GPR-3500 MO
Portable Oxygen Purity Analyzer

Owner's Manual

2855 Metropolitan Place, Pomona, CA 91767 USA Tel: 909-392-6900, Fax: 909-393-3665, e-mail: info@aii1.com, www.aii1.com

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1 Introduction

Your new oxygen portable oxygen purity analyzer incorporates an advanced electrochemical sensor specific to oxygen along with state-of-the-art digital electronics designed to give you years of reliable precise oxygen measurements in variety of industrial oxygen applications.

To obtain maximum performance from your new oxygen portable oxygen purity 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, to design the portable oxygen purity analyzer for superior performance and minimal cost of ownership. This portable oxygen purity 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 portable oxygen purity analyzer is your assurance that we stand behind every portable oxygen purity analyzer sold.

The serial number of this portable oxygen purity analyzer may be found on the inside the portable oxygen purity 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-3500MO Oxygen Purity Transmitter	S/N ____________________	________
Sensor:	GPR-11-120-4 Oxygen Sensor	S/N ____________________	________
Accessories:	Owner's Manual		________
	A-2221 Sensor Flow Housing 1/8" FNPT (integral)		________
			________
Configuration:	A-1151-B3 PCB Assembly	Software Ver. _________	________
	Range(s): 0-100%		________
	NEMA 4 rated wall mount enclosure		________
Test:	Default zero (without sensor)		________
	Default span @ 20uA		________
	No interruption in operation when connecting AC charger/adapter		________
	Calibrates at 20.9% oxygen in ambient air and 100% oxygen with adequate span		________
	Analog signal output 0-1V (0-100% oxygen)		________
	Baseline drift on zero gas < ± 2% FS over 24 hour period		________
	Noise level < ± 1.0% FS		________
	Span adjustment within 10-50% FS		________
Final:	Overall inspection for physical defects		________
Options:			________
Notes:			________

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. **Note:** In natural gas applications such as extraction and transmission, a low voltage current is applied to the pipeline itself to inhibit corrosion. As a result, electronic devices can be affected unless adequately grounded.

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 as the last page 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. Deviations are outside the specifications and will affect the life of the sensor. As a rule of thumb sensor life is inversely proportional to changes in the parameters.

Accuracy & Calibration: Refer to section 5 Operation.

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 fuel cell type oxygen sensors. With respect to analyzers equipped with Pico-Ion UHP and MS oxygen sensors, refer to the analyzer's specifications.

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 their particular rating 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.

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). To avoid generating a vacuum on the sensor (as described above) during operation, always select and install the vent fitting first and remove the vent fitting last.

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, they block the diffusion of oxygen into the sensor - 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 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, digital analyzers 50 watts without optional heaters. Optional 110V and 220V heaters AC powered heaters consume an additional 100-150 watts; DC powered digital analyzers consume 30 watts, 40 watts with the optional DC powered heater.

4 Features & Specifications

See last page, this page left blank intentionally.

5 Operation

Principle of Operation

The GPR-3500MO portable oxygen purity analyzer incorporates a unique advanced electrochemical galvanic fuel cell type sensor. The portable oxygen purity analyzer is configured in an intrinsically safe design and meets the intrinsic safety standards required for use in Class 1, Division 1, Groups A, B, C, D hazardous areas.

Advanced Galvanic Sensor Technology

The sensors are specific for oxygen. They measure the partial pressure of oxygen from low ppm to 100% levels in inert gases, gaseous hydrocarbons, helium, hydrogen, mixed gases, acid gas streams and ambient air. Oxygen, the fuel for this electrochemical transducer, diffusing into the sensor 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 ranges and remains virtually constant over its useful life. The sensor requires no maintenance and is easily and safely replaced at the end of its useful life.

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 and reliable quality. 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 expanding the operating temperature range for percentage range sensors from -30°C to 50°C.

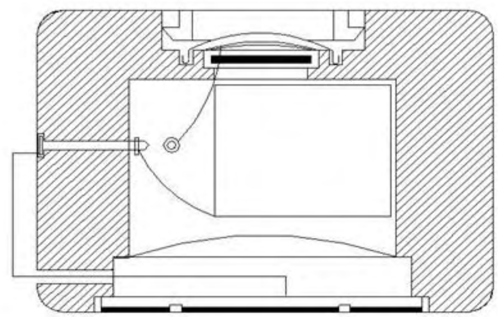
The sensor employed by the GPR-3500MO is but one part of the proprietary advancements in sensor technology. It is the only electrochemical galvanic sensor available that is capable measuring 100% oxygen on a continuous 24/7 basis.

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 power micro-processor based digital circuitry. 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 the 0-1V signal output jack.

Power is supplied by an integral rechargeable lead acid battery which provides enough power to operate the analyzer continuously for approximately 60 days. Expect 8-10 hours service from a single battery charge when using the pump on a regular basis. An LED located on the front panel provides a blinking 72 hour warning to recharge the battery. A 9VAC adapter (positive pole located on the inside of the female connector) can be used to recharge the battery from a convenience outlet. The analyzer is designed to be fully operational during the 8-10 hour charging cycle which is indicated by a second continuously lit LED.

Sample System

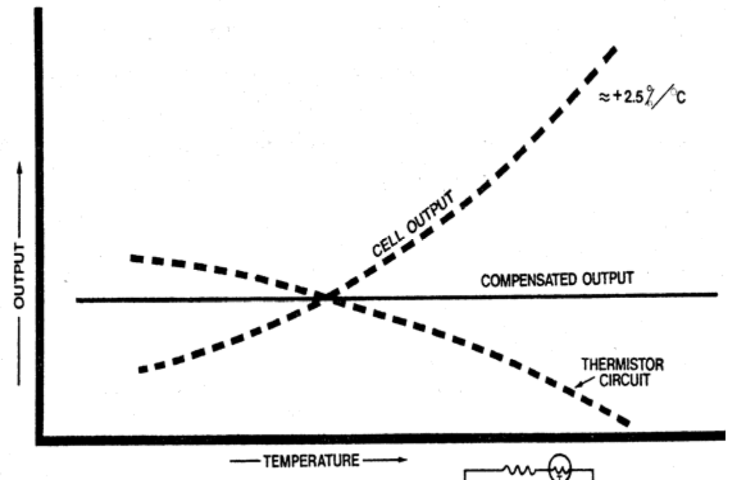
The GPR-3500MO is supplied with panel mounted flow meter for maximum portability. Users interested in adding their own sample conditioning system should consult the factory. Advanced Instruments Inc. offers a full line of sample handling, conditioning and expertise to meet your application requirements. Contact us at 909-392-6900 or e-mail us at aii2@earthlink.net

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.

