

NEW, MOTION STABLE WEAK ACID ELECTROLYTE OXYGEN SENSOR MAX-250 SERIES

FOR EMISSIONS TESTING, GAS BLENDING & AMBIENT AIR
MONITORING APPLICATIONS



Benefits

- Stable Signal
- Ideal for portable instruments
- Extra-Life, 900,000 O₂ % hrs
- Safe, Non-Caustic Electrolyte
- Unaffected by acid gases including CO, CO₂ and NO_x

Applications

- Combustion Efficiency Analysis
- Gas Blending
- Breathing Apparatus – SCUBA
- Compost Monitoring
- Food Storage Monitoring

GENERAL

The Maxtec MAX-250 Series oxygen sensors are of the galvanic cell type. They are similar to the conventional galvanic oxygen sensor (lead anode / KOH electrolyte) in operation. However, the chemistry of the MAX-250 Series sensors is quite unique. By implementing a weak acid electrolyte, MAX-250 sensors offer superior performance over the conventional oxygen sensor when used in applications such as emissions testing.

The weak acid electrolyte of the MAX-250 series sensor is unaffected by CO₂, CO, and NO_x. This results in a sensor with a superior technical advantage over KOH type sensors in applications where these gases are present.

1. Specifications MAX-250 Series Oxygen Sensor

Sensor Type:	Galvanic Cell (lead-oxygen battery) using patented weak acid electrolyte
Measurement Range:	0-100% oxygen
Output Voltage:	Temperature compensated and linear over full scale 13 ± 3mV in air at 23°C (± 1°C), 60 ± 5% RH, and 1,000mB
Response Time:	<ul style="list-style-type: none">▪ < 15 seconds for 90% response▪ < 25 seconds for 97% response
Accuracy:	± 2.0% Full Scale over operating temperature range ± 1.0% Full Scale @ constant temperature and pressure
Electrical Interface:	MAX-250: 150mm Leads: Red=Positive, Black = Negative MAX-250E: Switchcraft mini receptacle #712A, mating male jack: Switchcraft #760
Sample Port:	M16 x 1 Threaded Port w/BUNA-N O-Ring
Operating Temperature:	5° to 40°C (31 - 104°F)
Storage Temperature:	-15° to 50°C (5 - 122°)
Operating Humidity:	0-95% non-condensing
Recommended Load:	Minimum 1M Ohms
Zero Offset Voltage:	Less than 0.5mV in 100% N ₂ @ STP
Cross Interference:	Less than 0.1% O ₂ response to: <ul style="list-style-type: none">▪ 0-100% CO₂ ...balance nitrogen▪ 0-1% NO_x, CO, H₂, H₂S ...balance nitrogen
Life:	900,000 oxygen % hours
Warranty:	12 months from date of shipment under normal operating conditions (contact manufacturer for specific requirements)
Pressure Effect:	<ul style="list-style-type: none">▪ Continuous use in pressure range from 0.5 atm to 1.5 atm▪ Sensor output to be linear with partial pressure of oxygen within ± 2% of full scale
Required Sample Flow:	Minimal 3cc/minute, 100cc/minute typical
Stability:	Less than 1% drift over 8 hours at constant temp & pressure
Weight:	~32gm. (1.2 oz.)

Specifications subject to change without notice

2. Principle of Operation:

The MAX-250 series oxygen sensors are lead-oxygen batteries, each consisting of 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.

Reactions in the conventional KOH type oxygen sensor occur in the following manner.

Cathode:	$O_2 + 2H_2O + 4e \rightarrow 4OH^-$	(1a)
Anode:	$2Pb + 4OH^- \rightarrow 2PbO + 2H_2O + 4e$	(2a)
Overall:	$O_2 + 2Pb \rightarrow 2PbO$	(3a)

In the Maxtec MAX-250 series of oxygen sensors using the weak acid electrolyte, the following reaction occurs:

Cathode:	$O_2 + 4H^+ + 4e \rightarrow 2H_2O$	(1b)
Anode:	$2Pb \rightarrow 2Pb^{++} + 4e$	(2b)
Overall:	$O_2 + 4H^+ + 2Pb \rightarrow 2H_2O + 2Pb^{++}$	(3b)

In both the KOH and the 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 this point, PbO precipitates onto the lead anode which can cause eventual cell failure. However, the weak acid of the MAX-250 series a clear advantage over the KOH type electrolyte...

