Analytical Industries Inc.

Company Profile

Analytical Industries Inc. was founded by 3 former Teledyne executives whose combined experience included the development (original and recent patents), pioneering the application of electrochemical galvanic sensors and refining the manufacturing process. Incorporated in 1994, Analytical Industries Inc. started with a clean sheet of paper, their 60 years of experience and devoted their first year to R&D with the objective of advancing existing sensor technology.

The result provided Analytical with competitive advantages in terms of sensor performance, life and reliability. Augmented by uncompromising standards for quality, customer support and service Analytical Industries Inc. has become a recognized worldwide supplier of electrochemical oxygen sensors to the industrial, medical and diving industries. The quality assurance program is certified by the FDA, Europe and Canada.

Following this formula, Analytical Industries Inc. through their Advanced Instruments business unit has become the preferred supplier of electrochemical based oxygen analyzers to global companies in the field of industrial gases, petrochemical products, natural gas, beverages, metals, ventilators, anesthesia machines, diving and rebreathers, the latter includes supplying the U.S. Navy with O2 sensors for the MK16 rebreather since 1998.

Quality Assurance Program

Quality is taken very seriously. The quality assurance program is independently certified annually by the FDA, European and Canadian regulatory bodies:

U.S. FDA: 510(k) No. K952736
ISO 9001:2008

Europe: Annex II of Medical Device Directive 93/42/EEC
ISO 9001:2008

Canada: ISO 13485:2003

All products manufactured by Analytical Industries Inc. comply with the above quality standards. A formal written evaluation report of every product returned from the field is required, regardless of the reason. Our approach to customer service is proactive one, not only does Analytical provide customers with a copy of the report but we routinely contact them to discuss and educate, customers as well as ourselves.

Historically, less than 1% of the thousands of sensors shipped are returned to Analytical Industries Inc. for warranty claims, and, of that figure less than one-half are determined to have manufacturing defects.

Assessing these returns along with internal manufacturing yields has enabled Analytical Industries Inc. to continually improve our products and secure additional business at the expense of our competitors.

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Basic Principles of the Galvanic Oxygen Sensor

Materials: Membranes sealed to a plastic body encapsulate anode, cathode and electrolyte (base pH) consisting of mostly water. Wires conduct outputs from anode (-) and cathode (+) inside the sensor to soldered termination on a PCB (with resistor-thermistor temperature compensation network) attached externally to the rear of the sensor.

Operation: The galvanic fuel cell sensor is an electrochemical transducer which generates a current (µA) signal output, primarily from the cathode, that is both proportional and linear to the partial pressure of oxygen in the sample gas. The sensor has an inherent absolute zero, therefore, no oxygen no signal output. Oxygen diffuses through the front sensing membrane simultaneously contacting anode, cathode and electrolyte. Oxygen oxidizes the anode generating electrons which are conducted through the electrolyte conductor to activate the cathode or sensing electrode.

Signal Output: Historically specified as a nominal value ± 30% in air (20.9% oxygen) at 25ºC (77ºF) and 1 atm. The nominal value is based on the thickness, which determines the diffusion rate, of the front sensing membrane. The ±30% allows for variations in the membrane (manufacturing by a lamination process) and sealing process. The PCB network converts the signal output from current (µA) to (mV) signal output. Signal output can influenced and compensated by several factors. A higher or lower signal output without the specified output range offers no performance advantage.

Temperature: Influences the signal output at the rate of 2.54% per ^{0}C. Ambient (gradual) changes in temperature can be maintained within the ±2% accuracy specification by processing the signal output through an appropriate resistor-thermistor temperature compensation network, see PCB above. Although the initial effect has been reduced significantly, step (rapid) changes of 15^{0}C (59ºF) require up to 45 minutes for the compensated signal output to equilibrate, e.g. the electronic temperature sensor reacts immediately whereas the sensor (sensing membrane and electrolyte) react at a much slower rate. The effect depends on the temperature change inside the breathing circuit. Some rebreather manufacturers compensate electronically to eliminate the effect of temperature.

Pressure: Influences signal output on a proportional basis. The sensor is accurate at any constant pressure up to 30 atm provided the sensor (front and rear membranes) is pressurized and decompressed gradually (similar to human lungs).

Altitude: Dives of 200 ft. or .006 Bar do not have a significant effect on the signal output.