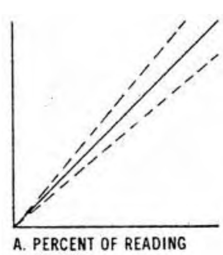
Pressure: Because sensors are sensitive to the partial pressure of oxygen in the sample gas their output is a function of the number of molecules of oxygen 'per unit volume'. Readouts in percent are permissible only when the total pressure of the sample gas being analyzed remains constant. The pressure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



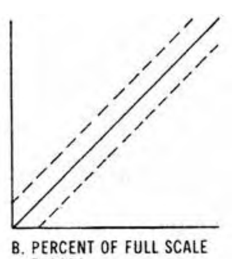
Temperature: The rate oxygen molecules diffuse into the sensor is controlled by a Teflon membrane otherwise known as an 'oxygen diffusion limiting barrier' and all diffusion processes are temperature sensitive, the fact the sensor's electrical output will vary with temperature is normal. This variation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

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 10-15º produce < 1% error.

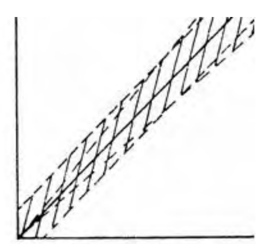
Accuracy: In light of the above parameters, the overall accuracy of an analyzer is affected by two types of errors: 1) those producing 'percent of reading errors', illustrated by Graph A below, such as ±5% temperature compensation circuit, tolerances of range resistors and the 'play' in the potentiometer 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.

Zero Calibration

In theory, the galvanic fuel cell type oxygen has an absolute zero meaning it produces no signal output when exposed to an oxygen free sample gas. In reality, expect the analyzer to generate 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 Offset capability of the analyzer is limited to 50% of lowest most sensitive range available with the analyzer.

As part of our Quality Control Certification process, the zero capability of every ppm 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 analyzer by the factory

Recommendations:

- Zero calibration is recommended only for online analyzers performing continuous analysis below 5% of the lowest most sensitive range available with a ppm analyzer, e.g. analysis below 0.05 ppm on the 0-1 ppm range, 0.5 ppm on the 10 ppm range, or below 0.1% (1000 ppm) with a percent analyzer.
- Determining the true Zero Offset requires approximately 24 hours to assure the galvanic fuel cell sensor has consumed the oxygen that has dissolved into the electrolyte inside the sensor while exposed to air or percentage levels of oxygen. Allow the analyzer to stabilize with flowing zero gas as evidenced by a stable reading or horizontal trend on an external recording device. For optimum accuracy, utilize as much of the actual sample system as possible.
- Zero calibration is not practical and not recommended for portable analyzers or measurements on higher ranges. However, satisfying these users that the zero offset is acceptable for their application without the 24 hour wait can be accomplished by introducing a zero gas (or sample gas with a low ppm oxygen concentration) to the analyzer. Unless the zero gas is contaminated or there is a significant leak in the sample connections, the analyzer should read less than 100 ppm oxygen within 10 minutes after being placed on zero gas thereby indicating it is operating normally.
- Zero calibration should precede span calibration.
- Initiate the DEFAULT ZERO and DEFAULT SPAN procedures before performing either a ZERO or SPAN CALIBRATION.
- **Caution:** Prematurely initiating the ZERO CALIBRATION function can result in negative readings near zero.
- Once the zero offset adjustment is made, zero calibration is normally not required again until the sample system connections are modified, or, when installing a new oxygen sensor.

Span Calibration

Span Calibration involves adjusting the transmitter electronics to the sensor's signal output at a given oxygen standard. Maximum drift from calibration temperature is approximately 0.11% of reading per °C. The frequency of calibration varies with the application conditions, 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 the analyzer back on-line can vary depending on a combination of factors and assume exposure to a zero/purge/sample gas** with an oxygen content below the stated thresholds immediately after span calibration:

Galvanic Sensor *	Oxygen Standard	Time Required to Come On-line**
O_2 levels above 1000 ppm / 0.1%	Air (209,000 ppm / 20.9%)	< 5 minutes
O_2 levels above 100 ppm	Air (209,000 ppm / 20.9%)	< 10 minutes
O_2 levels below 10 ppm	Air (209,000 ppm / 20.9%)	< 60 minutes for install or replacement
		< 30 minutes if in ppm service for > 1 week
O_2 levels below 10 ppm	800 ppm Certified Span Gas	< 5 minutes
O_2 levels below 10 ppm	80 ppm Certified Span Gas	< 1 minute

* Refer to analyzer specifications for comparable data on the Pico-Ion UHP and MS oxygen sensors.

Recommendations General:

- The interval between span calibrations should not exceed three (3) months.
- Initiate the DEFAULT ZERO and DEFAULT SPAN procedures before performing either a ZERO or SPAN CALIBRATION.
- **Caution:** Prematurely initiating the SPAN CALIBRATION function before the analyzer reading has stabilized can result in erroneous readings. This is especially true when installing a new sensor that must adjust to the difference in oxygen concentrations. It should take about 2 minutes for the sensor to equilibrate in ambient air from storage packaging.
- Always calibrate at the same temperature and pressure of the sample gas stream.
- For 'optimum calibration accuracy' calibrate with a span gas approximating 80% of the full scale range one or a higher range than the full scale range of interest (normal use) to achieve the effect of "narrowing the error" by moving downscale as illustrated by Graph A in the Accuracy & Calibration section.
- Calibrating with a span gas approximating 5-10% of the full scale range near the expected oxygen concentration of the sample gas is acceptable but less accurate than 'optimum calibration accuracy' method recommended – the method usually depends on the gas available.
- Calibrating at the same 5-10% of the full scale range for measurements at the higher end of the range (example: calibrating an Oxygen Purity Analyzer in air at 20.9% oxygen with the intention of measuring oxygen levels of 50-100%) results in the effect of "expanding the error" by moving upscale as illustrated by Graph A and Example 1 in the Accuracy & Calibration 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.

Recommendations Air Calibration:

- Do not calibrate an analyzer employing the Pico-Ion UHP or MS sensor, or, an oxygen purity sensor with air.
- The inherent linearity of the galvanic fuel cell type oxygen sensor enables the user to calibrate any analyzer with ambient air (20.9% oxygen) and operate the analyzer within the stated accuracy spec on the lowest most sensitive range available with the analyzer – it is not necessary to recalibrate the analyzer with span gas containing a lower oxygen concentration.
- When installing or replacing a ppm or percent oxygen sensor.
- To verify the oxygen content of a certified span gas.

- When certified span gas is not available to calibrate a ppm analyzer (immediately following air calibration reintroduce a gas with a low oxygen concentration to expedite the return to ppm level measurements as described above **).