The weak acid has a higher capacity to dissolve PbO than sensors which contain the conventional KOH electrolyte, (up to 20 times higher)! The weak acid electrolyte results in a sensor with an exceptional life characteristic.

Additionally, because each MAX-250 series sensor uses an acid electrolyte, it is virtually unaffected by the presence of background gasses such as CO₂, SO₂ and NO_x. **This characteristic results in an ideal oxygen sensor for emissions testing applications!**

Each MAX-250 series oxygen sensor is designed with an integral temperature compensation circuit. The temperature circuit effectively compensates cell output from 5° to 40° C. The sensor may be stored in a temperature range from -15° to 50° C.

Each sensor in the MAX-250 series utilises a specially formulated solution of acetic acid electrolyte. This results in two exceptional characteristics. The MAX-250 sensors exhibit low or non-existent cross sensitivity to gas species common in the end products of combustion. Additionally, the MAX-250 sensors show excellent signal stability to changes in position and to motion.

The sensor chemistry shows little effect by several other gasses including refrigerants and hydrocarbons. However, since the electrolyte is acidic, the MAX-250 series of sensors show some sensitivity to high concentrations of caustic vapours. See Figure 1.

Figure 1 Cross Sensitivity

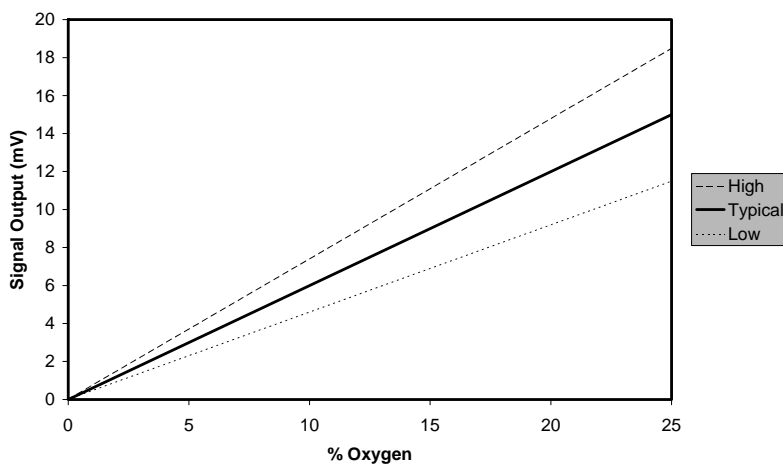
Effect	Type of Gas
No Effect	CO ₂ , N ₂ , Ar, CH ₄
Minor Effect	Cl ₂ , CFC's, SO ₂ , NH ₃ , HCl, CO, H ₂ S, NO _x , H ₂
Moderate Effect	Isopropyl Alcohol, Hexane, CCl ₄
Severe Effect in high concentrations; not recommended	Sodium Hydroxide, Acetone*, MEK* (* affects CPVC housing of sensor)

3. Sensor Characteristics:

3.1 Signal Output (Figure 2)

The MAX-250 series sensors are 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. MAX-250 series sensors are compensated for the effect of temperature in the range of 5° to 40°C. Each new sensor has a unique signal output which will fall within the area defined between the HI and LO curves as depicted in Figure 3. The accuracy in full scale (100% oxygen) of the MAX-250 series sensors is ± 2% or better over the operating temperature range. At constant temperature and pressure, the accuracy in full scale is ± 1% or better.

Signal Output @ 0-25% Oxygen



3.2 Response Time

The sensor will respond 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 of 0.6% oxygen in 25 seconds or less. The sensor will respond 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. Extensive testing indicate the typical MAX-250 series sensor responds much faster than the listed specification.

