Percent oxygen measurement, 0 to 100%
For gas blending, ambient air monitoring, and process control applications

Introduction
The Neutronics EC250 (CAG250) oxygen sensor is designed to measure oxygen in the range of 0 to 100% by volume. The sensor output is linear with respect to the partial pressure of oxygen. Although it is similar to conventional galvanic oxygen sensors (lead anode / KOH electrolyte) in operation, the chemistry of the EC250 sensor is quite unique. By using a weak-acid electrolyte, this sensor can withstand high levels of CO₂, CO, and other acidic gases. This results in a sensor with a superior technical advantage over KOH type sensors in applications where these gases are present.

Operation
The EC250 sensor housing holds a lead anode, oxygen cathode (gold), and weak-acid electrolyte. A non-porous Teflon FEP membrane is bonded to the gold electrode. Oxygen permeating the membrane is electrochemically reduced at the gold electrode. The current generated is directly proportional to the partial pressure of oxygen at the sensing surface of the cell.

The reaction equations are:

- **Cathode**: \( O_2 + 4H^+ + 4e^- \rightarrow 2H_2O \)
- **Anode**: \( 2Pb \rightarrow 2Pb^{++} + 4e^- \)
- **Overall**: \( O_2 + 4H^+ + 2Pb \rightarrow 2H_2O + 2Pb^{++} \)

In both the KOH and weak-acid type cells, the net reaction generates PbO. The PbO is normally dissolved into the electrolyte, however, there is a point at which the electrolyte becomes saturated with PbO. At that point, PbO precipitates onto the lead anode, which can cause eventual cell failure.

The weak-acid electrolyte has a higher capacity to dissolve the PbO than the conventional KOH electrolyte. This gives the EC250 sensor a more stable signal and an exceptional service life characteristic.

Features
- Wide measurement range – 0 to 100% oxygen
- Rapid response time – T₉₀ < 15 seconds
- Long service life – expected sensor service life is > 2 years
- Patented weak-acid based technology – withstands high levels of CO₂, CO, and other acidic gases
- Low output drift – less than 1% drift over an 8 hour operation period at constant temperature and pressure

Applications
- Industrial safety
- Oxygen deficiency monitoring
- Contact lens manufacturing
- Controlled environments
- Cryogenic gas storage areas
- Emissions monitoring
- Glove box systems
- Hazardous material storage areas
- Inert gas purity / nitrogen purity systems
- Laboratory and research facilities
Description
The EC250 sensor is designed with an integral temperature compensation circuit (see Figure 1). The circuit compensates the cell output from 5°C to 40°C.

Response time
The EC250 sensor responds to step changes in oxygen concentration on the order of 97% of the final value within 25 seconds or better. For example, if the sensor is exposed to 100% nitrogen from a starting concentration of 20.9% oxygen (air), the sensor output will correctly decrease to an equivalent t of 0.6% oxygen in 25 seconds or less.

The sensor responds to a 90% step change in oxygen concentration within 15 seconds or better. For example, if the sensor is exposed to 100% nitrogen from a starting concentration of 20.9% oxygen (air), the sensor output will correctly decrease to an equivalent of 2.1% oxygen in 15 seconds or less.

Zero offset
The housing material for the EC250 sensor is CPVC plastic. Theoretically, some oxygen from the surrounding air can permeate the housing wall into the sensor resulting in an extremely small baseline voltage. However, equilibrium with the surrounding air is quickly reached after the sensor is manufactured. The resulting baseline voltage of the typical sensor is very stable. When a gas stream consisting of 100% nitrogen is exposed to the sample port of the sensor, the baseline voltage (zero voltage) will be 500µV or less.

Humidity effects
The concentration of oxygen varies directly with changes in the relative humidity (RH) of the sample gas. That means that the output of the EC250 sensor is directly proportional to changes in the RH of a sampled gas. Figure 4 shows the change in concentration of oxygen in ambient air for the range of 0-100% RH at different temperatures. The change in the oxygen concentration is directly related to the dilution effect of water vapor.
EC250 ELECTROCHEMICAL OXYGEN SENSOR

Stability
Under normal operating conditions, the EC250 sensor exhibits less than 1% (full scale) drift over an 8 hour operation period at constant temperature and pressure. Factors that determine long-term stability and drift include:

- Operating temperature
- Sample pressure
- Shock/vibration
- Chemical exposure

Signal drift during sudden temperature changes is due to the response of the temperature compensation circuit, included in the EC250 sensor. The thermal mass of the sensor typically slows down any transient temperature effects. However, the EC250 may exhibit a slight increase in signal output when exposed to rapidly changing ambient temperatures. The drift is temporary as the sensor body normalizes with the surrounding ambient temperature. As a result, the sensor signal will not exhibit drift to changes in temperature of less than 1°C per hour.