Mounting the Analyzer

Normally mounting a portable analyzer is not a consideration. However, the GPR-3500 analyzer can operate continuously when connected to AC power using the appropriate charging adapter. The analyzer enclosure is cast with four (4) holes in the bottom section specifically intended for mounting to any flat vertical surface.

Gas Connections

The GPR-3500MO with its standard flow through configuration is designed for positive pressure samples and requires connections for incoming sample and outgoing vent lines. Zero and span inlet ports are offered as part of the optional sample systems. The user is responsible for calibration gases and the required components, see below.

With the pressure regulated to between 5-30 psig, 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. 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.

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 to do in this manual.
2. Designate one of the bulkhead tube fittings as the VENT and the other SAMPLE.
3. Regulate the pressure as described in Pressure & Flow above.
4. Connect a 1/8" vent line to the compression fitting to be used for venting the sample.
5. Connect a 1/8" ZERO, SPAN or SAMPLE line to the fitting designated SAMPLE.
6. If equipped with optional fittings and/or sample system, connect the ZERO and SPAN gas lines.
7. Allow gas to flow through the portable oxygen purity analyzers and set the flow rate to 2 SCFH.

Output connection:

The analyzer provides a 0-1V full scale with negative ground signal output for external recording devices.

Procedure:
1. Connect the lead wires from the external recording device to the male phone plug supplied with analyzer. (Note: Connect the positive lead to the center terminal of the male phone plug.)
2. Insert the male phone plug into the integral female OUTPUT jack located on the side of the enclosure.

Installing the Oxygen Sensor

The GPR-3500MO portable oxygen purity analyzer is equipped with an integral oxygen sensor. It has been tested and calibrated by the manufacturer prior to shipment and are fully operational from the shipping container. However, when the application requires a remote sensor (external to the electronics enclosure) or other special circumstances, the oxygen sensor will be packaged separately and must be installed prior to operating the portable oxygen purity analyzer. If the sensor has not been installed at the factory, it will be necessary to install the sensor in the field.

Caution: All portable oxygen purity analyzers must be calibrated once the installation has been completed and periodically thereafter as described below. Do not change the factory settings until instructed to do in this manual.

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 section. 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 manner similar to that of a common battery in accordance with local regulations.

Procedure:
1. Remove the four (4) screws securing the top section of the enclosure, set them aside for reinstallation and remove the front cover.
2. **Caution**: Do not remove or discard the gasket from the enclosure. Failure to reinstall the gasket will void the NEMA 4 rating and RFI protection.
3. Remove the oxygen sensor from the bag.
4. Screw the oxygen sensor into the sensor flow housing, equipped with elbows and tubing, finger tighten plus one half (1/2) turn to ensure a good seal from the o-ring affixed to the sensor.
5. Remove the shorting device (looped wire) from the receptacle located at the rear of the sensor. Minimize the time the sensor is exposed to ambient air.
6. Assure the keyway registration of the female plug on the cable and male receptacle on the sensor match up.
7. Push the female plug (including the knurled lock nut) molded to the cable into the male receptacle attached to the new sensor.
8. Screw the knurled lock nut attached the cable onto to the male connector attached to the sensor, tighten finger tight plus ¼ turn.
9. Replace the front cover of the portable oxygen purity analyzer and ensure that the gasket is replaced as well to maintain CE approval and NEMA 4 rating.
10. Tighten the four (4) screws to secure the front cover.
11. Connect the gas lines, vent line first, as previously described.
12. Proceed to calibration.

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.

Medical grade oxygen:
The FDA requires the use of certified gases for zeroing and calibrating analyzers used in certifying medical grade oxygen. Advanced Instruments Inc. recommends zeroing and calibrating the analyzer before each certification.

The analyzer zero gas must be a certified cylinder of nitrogen with a minimum purity of 99.9%. Once the analyzer has been zeroed (described below), calibrate (described below) with a certified cylinder of oxygen with a minimum purity of 99.2%.

Non-medical grade oxygen applications:
In non-medical grade oxygen applications the analyzer does not require zeroing before every calibration. It is recommended the analyzer be calibrated at least monthly. In most cases nitrogen zero gas of 99% minimum purity and a span gas of 95-100% oxygen purity is sufficient.

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.
- Flow meter to set the flow between 1-5 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-1200.

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.
9. **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 analyzer electronics by pushing the red ON/OFF key. The digital display responds instantaneously. When power is applied, the analyzer performs several diagnostic system status checks termed "START-UP TEST" as illustrated below.

The optional integral sampling pump is activated by a separate toggle switch located on the front of the analyzer.

Note: In the unlikely event the LED warning indicator LOW BATT comes on when the analyzer is turned on – proceed immediately to the section Battery Considerations at the end of section 5 Operation.

Note: The GPR-3500MO is supplied with an adapter for recharging the batteries or operating the analyzer continuously.

Charging the battery requires a common 9VDC adapter (positive pole located inside the female connector) supplied with the analyzer and a convenience outlet. The analyzer's charging circuit accepts 9VDC from any standard AC 110V or 220V adapter (specified when the order is placed). The electronic design enables the analyzer to remain fully operable during the 8-10 hour charging cycle.

When power is applied, the software performs several diagnostic system status checks termed "START-UP TEST" as illustrated below. **Note:** The analyzer display defaults to the sampling mode when 30 seconds elapses without user interface.

START-UP TEST

ELECTRONICS – PASS
LOOP POWER – PASS
TEMP SENSOR – PASS
BAROMETRIC SENSOR – PASS

93.3 %

AUTO SAMPLING
100% RANGE

24.5 C **100 KPA**

Menu Navigation

The four (4) pushbuttons located on the front of the portable oxygen purity analyzer operate the micro-processor:

1. Green ENTER (select)
2. Yellow UP ARROW
3. Yellow DOWN ARROW
4. Blue MENU (escape)

Main Menu

Access the MAIN MENU by pressing the MENU key:

MAIN MENU

AUTO SAMPLE
MANUAL SAMPLE
CALIBRATE

24.5 C **100 KPA**

Range Selection:

The GPR-3500MO portable oxygen purity analyzer is equipped with a single 0-100% measuring range (see specification); accordingly, there is no difference between auto and manual sampling.

Start-Up is complete . . .

Zero Calibration

In theory, the oxygen sensor produces no signal output when exposed to an oxygen free sample gas. However, the portable oxygen purity analyzer will generate an oxygen reading when sampling oxygen free sample 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

As mandated by the FDA, calibration requires the use of certified zero (99.9% nitrogen minimum purity) and span (99.2% oxygen minimum purity). For optimum accuracy and to take advantage of the portable oxygen purity analyzers' inherent accuracy of 0.1%, perform the zero and span calibration before each certification. Otherwise calibrate every eight (8) hours.

