to stabilize - the sensor was exposed to air.
4.) When off-line, maintain gas flow thru analyzer or cap connections (inlet first) to avoid damaging the sensor by exposing it to air (20.9% O_2).

Calibration Procedure

1.) Place analyzer SAMPLE/BYPASS valve(s) in SAMPLE mode, see (a) below.
2.) Allow the reading to stabilize, normally 2-10 minutes unless exposed to air.
3.) Once stable - initiate CALIBRATION routine (or unlock and adjust SPAN knob) from MAIN MENU, select SPAN CALIBRATE, enter SPAN VALUE, press ENTER.

Calibration successful?

No →
1.) Confirm span gas with portable analyzer calibrated with ambient air.
2.) Repeat at least twice.
3.) Replace sensor and repeat once.
4.) If unsuccessful with new sensor, STOP and contact factory.

Yes ↓

Troubleshooting

Note: SPAN CALIBRATION is complete and for TROUBLESHOOTING purposes demonstrates the sensor/analyzer responds normally - <u>under controlled conditions</u>.
For TROUBLESHOOTING purposes only: Connect one of the analyzer's signal outputs to an external recording device and continue the flow of span gas for 1-2 hours.

Reading stable?

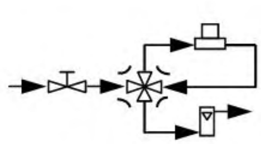
No →
1.) Replace sensor and repeat once.
2.) If unsuccessful with new sensor, STOP and contact factory.

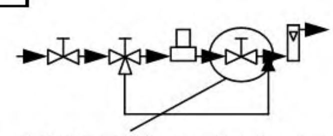
Yes ↓

Sampling

1.) Place analyzer SAMPLE/BYPASS valve(s) in BYPASS mode, see (a) below.
2.) Connect Gas Line - as above for sample gas.
3.) Place analyzer SAMPLE/BYPASS valve(s) in SAMPLE mode, see (a) below.

(a) Analyzer equipped (or supplied by user) with either type of BYPASS SAMPLE SYSTEM:



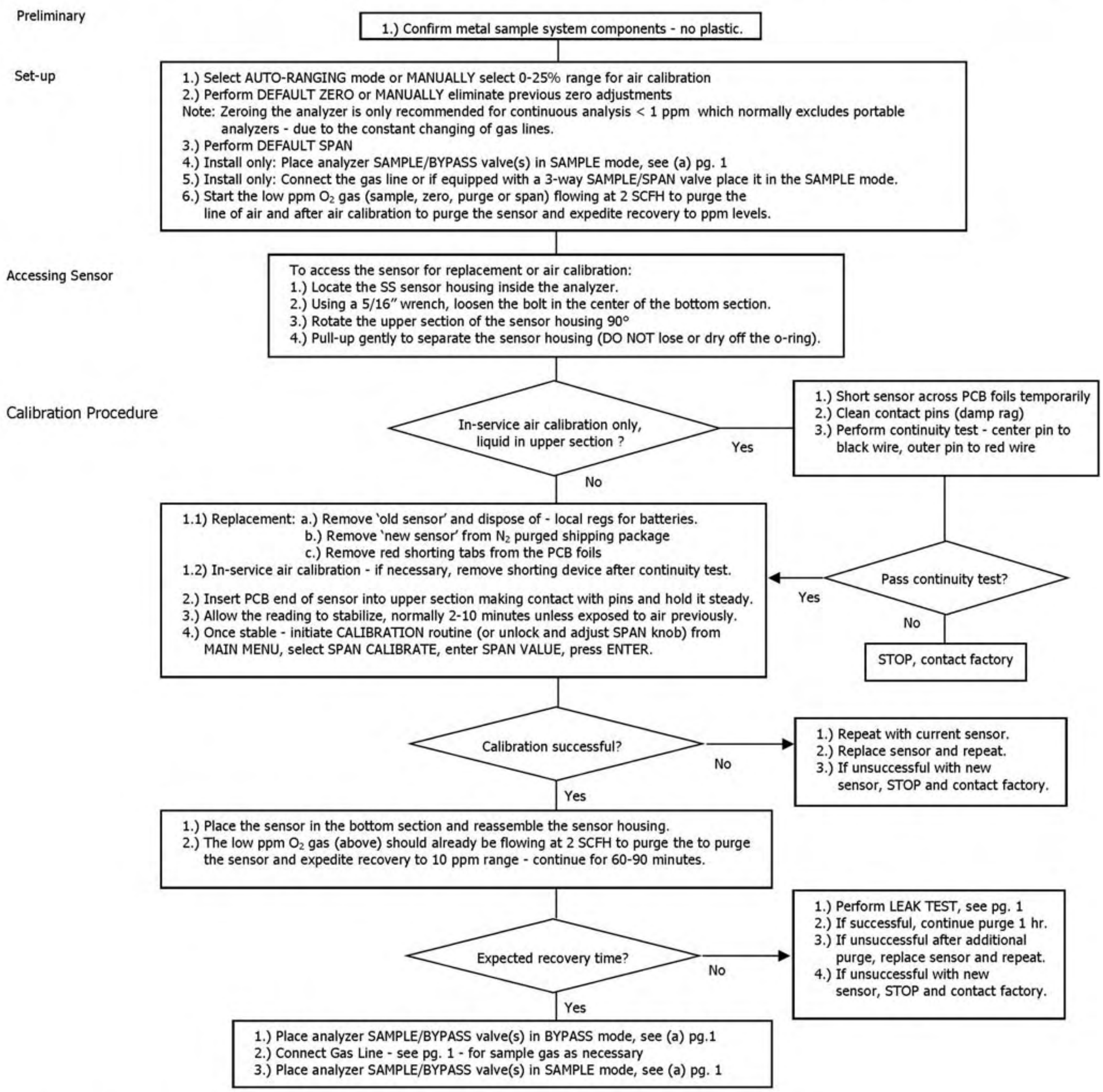


SHUT OFF VALVE - open first, close last

Purpose: AIR CALIBRATION of digital (reference to analog) ppm O_2 analyzer (only use for 0-25% range):
- a.) when installing a new sensor,
- b.) when span gas (instrument air piped to sensor - address as SPAN CALIBRATION) is not available or
- c.) when it is advantageous from a troubleshooting standpoint to employ a portable analyzer that has been calibrated with ambient air as a "referee" to confirm other analyzers or span gas values.

Note 1: The drawback to air calibration is the time required for a ppm sensor exposed to air (1-2 minutes for calibration purposes) to recover to the 0-10 ppm range and the added requirement for low ppm O_2 concentration gas (sample, zero, purge or span) to purge the sensor of the oxygen that dissolves into the sensor's electrolyte when exposed to air (20.9% or 209,000 ppm O_2)

Note 2: Expected recovery time to 10 ppm on 1-2 ppm purge gas is < 1 hr at installation and < 20 minutes for an analyzer that has been in-service > 2 weeks. For higher ppm analysis, expected recovery time to 80-100 ppm on 1-2 ppm purge gas is < 10 minutes.



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9 Warranty

The design and manufacture of Advanced Instruments Inc. oxygen analyzers and oxygen sensors are performed under a certified Quality Assurance System that conforms to established standards and incorporates state of the art materials and components for superior performance and minimal cost of ownership. Prior to shipment every analyzer is thoroughly tested by the manufacturer and documented in the form of a Quality Control Certification that is included in the Owner's Manual accompanying every analyzer. When operated and maintained in accordance with the Owner's Manual, the units will provide many years of reliable service.

Coverage
Under normal operating conditions, the analyzers and sensors are warranted to be free of defects in materials and workmanship for the period specified in accordance with the most recent published specifications, said period begins with the date of shipment by the manufacturer. The manufacturer information and serial number of this analyzer are located on the rear of the analyzer. Advanced Instruments Inc. reserves the right in its sole discretion to invalidate this warranty if the serial number does not appear on the analyzer.

If your Advanced Instruments Inc. analyzer and/or oxygen sensor is determined to be defective with respect to material and/or workmanship, we will repair it or, at our option, replace it at no charge to you. If we choose to repair your purchase, we may use new or reconditioned replacement parts. If we choose to replace your Advanced Instruments Inc. analyzer, we may replace it with a new or reconditioned one of the same or upgraded design. This warranty applies to all monitors, analyzers and sensors purchased worldwide. It is the only one we will give and it sets forth all our responsibilities.

There are no other express warranties. This warranty is limited to the first customer who submits a claim for a given serial number and/or the above warranty period. Under no circumstances will the warranty extend to more than one customer or beyond the warranty period.

Limitations
Advanced Instruments Inc. will not pay for: loss of time; inconvenience; loss of use of your Advanced Instruments Inc. analyzer or property damage caused by your Advanced Instruments Inc. analyzer or its failure to work; any special, incidental or consequential damages; or any damage resulting from alterations, misuse or abuse; lack of proper maintenance; unauthorized repair or modification of the analyzer; affixing of any attachment not provided with the analyzer or other failure to follow the Owner's Manual. Some states and provinces do not allow limitations on how an implied warranty lasts or the exclusion of incidental or consequential damages, these exclusions may not apply.

Exclusions
This warranty does not cover installation; defects resulting from accidents; damage while in transit to our service location; damage resulting from alterations, misuse or abuse; lack of proper maintenance; unauthorized repair or modification of the analyzer; affixing of any label or attachment not provided with the analyzer; fire, flood, or acts of God; or other failure to follow the Owner's Manual.

Service
Call Advanced Instruments Inc. at 909-392-6900 (or e-mail info@aii1.com) between 7:30 AM and 5:00 Pacific Time Monday thru Thursday or before 12:00 PM on Friday. Trained technicians will assist you in diagnosing the problem and arrange to supply you with the required parts. You may obtain warranty service by returning you analyzer, postage prepaid to:

Advanced Instruments Inc.
2855 Metropolitan Place
Pomona, Ca 91767 USA

Be sure to pack the analyzer securely. Include your name, address, telephone number, and a description of the operating problem. After repairing or, at our option, replacing your Advanced Instruments Inc. analyzer, we will ship it to you at no cost for parts and labor.