Humidity: Any gas, whether it is water vapor or exhaled breath, according to Dalton's Law exerts its own partial pressure when added to a gas stream, thereby, reducing the partial pressure of oxygen and the reading displayed. Conversion charts are available for air calibration which define the effect of humidity and temperature on the oxygen level.

Moisture/Liquid: Condensation that covers the sensing surface dramatically reduces the amount of oxygen diffusing through the membrane resulting in a corresponding reduction in signal output. Why? Physics, gas molecules like oxygen move through liquid at a dramatically slower rate than in the gas phase.

Life: In theory, a higher signal output yields a shorter life because the anode is being consumed at a faster rate. In reality however the Expected Life specification considers the upper limit (+30%) of the signal output range. Sensor life is inversely proportional to changes in oxygen concentration, temperature and pressure, see Signal Output above.

Load: The sensor does not tolerate reverse current flowing into the sensor. Maximum load is a flat 10K, no load is recommended. Increasing the load over 10K maximum produces an error in linearity.

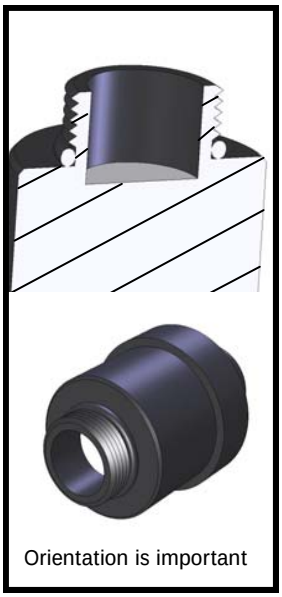
Calibration: Required before every dive for safety reasons. Perform at operating conditions, e.g. if measuring dry compressed gas, calibrate with same or if calibrating in air use a conversion chart which defines the effect the humidity (above) and temperature on the oxygen level.

Mode of Failure: Defect or Misuse

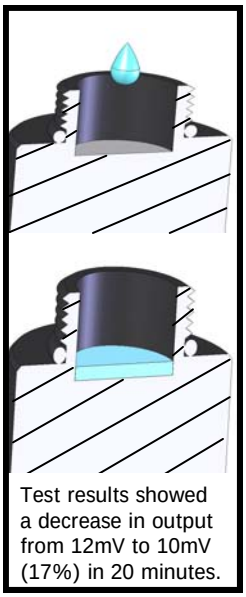
Preface: Historically, when a sensor does not function beyond its warranty period the issue of what is a defect as opposed to misuse arises. The discussion depends on whether your perspective and expectations are that of manufacturer or user. When manufacturers of rebreathers and sensors cooperate in the design phase, problems are greatly reduced.

Normal Operation: Complete oxidation of the anode characterized by a sharp decrease in signal output during the last 5-10% of service life which prevents calibration of the electronics (the signal output falls below the lower limit designed into the electronics). See Signal Output and Life topics in the Principles section for parameters.

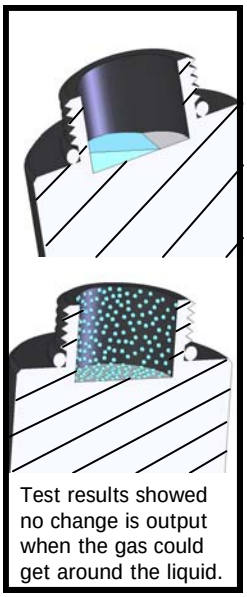
Liquid / Moisture: Condensation on the sensing surface of the sensor reduces the signal output and is mistakenly categorized as a sensor defect, when in fact it is law of physics. The reality, remove the liquid and the signal output returns.



Orientation is important



Test results showed a decrease in output from 12mV to 10mV (17%) in 20 minutes.



Test results showed no change is output when the gas could get around the liquid.

Shock: Dropping a sensor that has been removed from its shipping package can damage the sensor in a number of ways: (a) compromise electrical connections resulting in erratic readings, (b) broken wires, (c) dislodging an anode which contacts the a cathode connection creating a short circuit, (c) tests show that dropping a sensor from 3 ft. onto a carpeted concrete office slab results in a reduction in signal output ranging from 25% to zero signal output.

Erratic Oxygen Readings: (a) Dropping a sensor that has been removed from its shipping package, (b) blocking the "breather holes" in the PCB at the rear of the sensor prevents the pressure surrounding the sensor (front and rear membranes) from equalizing, (c) a load in excess of 10K Ohm.