Medical grade oxygen:
The FDA requires the use of certified gases for zeroing and calibrating analyzers used in certifying medical grade oxygen. Advanced Instruments Inc. recommends zeroing and calibrating the analyzer before each certification.

The analyzer zero gas must be a certified cylinder of nitrogen with a minimum purity of 99.9%. Once the analyzer has been zeroed (described below), calibrate (described below) with a certified cylinder of oxygen with a minimum purity of 99.2%.

Non-medical grade oxygen applications:
In non-medical grade oxygen applications the analyzer does not require zeroing before every calibration. It is recommended the analyzer be calibrated at least monthly. In most cases nitrogen zero gas of 99% minimum purity and a span gas of 95-100% oxygen purity is sufficient.

For the reasons above, it is not practical to zero a percent portable oxygen purity analyzer. Finding the true zero offset is not always necessary particularly in the case of applications requiring higher level oxygen measurements because of the low offset value, normally < 0.1 ppm, is not material to the accuracy of higher level measurements.

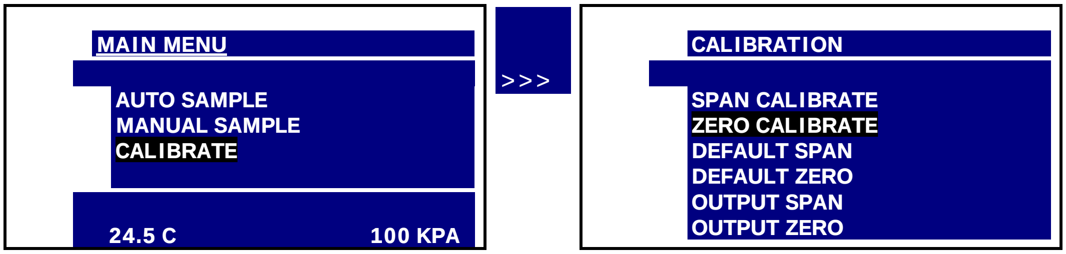
Caution: Prematurely zeroing the analyzer can cause a negative reading in both the ZERO and SAMPLE modes.

Default Zero:
The software will eliminate any previous zero calibration adjustment and display the actual the signal output of the sensor at a specified oxygen concentration. For example, assuming a zero gas is introduced, the display will reflect an oxygen reading representing basically the zero calibration adjustment as described above. This feature allows the user to test the sensor's signal output without removing it from the sensor housing.

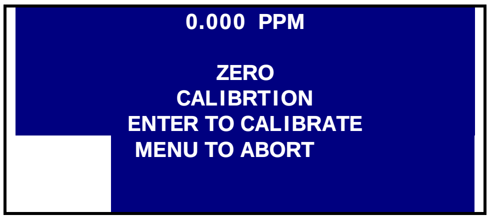
Recommendation: Initiate the DEFAULT ZERO procedure before performing either a ZERO or SPAN CALIBRATION.

Procedure – Zero Calibration:
Refer to Span Calibration below for the detailed procedure. Differences include the displays illustrated below, substituting a suitable zero gas for the span gas.

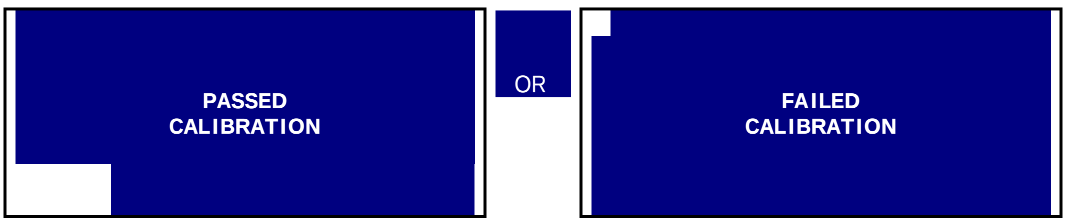
1. Access the MAIN MENU by pressing the MENU key.
2. Advance the reverse shade cursor using the ARROW keys to highlight CALIBRATE.
3. Press the ENTER key to select the highlighted menu option.
4. Advance the reverse shade cursor using the ARROW keys to highlight DEFAULT ZERO, to remove all previous adjustments.
5. Press the ENTER key to select the highlighted menu option.
6. Repeat to select ZERO CALIBRATE.
7. The following displays appear:



8. Press the ENTER key to calibrate or MENU key to abort and return to SAMPLING mode.

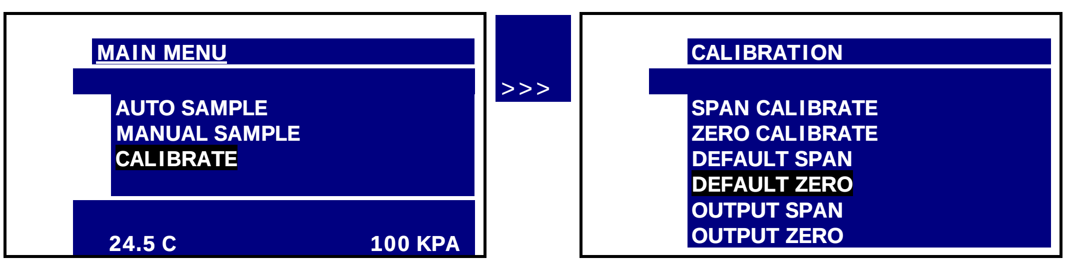


9. Allow approximately 60 seconds for the calibration process while the processor determines whether the signal output or reading has stabilized within 60% of the full scale low range.
10. Both the Zero Calibrate and Span Calibrate functions result in the following displays:



For non-medical grade oxygen analysis, satisfying users that the zero offset is reasonably acceptable for their application can be accomplished much quicker. Unless the zero gas is contaminated or there is a significant leak in the sample connections, the portable oxygen purity analyzer should read less than 100 ppm oxygen within 10 minutes after being placed on zero gas.

The maximum zero calibration adjustment permitted is 60% of the lowest full scale range available, which normally is 1%. Thus the maximum zero calibration adjustment or zero offset is 0.6% oxygen. Accordingly, the portable oxygen purity analyzers' ZERO has not been adjusted prior to shipment because the factory conditions are different from the application condition at the user's installation.



Output Zero

Accuracy due to manufacturer tolerances may result in a slight difference between the LCD display and the 0-1V analog output. However, the difference is less than 0.25% of range and falls well below the specified accuracy of the analyzer. In rare instances the 0-1V analog signal output may not agree to the reading displayed by the LCD. This feature enables the user to adjust the 0V analog signal output when the LCD displays 00.00. **Note:** Adjust the 1V analog signal output with the OUTPUT SPAN option described below.

