

**DELTA F CORPORATION**  
**APPLICATION NOTE NO.**  
**102**



## **Monitoring Oxygen in a Heat Treating Furnace**

What do an engine crankshaft, lawnmower blade, door knob and belt buckle all have in common? Besides being fabricated out of metal, each had to be heat treated for purposes of strength, flexibility, sheen, etc. Most people are unaware of the importance heat treating plays in helping to maintain today's high standards of living. Since the days of the village blacksmith, heat treating has evolved to a level of complexity paralleling that of other high tech industries.

When heat treating furnaces were first used, the gas atmosphere within the furnace was generated from the combustion of fossil fuels such as coal, wood or oil. Control of this atmosphere was difficult – very often leading to poor quality parts. With time, it became apparent that the furnace gas atmosphere had to be controlled in order to improve the quality of the treated metal parts. Gases such as oxygen, carbon dioxide, water vapor, carbon monoxide, etc. were monitored and then eventually controlled in any attempt to improve both product yield and quality.

### **The Role of Oxygen Analyzers**

For many heat treating processes, the measurement of oxygen plays an important part in helping to ensure the quality of the treated metal parts. For example the combustion mixture associated with a rich exothermic gas atmosphere must often be controlled to reduce the levels of oxygen in order to increase the amounts of carbon monoxide and hydrogen. Applications include bright annealing, low and medium carbon steels, brazing with bright finish or clean hardening of low and medium carbon steels.

For endothermic gas atmospheres, the oxygen concentration of the furnace atmosphere is a good indicator of the suitability of the overall gas mixture. Endothermic gas mixtures are used for hardening without decarburization of high carbon steels, and the carrier gas for carburizing and carbonitriding.

### **National Fire Protection Association (NFPA) Standard 86C For Industrial Furnaces Using A Special Processing Atmosphere**

In addition to their value as a quality control tool, oxygen analyzers are being used to help protect against accidental explosions and fires in furnaces that utilize special processing atmospheres such as hydrogen, dissociated ammonia, etc. The NFPA recommends that under certain conditions, furnace atmospheres be monitored for oxygen prior to start up to help ensure that the atmosphere is below its explosive limit. NFPA further suggests that in some instances, backfilling with the required furnace atmosphere should not be started until verification that the oxygen concentration of the purge gas is acceptable.

### **Conventional Approach to Monitoring Oxygen**

Most oxygen sensors used to monitor heat treating atmospheres have a relatively short life span of several months. The reason is simple. They operate on a batter principle wherein life expectancy is a function of usage. Furthermore, as these sensors age, they have a tendency to read low due to a loss in sensitivity. For heat treating applications, false low oxygen readings can produce dire consequences. As a result, analyzers that use battery type sensors must be recalibrated on a frequent basis, as often as once per day depending on the critical nature of the application.

Another major drawback of battery-type sensors, particularly when used for trace oxygen measurements. is their susceptibility to “oxygen shock”. If exposed to a large concentration of oxygen, these sensors can take several hours to recover. One manufacturer of battery-type oxygen sensors suggests their analyzers be “purged overnight” with an inert gas if accurate readings under 10 PPM are required! The combination of false low readings, frequent recalibrations and slow speed of response has prompted heat treaters to look for a better solution.

## The Delta F Difference

Delta F has solved the problems associated with battery-type sensors with its unique non-depleting electrochemical sensor. Unlike battery-type sensors, the Delta F Sensor *does not require periodic replacement* and does not produce false low readings due to loss of measurement sensitivity. Whereas conventional electrochemical sensors use a consumable electrode as the driving mechanism for the reaction, an external EMF of 1.3 VDC drives the reaction in the Delta F Sensor. The sensor electrodes are non-depleting. Therefore, neither electrode undergoes chemical changes as oxygen is being measured. As a result, much better measurement stability is achieved and periodic sensor replacement is eliminated.

**All Delta F Sensors Have A Five Year Warranty.**

### Comparison of Delta F's Oxygen Analyzers vs Battery-Type Oxygen Analyzers

<u>Item</u>	<u>Delta F Analyzers</u>	<u>Battery-Type Sensors</u>
<b>Sensor Electrodes:</b>	Non-Depleting: Neither electrode undergoes chemical change.	Depleting: The depolarizing metal anode reacts to form a metal oxide. This eventually leads to sensor replacement.
<b>Sensor Life:</b>	Typically the life of the instrument.	Average 6 months. (Replacement sensors can cost up to several hundred dollars.)
<b>Sensor Warranty:</b>	5 Years.	Factory calibration is usually not provided-user must establish initial accuracy.
<b>Field Calibration:</b>	Recommend calibration check once every 3-4 months.	Typical frequency: once every few days depending on the critical nature of the application.
<b>Susceptibility of trace</b>	None-readings to under 10	Yes – exposure to high O <sub>2</sub>

**analyzers to “oxygen shock”:**

PPM from air can be made within minutes.

concentrations will shock sensor, requiring several hours to establish equilibrium conditions. In some cases, manufacturers recommend “overnight purging” of the analyzer to measure under 10 PPM accurately.

**Gas Compatibility:**

Optional STAB-EL Electrolyte System allows continuous operation with samples containing acid gases such as H<sub>2</sub>S, CO<sub>2</sub>, Cl<sub>2</sub>, HCl, SO<sub>2</sub>, NO<sub>x</sub>, etc.

The sensors typically cannot tolerate acid gases. Gas scrubbers are recommended.

**Recognized For Quality**

Delta F's Quality Management System has been certified to ISO-9001 by Lloyd's Register Quality Assurance Ltd. This demonstrated compliance with an internationally accepted standard assures you of the highest quality in product design, manufacturing, and service.

Delta F Oxygen Analyzers can be ordered with a full scale range of 0-2 parts per billion (ppb) to as high as 0-25 percent. For specific product recommendations, contact Delta F Corporation, 4 Constitution Way, Woburn, MA 01801-1087, Tel. (781)935-4600, FAX (781)938-0531, e-mail [marketing@delta-f.com](mailto:marketing@delta-f.com).