High Oxygen Readings: The amount of oxygen entering into the sensor increases due to sub-microscopic pin holes in the sensing membrane resulting from: (a) latent manufacturing defects in the lamination acerbated by high temperature, (b) pressing on the sensing surface (out of curiosity or in an attempt to remove liquid), (c) mishandling during assembly (possible but unlikely due to stringent leak testing as described in Quality Control section).

Storage: Prolonged exposure above 50ºC (122ºF) can adversely affect (a) the seals that secure the front and rear membranes to the sensor, and, (b) acerbate any sub-microscopic pin holes in the laminated front sensing membrane, both of which result in electrolyte leakage in the shipping bag. Refer to Life topic in the Principles section, an increase in temperature above 25ºC (77ºF) reduces expected sensor life because the membrane expands with temperature allowing more oxygen to diffuse into the sensor thereby increasing the rate at which the anode is consumed.

Quality Control

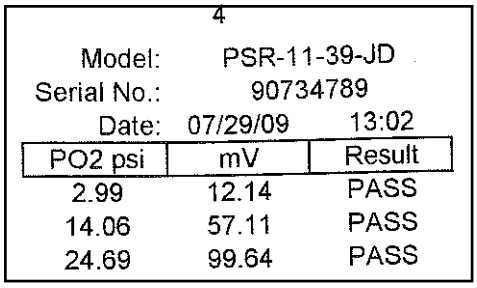
Design: After years of experience working with and studying competitive galvanic oxygen sensors, Analytical Industries has focused on advancing the quality and reliability (along with performance) of their sensors by simplifying the assembly process and eliminating sources of internal contamination. As a result, there are no welds, epoxy or dissimilar metals inside the Analytical Industries sensor.

Cleaning Process: In an effort to minimize external contamination from suppliers and employees, critical internal components undergo a proprietary cleaning process before assembly commences. With respect to the human element, hand lotions are prohibited throughout the facility. A single approved hand soap is available for washing after every break.

Leak Test: To detect sub-microscopic pin holes in the laminated membranes and marginal membrane seals, 100% of the base electrolyte sensors are subjected to a stringent proprietary procedure designed to identify leaks of any type.

Output Testing: Following leak test, 100% of the base electrolyte sensors sit for a predetermined period of time to allow the signal output to stabilize. Next, the current output (µA) of every sensor is tested and recorded. Diving sensors are then equipped with a PCB for temperature compensation which converts the signal output to (mV) and tested 3x more times during the remainder of the assembly process before the sensor is accepted and serialized.

Dive Pressure Test: Analytical Industries tests all diving sensors for output in air (20.9%) and linearity at 100% oxygen, and, under 1.6 ATA using a proprietary automated system. Individual print outs, illustrated at the right, identify the sensor by model, serial number, date and time tested, accompany every sensor shipped. The print out documents the chamber pressure (PO2 psi), signal output (mV) and whether the sensor pass/failed (Result) within an error of ±3%.



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Model:	PSR-11-39-JD	
Serial No.:	90734789	
Date:	07/29/09	13:02
PO2 psi	mV	Result
2.99	12.14	PASS
14.06	57.11	PASS
24.69	99.64	PASS

Serialization / Date Code

Oxygen sensors have a finite life. Understanding the date code is vital to getting the benefit of the warranty period, which starts with the date shipped from factory, and helping users avoid buying and/or diving with aged sensors. For example, the serial number above 90734789 breaks down as follows:

Digit #1: (9) denotes the year of manufacture as 2009;

Digits #2,3: (07) indicates July as the month of manufacture;

Digits remaining: sequentially issued for uniqueness.

As the result of a number of issues related to the use of aged sensors, Analytical Industries will add this definition of the serial number to the sensor's labeling along with the recommendation that sensors be purchased within 6 months of the manufacture date.

Warranty Policy

Sensors are warranted to be free of defects in materials and workmanship for 12 months starting with the date shipped from the factory, provided the sensor is properly installed and operated.

Analytical Industries Inc. shall not be liable for buyer's negligence, misuse, abuse or alteration. The sole remedy for a sensor determined to be defective by Analytical Industries Inc. is limited to replacing the defective sensor. Simply return your sensor and receive our documented evaluation and warranty determination within a week . . . no forms to fill out.