1. Access the MAIN MENU by pressing the MENU key.
2. Advance the reverse shade cursor using the ARROW keys to highlight CALIBRATION.
3. Press the ENTER key to select the highlighted menu option and the following displays appear:

```
MAIN MENU                    >>>    CALIBRATION

  AUTO SAMPLE                       SPAN CALIBRATE
  MANUAL SAMPLE                     ZERO CALIBRATE
  CALIBRATION                       DEFAULT SPAN
                                    DEFAULT ZERO
                                    OUTPUT SPAN
                                    OUTPUT ZERO
```

4. Advance the reverse shade cursor using the ARROW keys to highlight DEFAULT ZERO.
5. Press the ENTER key to select the highlighted menu option.
6. The following display appears:

```
100.0

OUTPUT  ZERO  OFFSET

PRESS UP OR DOWN
TO CHANGE VALUE
ENTER TO SAVE
MENU TO RETURN
```

7. Compute the adjustment value as described in Appendix B or consult the factory. The true adjustment value must be determined empirically by trial and error. Adjust the initial adjustment value for additional percent errors.

```
090.0

OUTPUT  ZERO  OFFSET

PRESS UP OR DOWN
TO CHANGE VALUE
ENTER TO SAVE
MENU TO RETURN
```

8. Press the ENTER key to advance the underline cursor right or press the MENU key to advance the underline cursor left to reach to the desired digit of the OUTPUT ZERO OFFSET value.
9. Press the ARROW keys to enter the OUTPUT ZERO OFFSET value.
10. Repeat until the complete OUTPUT ZERO OFFSET value has been entered.
11. **Save the adjustment value by pressing the ENTER key or abort by pressing the MENU key.**
12. The system returns to the SAMPLING mode.

Span Calibration

Maximum drift from calibration temperature is approximately 0.11% of reading per °C. The analyzer has been calibrated at the factory. However, in order to obtain reliable data, the analyzer must be calibrated at the initial start-up and periodically thereafter. The maximum calibration interval recommended is approximately 3 months, or as determined by the user's application.

Calibration involves adjusting the portable oxygen purity analyzer electronics to the sensor's signal output at a given oxygen standard. As mandated by the FDA, calibration requires the use of certified zero (99.9% nitrogen minimum purity) and span (99.2% oxygen minimum purity). For optimum accuracy and to take advantage of the portable oxygen purity analyzers' inherent accuracy of 0.1%, perform the zero and span calibration before each certification. Otherwise calibrate every eight (8) hours.

Recommendation: Initiate the DEFAULT SPAN procedure before performing either a ZERO or SPAN CALIBRATION.

Caution: The user must ascertain that the oxygen reading (actually the sensor's signal output) has reached a stable value within the limits entered below before entering the span adjustment. Failure to do so will result in an error.

Caution: Do not attempt to span the portable oxygen purity analyzer with air or 21% oxygen and then operate it for either elevated or high purity oxygen measurements.

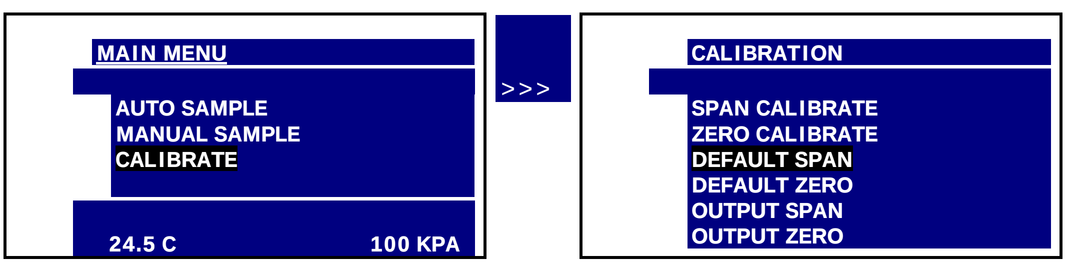
Medical grade oxygen:
The FDA requires the use of certified gases for zeroing and calibrating analyzers used in certifying medical grade oxygen. Advanced Instruments Inc. recommends zeroing and calibrating the analyzer before each certification.

The analyzer zero gas must be a certified cylinder of nitrogen with a minimum purity of 99.9%. Once the analyzer has been zeroed (described below), calibrate (described below) with a certified cylinder of oxygen with a minimum purity of 99.2%.

Non-medical grade oxygen applications:
In non-medical grade oxygen applications the analyzer does not require zeroing before every calibration. It is recommended the analyzer be calibrated at least monthly. In most cases nitrogen zero gas of 99% minimum purity and a span gas of 95-100% oxygen purity is sufficient.

Default Span
The software will set the SPAN adjustment based on the average oxygen reading (actually the sensor's signal output) at a specified oxygen concentration. For example, when a span gas is introduced, the micro-processor will display an oxygen reading within ±50% of the span gas value. This feature allows the user to test the sensor's signal output without removing it from the sensor housing.

1. Access the MAIN MENU by pressing the MENU key.
2. Advance the reverse shade cursor using the ARROW keys to highlight CALIBRATE.
3. Press the ENTER key to select the highlighted menu option.
4. The following displays appears:

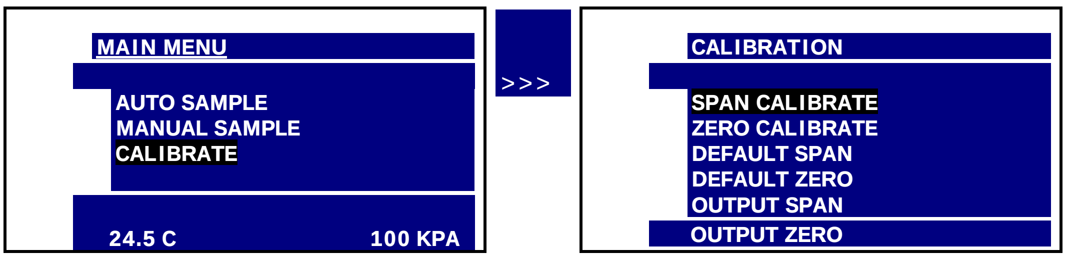


Required components: Refer to Installing Span Gas section above.