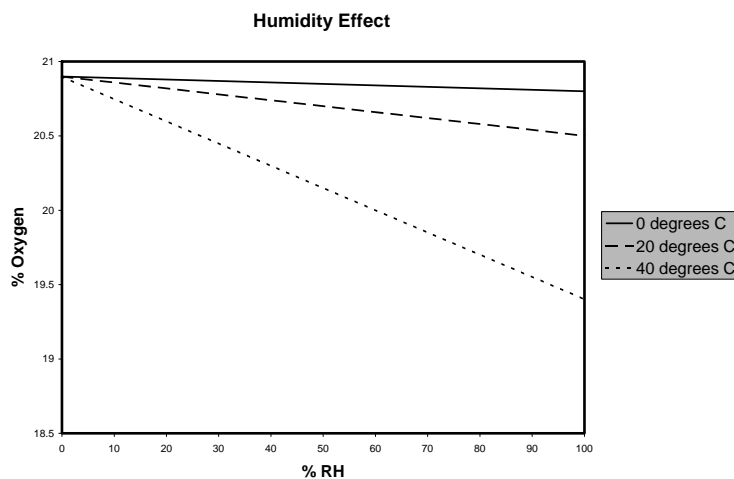
3.3 Zero Offset

MAX-250 series sensors utilize an CPVC plastic housing. 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 manufacture. The resultant 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 MAX-250 series sensor, the baseline voltage, (zero voltage) will be 500 μ V or less.

3.4 Humidity Effects

The concentration of oxygen varies directly with changes in the Relative Humidity (RH) of a sampled gas. Thus the output of a MAX-250 series sensor is directly proportional to changes in the RH of a sampled gas. Figure 3 depicts 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 vapour.



3.5 Stability

Under normal operating conditions, MAX-250 series oxygen sensors exhibit less than 1% (Full Scale) drift over an 8 hour operation period at constant temperature

and pressure. However, there are many factors which determine long term stability and drift of oxygen sensors. The factors are directly related to the application and include:

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

Signal drift during sudden temperature changes are due to the response of the temperature compensation circuit which is built into the MAX-250 sensors. The thermal mass of the sensor typically slows down any transient temperature effects on the sensor. However, the MAX-250 may exhibit a slight increase in signal output when exposed to rapidly changing ambient temperatures. The drift is temporary as the sensor body itself normalizes with the surrounding ambient temperature. For this reason, the sensor signal will not exhibit drift to changes in temperature of less than 1°C per hour.

3.6 Pressure Effect & Sample Flow

Max-250 series sensors measure the partial pressure of oxygen and thus are affected by changes in the sample / barometric pressures. The signal output is proportional and linear with respect to changes in the resultant partial pressure of oxygen. The relationship of signal output to changes in the barometric pressure may be expressed by the formula:

$$S_t = S_m \times P / 1013$$

Where:

$S_t =$	Theoretical signal output
$S_m =$	Measured signal output @ 1013 mb
$P =$	Barometric pressure (mb)

The sensor output is not directly affected by sample flow. However, a minimum flow of 3 cc/minute should be maintained to assure sample exchange at the sample position. A sample flow of 100 cc/minute is typical for most applications.

4. Expected Life and Warranty

Since the MAX-250 series oxygen sensors are galvanic cells, life is calculated based on the theoretical consumption of cell components (ie: lead anode & electrolyte). Life is stated in oxygen-percent-hours: [Oxygen concentration (%)] x [Exposure time (hours)]. For all sensors of the MAX-250 series, lifetime is estimated to be approximately 900,000 oxygen % hours. This indicates an expected lifetime of over 4 years in ambient air (20.9%). It is important to note that several factors effect the actual lifetime of a sensor. These factors include storage temperature, operating temperature / pressure, and exposure to chemicals. The standard warranty period for MAX-250 series oxygen sensors is 1 year from the date of shipment under normal operating conditions.

5. Installation Guidelines

MAX-250 series oxygen sensors are designed for the industrial environment, Excellent performance can be attained by following a few simple guidelines:

- ⇒ Do not expose the sensor to gas sample streams exceeding those listed under “Operating Temperature”.
- ⇒ In general, there are no attitude restrictions for installation of the sensor. However, for optimal performance and life characteristics, it is recommended that the sensor be mounted with the sensing surface pointed down or in a horizontal position. It is recommended that the sensor not be installed with the sensing surface facing in an upwards position. This guideline should also be noted for storage of the sensor.
- ⇒ Take precautions to prevent condensations on the surface of the sensing surface.
- ⇒ Do not subject the sensor to excessive shock or vibration.
- ⇒ Do not expose the sensor to a biased voltage. Namely, do not design circuitry which would inherently charge the sensor.
- ⇒ Associated instrumentation should be designed so that the minimum operating load on the sensor is 1M Ohms.