

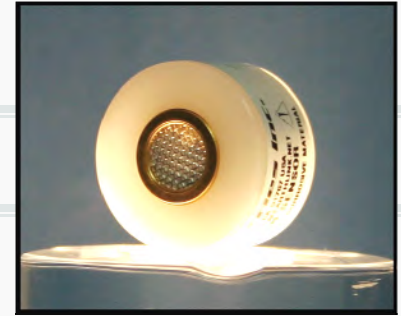


Analytical Industries Inc.
Advanced Instruments Inc.

Galvanic Percent Oxygen Sensors

An innovative and cost effective solution that provides 2 years of continuous measurements of up to 100% oxygen concentrations in a maximum suppressed range of 90-100% full scale with minimum drift, extended periods between calibration, unaffected by vibration and minor amounts of particulates and moisture.

- Accuracy: $\pm 1\%$ FS under constant conditions
Inherent 0.1% after calibration with 100% oxygen
- Sensitivity: 0.5% of full scale range
- High range: 90-100% suppressed full scale range
- Response time: 90% of full scale: < 13 seconds
- Expected life: 24 months at 100% oxygen levels



Background

Historically, the production of pure oxygen has been confined to medical grade oxygen (99.0%). However, the demand for oxygen is expanding rapidly due to developments in chemical processes requiring elevated levels of oxygen (85-95%) that boost yields and reduce emissions without significant cost increases. To a lesser extent the growth of transfilling oxygen (92%) cylinders for home care use. The oxygen supplied can be produced cryogenically, by pressure (PSA) or by vacuum (VSA) swing adsorption methods.

Analyzers based on paramagnetic sensors have been the primary method of measuring oxygen purity. These sensors offer highly accurate results especially at the suppressed ranges of 98-100% oxygen. However, they are very sensitive to changes in the flow rate of the sample gas, the presence of minute particulates and moisture, temperature variations and vibration. As a result, compensating for these characteristics is expensive and requires frequent calibration of paramagnetic oxygen analyzers.

Analyzers based on galvanic oxygen sensors have always generated interest for oxygen purity measurements because they are specific to oxygen, versatile, low maintenance and less expensive. However, short sensor life and drift in the sensor's signal output with time have precluded their use.

Major Advancement in Galvanic Sensor Technology

An advanced galvanic sensor has been developed that is capable of accurately measuring 100% oxygen concentrations continuously over a two (2) year period. This proprietary design addresses the challenges of: 1) providing a sufficient amount of anode material to support the reduction of oxygen over several years, 2) maintaining at all times a sufficient concentration of hydroxyl ions to support the reduction of oxygen at and near the sensing electrode, and, 3) preventing the build-up of PbO at and near the sensing electrode that can cause the signal output of the sensor to drop or drift with time.

Through proprietary means the production rate of the reaction product is controlled without sacrificing either the fast response time (less than 13 seconds) or any of the features (described above) of analyzers based on galvanic sensors. The performance of this proprietary sensor was confirmed over 14 months of testing and exhibited excellent stability in 100% oxygen.

Performance Test Results

With the sensor and sample gas lines temperature controlled and the signal output of the sensor compensated for ambient pressure variations, it was possible to measure oxygen in the suppressed range of 90-100% with less than $\pm 1\%$ of full scale ($\pm 0.1\%$ oxygen) accuracy. The calibration was checked periodically and found to be within $\pm 1\%$ of full scale over the 14 month test period suggesting the interval between calibrations could be extended to several months.

To demonstrate the stability of the new analyzer, 99.5% oxygen was introduced (typically the threshold for manufacturers of pure oxygen) for 30 days and the output trended. The maximum variation in the signal output is $\pm 0.1\%$ oxygen over a 24 hour period and is primarily attributed to the variation in ambient temperature.

Based on the foregoing, the new analyzer galvanic sensor based analyzer offers a very viable and cost effective solution for measuring elevated oxygen levels up to and above 99.5% in a maximum suppressed range of 90-100% with excellent accuracy and stability, a significant reduction in calibration requirements, unaffected by vibration and minor amounts of particulates and moisture.