10 MSDS – Material Safety Data Sheet

Product Identification	
Product Name	Oxygen Sensor Series - PSR, GPR, AII, XLT
Synonyms	Electrochemical Sensor, Galvanic Fuel Cell
Manufacturer	Analytical Industries Inc., 2855 Metropolitan Place, Pomona, CA 91767 USA
Emergency Phone Number	909-392-6900
Preparation / Revision Date	January 1, 1995
Notes	Oxygen sensors are sealed, contain protective coverings and in normal conditions do not present a health hazard. Information applies to electrolyte unless otherwise noted.
Specific Generic Ingredients	
Carcinogens at levels > 0.1%	None
Others at levels > 1.0%	Potassium Hydroxide or Acetic Acid, Lead
CAS Number	Potassium Hydroxide = KOH 1310-58-3 or Acetic Acid = 64-19-7, Lead = Pb 7439-92-1
Chemical (Synonym) and Family	Potassium Hydroxide (KOH) – Base or Acetic Acid (CH_3CO_2H) – Acid, Lead (Pb) – Metal
General Requirements	
Use	Potassium Hydroxide or Acetic Acid - electrolyte, Lead - anode
Handling	Rubber or latex gloves, safety glasses
Storage	Indefinitely
Physical Properties	
Boiling Point Range	KOH = 100 to 115° C or Acetic Acid = 100 to 117° C
Melting Point Range	KOH -10 to 0° C or Acetic Acid – NA, Lead 327° C
Freezing Point	KOH = -40 to -10° C or Acetic Acid = -40 to -10° C
Molecular Weight	KOH = 56 or Acetic Acid – NA, Lead = 207
Specific Gravity	KOH = 1.09 @ 20° C, Acetic Acid = 1.05 @ 20° C
Vapor Pressure	KOH = NA or Acetic Acid = 11.4 @ 20° C
Vapor Density	KOH – NA or Acetic Acid = 2.07
pH	KOH > 14 or Acetic Acid = 2-3
Solubility in H_2O	Complete
% Volatiles by Volume	None
Evaporation Rate	Similar to water
Appearance and Odor	Aqueous solutions: KOH = Colorless, odorless or Acetic Acid = Colorless, vinegar-like odor
Fire and Explosion Data	
Flash and Fire Points	Not applicable
Flammable Limits	Not flammable
Extinguishing Method	Not applicable
Special Fire Fighting Procedures	Not applicable
Unusual Fire and Explosion Hazards	Not applicable
Reactivity Data	
Stability	Stable
Conditions Contributing to Instability	None
Incompatibility	KOH = Avoid contact with strong acids or Acetic Acid = Avoid contact with strong bases
Hazardous Decomposition Products	KOH = None or Acetic Acid = Emits toxic fumes when heated
Conditions to Avoid	KOH = None or Acetic Acid = Heat
Spill or Leak	
Steps if material is released	If the sensor leaks inside the plastic shipping bag or inside an analyzer sensor housing do not remove it without rubber or latex gloves and safety glasses and a source of water. Wipe all surfaces repeatedly with water or wet paper towel (fresh each time).

Disposal	In accordance with federal, state and local regulations.
Health Hazard Information	
Primary Route(s) of Entry	Ingestion, eye and skin contact
Exposure Limits	Potassium Hydroxide - ACGIH TLV 2 mg/cubic meter or Acetic Acid - ACGIH TLV / OSHA PEL 10 ppm (TWA), Lead - OSHA PEL .05 mg/cubic meter
Ingestion	Electrolyte could be harmful or fatal if swallowed. KOH = Oral LD50 (RAT) = 2433 mg/kg or Acetic Acid = Oral LD50 (RAT) = 6620 mg/kg
Eye	Electrolyte is corrosive and eye contact could result in permanent loss of vision.
Skin	Electrolyte is corrosive and skin contact could result in a chemical burn.
Inhalation	Liquid inhalation is unlikely.
Symptoms	Eye contact - burning sensation. Skin contact - soapy slick feeling.
Medical Conditions Aggravated	None
Carcinogenic Reference Data	KOH and Acetic Acid = NTP Annual Report on Carcinogens - not listed; LARC Monographs - not listed; OSHA - not listed
Other	Lead is listed as a chemical known to the State of California to cause birth defects or other reproductive harm.
Special Protection	
Ventilation Requirements	None
Eye	Safety glasses
Hand	Rubber or latex gloves
Respirator Type	Not applicable
Other Special Protection	None
Special Precautions	
Precautions	Do not remove the sensor's protective Teflon and PCB coverings. Do not probe the sensor with sharp objects. Wash hands thoroughly after handling. Avoid contact with eyes, skin and clothing. Empty sensor body may contain hazardous residue.
Transportation	Not applicable