

DELTA F CORPORATION

APPLICATION NOTE NO.

111



Measuring Oxygen in a Welding Gas

Certain welding applications must be carried out in an inert atmosphere with low levels of oxygen. Excess oxygen can ruin the weld and, thus, the product itself. Monitoring oxygen can produce higher yield and improve product quality.

Inert Gas Welding

The art of joining metals dates back to the Bronze Age. Throughout the centuries, there have been numerous developments in modern welding processes. One of those developments is Inert Gas Welding. There are two common procedures for this, Tungsten Inert Gas (TIG) and Metal Inert Gas (MIG) welding.

The TIG process utilizes a nonconsumable electrode, usually tungsten, to create an arc at the weld joint with enough heat to create a molten pool. The weld is protected from atmospheric contamination by an inert gas, typically argon, helium, or a mix of the two. The gas is often delivered to the weld location through a torch which also holds the electrode. In applications where tight quality control of the weld is required, the gas is used to purge a glovebox, or mini-environment, around the entire welding area.

By welding in an inert atmosphere, high purity welds which are free of oxidation are formed. This results in a high quality product with a cost savings due to less scrap.

Weld Gas Purity Is Critical to Success

Inert welding gases are prepared by companies that specialize in producing high purity bottled gases for end-users such as welders. Preparation of welding gas cylinders involves the blending of precise mixtures of high purity inert gases, such as N₂, Ar, He, and CO₂, into cylinders for specific welding applications. In order to insure these mixtures will meet the stringent requirements of welders, care must be taken to eliminate potential contaminants at every stage of the manufacturing process.

Oxygen is the most important and easiest contaminant to measure because it can identify the infiltration of all atmospheric contaminant, for example moisture or nitrogen, which can corrupt pure gases through any fault in the filling or storage system. The starting point in the process is the purity verification of the source gases used for cylinder filling and mixtures. Continuous monitoring, or at least spot-checking, the purity of the source gases protects against a major disruption in production.

The most common place that contaminants are introduced is in the area of cylinder preparation prior to filling. It is imperative that the cylinder pump-down and bake-out procedures are stringently followed to remove all contaminants.

Also, the blending process must be monitored and controlled. Any minuscule leak from the bulk gas storage, compressors, or distribution and cylinder fill manifolds can allow enough oxygen to enter into the process to exceed targeted specifications. However, even with proper preparation of the cylinders and control of the gas distribution system and blending process, good manufacturing practice dictates a purity verification at all of the critical stages of the cylinder production process.

Lastly, gas producers must make a Final Product Quality analysis to check for the presence of contaminants in gas mixtures prior to shipment to the end-user. It is an essential part of the production process to have Statistical Quality Control (SQC) analysis of the final product quality for each individual or batch of cylinders. These records

must be kept for appropriate SQC traceability.

There are several approaches for accurately measuring and monitoring the amount of oxygen in the various stages of manufacturing, but only one provides an extremely stable, reliable and maintenance-free approach.

The Delta F Difference

Delta F has solved the problems associated with fuel cell based oxygen analyzers with its unique non-depleting coulometric sensor that has carbon electrodes which never undergo chemical change. The Delta F sensor provides unmatched performance features such as:

- Extremely Stable, Long-term, Drift-Free Operation
- No False Low Readings
- 5-Year Sensor Warranty
- Factory Calibrated to NIST Traceable Standards
- Acid Gas Operation with STAB-EL™ Option
- Quick Start-up and Rapid Response
- Immunity to O₂ Shock

Unlike other types of sensors, the Delta F sensor does not require periodic replacement and does not produce false low readings due to loss of measurement sensitivity or reaction with sample gas components. The sensors operate on a simple coulometric process whereby oxygen in the sample gas is reduced at the cathode to hydroxyl ions. Assisted by the potassium hydroxide electrolyte, the ions migrate to the anode, where they are oxidized back to oxygen which vents out of the sensor. Whereas conventional electrochemical sensors use a consumable lead anode and a silver cathode, the Delta F electrodes are made of carbon and are non-depleting, i.e. neither electrode undergoes chemical changes.

As a result, much better measurement stability is achieved and the need for periodic sensor replacement is eliminated. In contrast to galvanic sensors which require frequent calibrations, the Delta F sensor may only require yearly span checks, not recalibrations, and addition of water. Even after sitting unused, the Delta F analyzer will be ready to provide calibrated readings whenever needed. The fast speed of response of the Delta F sensor gives immediate indication of changes in the oxygen level whether they are caused by an ambient air leak or by an incorrect inert gas purge rate.

Delta F's STAB-EL™ option is available to protect the analyzer from the harmful effects of trace acid gas contaminants, such as CO₂. The STAB-EL™ option counteracts electrolyte contamination and the carbon electrodes are highly resistant to acid gas poisoning.

Delta F's sensor will measure accurately in a wide variety of background gases and mixtures with the easy application of a "background gas scaling factor." It is a simple numerical constant that can be dialed in when using background gases that are either much heavier or lighter than N₂, such as H₂, He, CO₂ and hydrocarbons. This can be done within the analyzer itself, or applied directly by the user as a simple multiplier to analyzer readings. The Delta F sensor does not require calibration with the specific gas or mixture in which the user wants to measure. Other sensor technologies can only read accurately if they are calibrated with bottled standards of O₂ in the same background gas that the analyzer is expected to read, such as H₂, He, Ar, CO₂, or any mixture.

Conventional Approaches to Monitoring Oxygen

The galvanic oxygen sensor technology uses two dissimilar metal electrodes, typically silver and lead, which are consumed in the process of measuring O₂. The sensors have a relatively short life span of several months because:

- The lead anode is consumed
- The silver cathode is attacked by acid gases
- The electrolyte is sensitive to off-gas vapor contamination

The galvanic sensors operate on a battery principle where the life expectancy is a function of usage. They will eventually read low due to a loss in sensitivity as electrode sites are depleted. Analyzers with replaceable battery-type galvanic sensors must also be recalibrated on a frequent basis because the silver cathode is poisoned by very low levels of acid gases, such as H₂S, which are often by-products of the process. These trace contaminants oxidize the sites of the silver cathode and periodic sensor replacements are required. If analyzer calibration is not done frequently, the sensor can read falsely low resulting in poor quality or scrap product.

The depleting, battery-type sensors are covered by a permeable membrane which separates the gas sample from the electrolyte and allows the oxygen ions to migrate into solution. If the sensor is exposed to an over-range condition, the electrolyte will saturate with oxygen from ambient air and it can take hours to return to PPM levels. These sensors are not ideal in applications which do not continuously expose them to an inert gas.

Delta F Analyzers

Delta F offers a full line of analyzers to meet your needs. There are complete analyzers and OEM versions for customer integration. Analog outputs, adjustable setpoints with relays, and RS232 or RS485 outputs are available to interface with your computer system to allow you to control alarms or purge flow. Delta F custom configures analyzers to meet each customers' requirements.

Recognized For Quality

Delta F's R&D, Manufacturing, and Customer Support functions are 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.