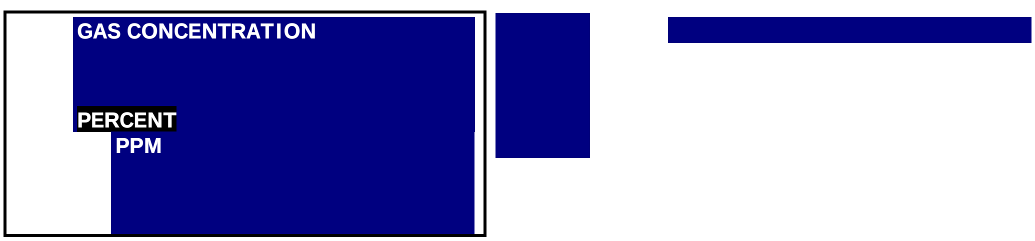
Procedure – Span Calibration:
This procedure assumes a span gas under positive pressure and is recommended for a portable oxygen purity analyzer without an optional sampling pump, which if installed downstream of the sensor should be placed in the OFF position and disconnected so the vent is not restricted during calibration.

Caution: To assure an accurate calibration, the temperature and pressure of the span gas must closely approximate the sample conditions. The GPR-3500MO has a single 0-100% range and should be calibrate as described above.

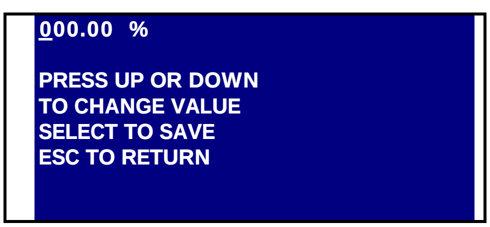
1. Access the MAIN MENU by pressing the MENU key.
2. Advance the reverse shade cursor using the ARROW keys to highlight CALIBRATE.
3. Press the ENTER key to select the highlighted menu option.
4. Advance the reverse shade cursor using the ARROW keys to highlight DEFAULT SPAN, to remove all previous adjustments.
5. Press the ENTER key to select the highlighted menu option.
6. Repeat to select SPAN CALIBRATE.
7. The following displays appear:



8. Assure there are no restrictions in vent line.
9. Regulate the pressure and control the flow rate as described above at 5-30 psig and a 2 SCFH flow rate.
10. Allow the span gas to flow for 2-3 minutes to purge the air trapped in the span gas line.
11. Disconnect the sample gas line and install the purged span gas line.
12. **Caution: Keep the span gas flowing and wait until the reading is stable before proceeding with calibration**.
13. Press the ENTER key to select the SPAN CALIBRATE option.
14. **Note:** A span gas concentration above 1000 ppm dictates the selection of the PERCENT option.
15. Advance the reverse shade cursor using the ARROW keys to highlight the desired GAS CONCENTRATION.
16. Press the ENTER key to select the highlighted menu option.



17. The user must ascertain that the oxygen reading (actually the sensor's signal output) has reached a stable value within the limits entered below before entering the span adjustment. Failure to do so will result in an error.
18. The following display appears:



18. Press the UP/ DOWN ARROWS to enter the first digit of the span value.
19. Press the ENTER key to advance the underline cursor **right** to the second digit of the span value.
20. Press the MENU key to advance the underline cursor **left** to the previous digit.
21. Press the UP/ DOWN ARROWS to enter the second digit of the span value.
22. Repeat until the complete span value has been entered.

100.00 %

SPAN
CALIBRATION
ENTER TO CALIBRATE
MENU TO ABORT

23. Press ENTER to initiate the span calibration procedure
24. Allow approximately 60 seconds for the calibration process while the processor determines whether the signal output or reading has stabilized within 60% of the full scale low range.
25. Both the ZERO CALIBRATE and SPAN CALIBRATE functions result in the following displays:

PASSED
CALIBRATION

OR

FAILED
CALIBRATION

26. If the calibration is successful, the analyzer returns to the SAMPLING mode after 30 seconds.

93.3 %

AUTO SAMPLING
100% RANGE
24.5 C 100 KPA

18. If the calibration is unsuccessful, return to the SAMPLING mode with span gas flowing through the portable oxygen purity analyzer, make sure the reading stabilizes and repeat the SPAN CALIBRATE procedure before concluding the equipment is defective.
19. Before disconnecting the span gas line and connecting the sample gas line, restart if necessary the flow of sample gas and allow it to flow for 1-2 minutes to purge the air inside the line.
20. Disconnect the span gas line and replace it with the purged sample gas line.
21. Wait 10-15 minutes to ensure the reading is stable and proceed to sampling.

Output Span:
Accuracy due to manufacturer tolerances may result in a slight difference between the LCD display and the 0-1V analog output. However, the difference is less than 0.25% of range and falls well below the specified accuracy of the analyzer. In rare instances the 0-1V signal output may not agree to the reading displayed by the LCD. This feature enables the user to adjust the 1V signal output should the LCD display not agree. **Note:** Adjust the 0V signal output with the OUTPUT ZERO option described above.

1. Access the MAIN MENU by pressing the MENU key.
2. Advance the reverse shade cursor using the ARROW keys to highlight CALIBRATION.
3. Press the ENTER key to select the highlighted menu option.
4. The following displays appear:

MAIN MENU

AUTO SAMPLE
MANUAL SAMPLE
CALIBRATION
CONFIG ALARMS
BYPASS ALARMS

>>>

CALIBRATION

SPAN CALIBRATE
ZERO CALIBRATE
DEFAULT SPAN
DEFAULT ZERO
OUTPUT SPAN
OUTPUT ZERO

5. Advance the reverse shade cursor using the ARROW keys to highlight DEFAULT SPAN.
6. Press the ENTER key to select the highlighted menu option and the following display appears:

100.0

OUTPUT SPAN OFFSET

PRESS UP OR DOWN
TO CHANGE VALUE
ENTER TO SAVE
MENU TO RETURN

7. Compute the adjustment value as described in Appendix B or consult the factory. The true adjustment value must be determined empirically by trial and error. Adjust the initial adjustment value for additional percent errors.

099.0

OUTPUT SPAN OFFSET

PRESS UP OR DOWN
TO CHANGE VALUE
ENTER TO SAVE
MENU TO RETURN

8. Press the ENTER key to advance the underline cursor right or press the MENU key to advance the underline cursor left to reach to the desired digit of the OUTPUT SPAN OFFSET value.
9. Press the ARROW keys to enter the OUTPUT SPAN OFFSET value.
10. Repeat until the complete OUTPUT SPAN OFFSET value has been entered.
11. **Save the adjustment value by pressing the ENTER key or abort by pressing the MENU key.**
12. The system returns to the SAMPLING mode.

Sampling

GPR-3500MO Oxygen Portable oxygen purity analyzer requires positive pressure to flow the sample gas by the sensor to measure the oxygen concentration in a sample gas. If not available see Pressure & Flow section.