Pressure effect and sample flow
The partial pressure EC250 is affected by changes in barometric pressures. The signal output is proportional and linear with respect to changes in the resulting partial pressure of oxygen. The relationship of signal output to changes in the barometric pressure may be expressed by the formula:

\[ S_t = S_{\text{measured}} \times \frac{P}{1013} \]

Where:
- \( S_t \) = theoretical signal output
- \( S_m \) = measured signal output @ 1013 mbar
- \( P \) = barometric pressure (mbar)

The sensor output is not directly affected by sample flow, however, a minimum flow of 3 sccm should be maintained to ensure sample exchange at the sample port. A sample flow of 100 sccm is typical for most applications.

Expected service life
Since the EC250 is a galvanic type cell, service life is calculated based on the theoretical consumption of cell components (lead anode and electrolyte). Life is stated in oxygen-percent hours:

\[ \text{oxygen concentration (\%) x exposure time (hours)} \]

For the EC250, service life is estimated at approximately 1,500,000 oxygen % hours. That indicates an expected lifetime of more than 5 years in ambient air (20.9% oxygen). It is important to note that several factors affect the actual service life of the sensor. These include storage temperature, operating temperature and pressure, and exposure to chemicals.

Installation guidelines
The EC250 sensors (see Figure 5) are designed for industrial applications. Guidelines for use include:

- Do not expose the sensor to gas sample streams that exceed the recommended operating temperatures
- For optimal performance and service life, mount the sensor with the sensing surface pointed down or in a horizontal position. Do not install the sensor with the sensing surface pointing in an upward position. Follow these recommendations for sensor storage.
- Take precautions to prevent condensation on the surface of the sensing surface
- Do not expose the sensor to biased voltage

Fig. 4, humidity effects
Fig. 5, sensor configuration
## Technical specifications

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<tr>
<th>Parameter</th>
<th>Specification</th>
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<td>Measurement technology</td>
<td>Electrochemical</td>
</tr>
<tr>
<td>Measured gas</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Measurement range</td>
<td>0 to 100%</td>
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<tr>
<td>Output</td>
<td>10.0 to 15.5mV in air at 1013 mbar and a temperature range of 23 ±2°C</td>
</tr>
<tr>
<td>Zero offset</td>
<td>≤ 0.50mV when exposed to 99.9% to 100% nitrogen at STP</td>
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<tr>
<td>Response time (T&lt;sub&gt;90&lt;/sub&gt;)</td>
<td>≤ 15 seconds at 23 ±2°C</td>
</tr>
<tr>
<td>Linearity</td>
<td>Within ±1% of full scale</td>
</tr>
<tr>
<td>Stability</td>
<td>&lt; 1% of full scale over an 8 hour period at constant temperature, pressure, and humidity</td>
</tr>
<tr>
<td>Operating service life</td>
<td>&gt; 24 months (&gt; 1,500,000% oxygen hours under normal operating conditions)</td>
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<tr>
<td>Operating temperature range</td>
<td>5°C to 40°C (41°F to 104°F)</td>
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<tr>
<td>Zero offset</td>
<td>≤ 0.5 mV when exposed to 99.9% to 100% nitrogen</td>
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<td>Humidity range</td>
<td>5 to 95% RH non-condensing</td>
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<tr>
<td>Storage life</td>
<td>6 months</td>
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<tr>
<td>Optimal storage temperature</td>
<td>5°C to 25°C (41°F to 77°F)</td>
</tr>
<tr>
<td>Maximum storage temperature</td>
<td>-15°C to 50°C (5°F to 122°F)</td>
</tr>
<tr>
<td>Interference</td>
<td>&lt; 2% of full scale in presence of 10% carbon dioxide</td>
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<tr>
<td></td>
<td>&lt; 2% of full scale in presence of 70% helium</td>
</tr>
<tr>
<td></td>
<td>&lt; 2% of full scale in presence of 75% nitrous oxide</td>
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<tr>
<td></td>
<td>&lt; 2% of full scale in presence of 5% halothane</td>
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<tr>
<td>Pressure effect</td>
<td>Continuous use in pressure range from 0.5 to 1.5 atm</td>
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<tr>
<td>Electrical connector</td>
<td>Switchcraft 712A power connector</td>
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<tr>
<td>Process connection</td>
<td>M16 x 1 thread</td>
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<td>Mounting</td>
<td>For optimal performance, install the sensor with the sensing surface pointing down or horizontal</td>
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<tr>
<td>Warranty</td>
<td>12 months from date of shipment</td>
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<td>Part number</td>
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