Note: Prematurely zeroing the portable oxygen purity analyzer can cause the portable oxygen purity analyzer to display a negative reading in both the ZERO and SAMPLE modes.

Procedure:
1. Following calibration the portable oxygen purity analyzer returns to the SAMPLE mode after 30 seconds.
2. Selecting the desired sampling mode is not applicable with this single range analyzer - auto or manual are the same.
3. Use metal tubing to transport the sample gas to the portable oxygen purity analyzer.
4. The main consideration is to eliminate air leaks which can affect oxygen measurements above or below the 20.9% oxygen concentration in ambient air - ensure the sample gas tubing connections fit tightly into the 1/8" male NPT to tube adapter, and, the NPT end is taped and securely tightened into the mating male quick disconnect fittings which mate with the female fittings on the portable oxygen purity analyzer
5. Assure there are no restrictions in the sample line.
6. For sample gases under positive pressure the user must provide a means of controlling the inlet pressure between 5-30 psig and the flow of the sample gas between 1-5 SCFH, a flow rate of 2 SCHF is recommended
7. For sample gases under atmospheric or slightly negative pressure an optional sampling pump is recommended to draw the sample into the portable oxygen purity analyzer. Generally, no pressure regulation or flow control device is involved.
8. **Caution:** If the analyzer is equipped with an optional sampling pump and is intended for use in both positive and atmospheric/slightly negative pressure applications where a flow meter valve is involved – ensure the valve is completely open when operating the sampling pump. Refer to the Pressure & Flow section above.
9. Assure the sample is adequately vented for optimum response and recovery – and safety.
10. Allow the oxygen reading to stabilize for approximately 10 minutes at each sample point.

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 (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 particulates, liquids or condensation collect on the sensor that could block the diffusion of oxygen into the sensor.
- If the portable oxygen purity 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.

Standby
- The portable oxygen purity analyzer has no special storage requirements.
- The sensor should remain connected during storage periods.
- Store the portable oxygen purity 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 portable oxygen purity 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 Features & Specifications define the normal operating conditions and expected life of the standard sensor utilized by the GPR-3500MO portable oxygen purity 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. 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.

Procedure:

1. Remove the four (4) screws securing the hinged front panel of the portable oxygen purity analyzer.
2. **Caution:** Do not remove or discard the gaskets from the enclosure. Failure to reinstall the gasket will void the NEMA rating.
3. Unscrew the knurled lock nut connecting the cable to the sensor.
4. Disconnect and remove the female plug (including the knurled lock nut) molded to the cable from the male receptacle attached to the sensor.
5. Unscrew the old sensor from the threaded hole in the sensor flow housing.
6. Open the barrier bag containing the new sensor.
7. If the sensor is equipped with a shorting loop, remove the shorting wire from the pins of the female socket attached to the new sensor.
8. Screw the new sensor, finger tight plus 1/2 turn, into the threaded hole in the flow housing and ensure the o-ring seal is engaged.
9. Assure the keyway registration of the female plug on the cable and male receptacle on the sensor match up.
10. Push the female plug (including the knurled lock nut) molded to the cable into the male receptacle attached to the new sensor.
11. Screw and tighten the knurled lock nut attached the cable onto to the male connector attached to the sensor.
12. Replace the front cover of the portable oxygen purity analyzer, replace the gasket to maintain CE approval and NEMA 4 rating and tighten the four (4) screws to secure the front cover.
13. Calibrate the portable oxygen purity analyzer as described in section 5.

Battery

Charging the battery requires a common 9VDC adapter (positive pole located inside the female connector) supplied with the analyzer and a convenience outlet. The analyzer's charging circuit accepts 9VDC from any standard AC 110V or 220V adapter. The electronic design enables the analyzer to remain fully operable during the 8-10 hour charging cycle.

Procedure:

1. Unless the analyzer is to be operated while charging, turn the analyzer OFF when charging the battery for the shortest charging cycle.
2. Connect the appropriate 9VDC adapter supplied with the analyzer to a 110V or 220V outlet.
3. Insert the male phone plug from the 9VDC adapter into the integral female CHARGE jack located on the bottom of the enclosure.
4. **Caution:** The analyzer is designed to operate in the charging mode, however, operating the analyzer in hazardous or explosive atmospheres while charging the battery IS NOT recommended.

Service: A single charge is sufficient to operate the GPR-2000 Series analyzers continuously for a period of 60 days. Expect 8-10 hours of service if the integral sampling pump of the GPR-2000P Series analyzer is operated continuously.

Warning indicators:

An LED indicator located on the front panel will light continuously during the CHARGE cycle.
A second LED indicator located on the front panel provides a blinking 72 hour warning LOW BATT of the need to recharge the battery.
Caution: Operating the analyzer beyond this 72 hour warning may permanently damage the battery.

7 Spare Parts

Recommended spare parts for the GPR-3500MO Oxygen Portable oxygen purity analyzer:

Item No.	Description
GPR-11-120-OP	Oxygen Sensor

Other spare parts:

Item No.	Description
FITN-1018	Connector SS 1/8" MNPT to 1/8" Tube
FITN-1039	Elbow SS 1/8"
FMTR-1007-1	Flow Meter with Integral Metering Valve
A-3051	Housing Flow Adaptor
MTR-1011	Meter Digital Panel LCD Backlight
A-1151-B3	PCB Assembly Main / Display

8 Troubleshooting

Symptom	Possible Cause	Recommended Action
Reading does not reflect expected values	Sensor was not calibrated at the pressure, flow rate and temperature anticipated in the sample gas stream	Recalibrate the analyzer
Oxygen reading drifts toward zero	Indication sensor is nearing the end of its useful life	Replace sensor, see section 6 Maintenance
Slow response time Erratic oxygen reading No oxygen reading	Liquid covering sensing membrane Presence of interference gases Unauthorized maintenance Defective electrical connection Sensor failure	Gently remove with damp lint free towel. Consult factory Consult factory Replace sensor and/or consult factory
High oxygen reading	Inadequate control of flow rate Abnormality in span gas	See Pressure and Flow Qualify source

9 Warranty

The design and manufacture of GPR Series oxygen analyzers, monitors 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 monitor, analyzers and sensor 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. monitor, 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 PM Pacific Time Monday thru Thursday or 8:00 AM to 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	Advanced Instruments 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	Sensor is packaged in a sealed plastic bag, check the sensor inside for electrolyte leakage. If the sensor leaks inside the plastic bag or inside an analyzer sensor housing do not remove it without rubber or latex gloves and safety glasses and a source of water. Flush or 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

Appendix B

Correlating Readings – LCD Display and 4-20mA or 0-1V Signal Outputs

In rare instances the signal output may not agree to the reading displayed by the LCD. The OUTPUT ZERO and OUTPUT SPAN features enable the user to adjust the signal output to correlate with the LCD reading.

For optimum accuracy make two separate adjustments as follows:

1. OUTPUT ZERO feature: To adjust the 4mA or 0V signal output and requires zero gas.
2. OUTPUT SPAN feature: To adjust the 20mA or 1V signal output and requires span gas near full range.

Note: In the field or in the absence of the preferred gases, use the OUTPUT SPAN feature and adjust the 20mA or 1V signal output using the span gas available.

Guideline:

If the actual signal output value < the theoretical LCD value, the adjustment value will be < 100%.

If the actual signal output value > the theoretical LCD value, the adjustment value will be > 100%.

Procedure – regardless of type of adjustment – with examples:	**Signal Output** 4-20mA	0-1V
1) The OUTPUT ZERO and OUTPUT SPAN default values	100.0%	100.0%
2) **Adjust the "actual signal output" . . .**	24mA	1.2V
to the "theoretical signal output " based on the "span gas value" of . . .	84 ppm span gas	84% span gas
3) **and the "actual LCD reading" . . .**	60 ppm	80%
a) "actual LCD reading" divided by the "span gas value"	60 / 84 = .71	80 / 84 = .95
b) 16mA (20mA less 4mA) multiplied by the result in 3a)	.71 x 16 = 11.36	NA
c) 4mA plus the result of 3b) = "theoretical signal output"	4 + 11.36 = 15.36mA	.95V (from a)
4) "**Adjustment Value**" = ("theoretical" divided by "actual signal output ") x 100	(15.36 / 24) x 100 = 64	(.95 / 1.2) x 100 = 79
5) Proof = ("actual signal output" multiplied by "adjustment value") divided by 100	(24 x 64) / 100 = 15.36mA	(1.2 x 79) / 100 = .95V
6) ENTER "adjustment value" via OUTPUT ZERO or OUTPUT SPAN routines below.	64	79
7) Fine tuning . . . after checking the new "actual signal output" at the PLC	19.5mA	.98V
8) Repeat Step #4 and substitute the latest "actual signal output"	(15.36 / 19.5) x 100 =78.8	(.95 / .98) x 100 = 96.9
9) Proof = ("actual signal output" multiplied by "adjustment value") divided by 100	(19.5 x 78.8) / 100 = 15.36	(.98 x 96.9) / 100 = 95
10) ENTER "adjustment value" via OUTPUT ZERO or OUTPUT SPAN routines below.	75	95

Output Zero Procedure:

1. Access the MAIN MENU by pressing the MENU key.
2. Advance the reverse shade cursor using the ARROW keys to highlight CALIBRATION.
3. Press the ENTER key to select the highlighted menu option.
4. The following displays appear:

```
MAIN MENU                >>>     CALIBRATION

AUTO SAMPLE                      SPAN CALIBRATE
MANUAL SAMPLE                    ZERO CALIBRATE
CALIBRATION                      DEFAULT SPAN
CONFIG ALARMS                    DEFAULT ZERO
BYPASS ALARMS                    OUTPUT SPAN
                                 OUTPUT ZERO
```

5. Advance the reverse shade cursor using the ARROW keys to highlight OUTPUT ZERO.
6. Press the ENTER key to select the highlighted menu option.
7. The following display appears:

```
100.0

OUTPUT  ZERO  OFFSET

PRESS UP OR DOWN
TO CHANGE VALUE
ENTER TO SAVE
MENU TO RETURN
```

8. Enter the OUTPUT ZERO adjustment value as follows . . .
9. Selecting digits of the adjustment value to change - Press the ENTER key to advance the underline cursor **right** or press the MENU key to advance the underline cursor **left** to reach to the desired digit.
10. Changing the digits of the adjustment value . . . Press the UP/DOWN ARROW keys to change a digit of the adjustment value.
11. Repeat steps 9 and 10 until the complete zero value has been entered and the following display appears.

```
099.0

OUTPUT  ZERO  OFFSET

PRESS UP OR DOWN
TO CHANGE VALUE
ENTER TO SAVE
MENU TO RETURN
```

12. **Save the adjustment value by pressing the ENTER key or abort by pressing the MENU key.**
13. The system returns to the SAMPLING mode.
14. **Note:** After the initial adjustment is made, check the actual signal output at the PLC and if necessary calculate a further fine tuning adjustment value as illustrated above.
15. Enter subsequent fine tuning adjustments as described above.

Output Span Procedure:

1. Access the MAIN MENU by pressing the MENU key.
2. Advance the reverse shade cursor using the ARROW keys to highlight CALIBRATION.
3. Press the ENTER key to select the highlighted menu option.
4. The following displays appear:

MAIN MENU		CALIBRATION
AUTO SAMPLE	>>>	SPAN CALIBRATE
MANUAL SAMPLE		ZERO CALIBRATE
CALIBRATION		DEFAULT SPAN
CONFIG ALARMS		DEFAULT ZERO
BYPASS ALARMS		OUTPUT SPAN
		OUTPUT ZERO

5. Advance the reverse shade cursor using the ARROW keys to highlight OUTPUT SPAN.
6. Press the ENTER key to select the highlighted menu option.
7. The following display appears:

100.0

OUTPUT SPAN OFFSET

PRESS UP OR DOWN
TO CHANGE VALUE
ENTER TO SAVE
MENU TO RETURN

8. Enter the adjustment value as follows . . .
9. Selecting digits of the adjustment value to change - Press the ENTER key to advance the underline cursor **right** or press the MENU key to advance the underline cursor **left** to reach to the desired digit.
10. Changing the digits of the adjustment value . . . Press the UP/DOWN ARROW keys to change a digit of the adjustment value.
11. Repeat steps 9 and 10 until the complete span value has been entered and the following display appears.

064.0

OUTPUT SPAN OFFSET

PRESS UP OR DOWN
TO CHANGE VALUE
ENTER TO SAVE
MENU TO RETURN

12. **Save the adjustment value by pressing the ENTER key or abort by pressing the MENU key.**
13. The system returns to the SAMPLING mode.
14. **Note:** After the initial adjustment is made, check the actual signal output at the PLC and if necessary calculate a further fine tuning adjustment value as illustrated above.
15. Enter subsequent fine tuning adjustments as described above.

075.0

OUTPUT SPAN OFFSET

PRESS UP OR DOWN
TO CHANGE VALUE
ENTER TO SAVE
MENU TO RETURN

16. **Save the adjustment value by pressing the ENTER key or abort by pressing the MENU key.**
17. The system returns to the SAMPLING mode.