SERVOMEX

EXPERT PAPER

MonoExact DF150E

Selecting oxygen analysis for reflow furnace applications.

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Maintenance of low oxygen concentration in reflow furnaces produces higher quality product, less product defect, and lower maintenance costs - potentially saving thousands of dollars per year. But only the advent of a unique non-depleting oxygen sensor by Servomex avoids problems with sensor contamination and depletion experienced by traditional sensing technologies.

THE ROLE OF OXYGEN ANALYSIS IN REFLOW FURNACES

Following the widespread elimination of chlorofluorocarbons (CFCs) due to environmental concerns, PCB manufacturers are usually required to create an inert environment in the solder furnace to reduce oxygen (O_2) concentration. Historically, PCBs were cleaned with CFC-based agents, but newer solders are able to be applied in a nitrogen (N_2) purged environment without any loss in quality.

The two common solder processes are wave and reflow soldering. In the wave process, the PC board is passed over a cylinder of molten solder. In the reflow process, the boards are pre-pasted with solder, and conveyed through a pre-heater to allow the solder paste to run onto the components and hold them in place.

When O_2 is present in a solder furnace, it can compromise the wetting properties of the solder as it flows to the components. The result is poor solder joints: O_2 compromise can be observed as grey solder joints which indicate oxidation has occurred as the solder joined the components. Monitoring the level of O_2 in a furnace will ensure consistent welding quality. Also, metered N_2 levels ensure optimized soldering without excessive N_2 consumption.

GALVANIC SENSOR TECHNOLOGY (FIG.1)

Traditionally galvanic sensor technology has been used to monitor O_2 within the reflow process. A galvanic cell uses two dissimilar metal electrodes – typically silver and lead - which are consumed in the process of measuring O_2. The sensors have a relatively short life span of several months for a variety of reasons that include:

- The lead anode being consumed
- The silver cathode being attacked and compromised by acid gases
- Sensitivity of the electrolyte to flux vapour contamination
- Accelerated depletion when exposed to ambient air
- Loss of measurement accuracy as depletion occurs

Galvanic sensors operate on a battery principle where the life expectancy is a function of usage. They eventually read low due to a loss in sensitivity as electrode sites are depleted. Analyzers using replaceable battery-type galvanic sensors must also be recalibrated on a frequent basis, as silver cathode is poisoned by trace level acid gases generated in the atmosphere by the flux on the PCBs.

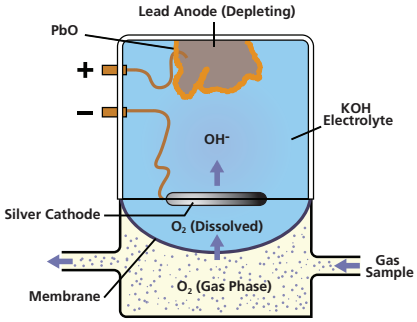

Fig.1: Galvanic Sensor

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 be reading 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 O_2 ions to migrate into solution. If the sensor is exposed to an over range condition - for example the opening of the solder system hood - the membrane will saturate with oxygen from ambient air, from which it can take hours for O_2 to return to ppm levels.

ZIRCONIUM OXIDE SENSORS (FIG. 2)

Zirconium oxide (ZrO_2) sensors, otherwise known as high temperature electrochemical sensors or hot probes, consist of a cell made of yttria stabilized zirconia ceramic, which operates at temperatures above 1200°F or 650°C. Reducing gas in the sample – i.e. any gases that can be oxidized by reaction with O_2, such as CO, H_2, NH_3, and all hydrocarbons - being measured by a ZrO_2 sensor significantly interferes with the accuracy of its reading.

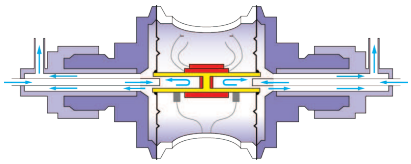

Fig.2: Zirconium Oxide Sensor

Due to the high temperature of the sensor, the O_2 is reacted with hydrocarbons that are given off by the flux in the furnace. As this reacted O_2 is not being measured, ZrO_2 can give false low readings that result in poor quality welding and product scrap or low quality products.

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COULOMETRIC OXYGEN SENSING - A SOLUTION FOR REFLOW OXYGEN ANALYSIS (FIG.3)

Utilizing carbon electrodes which are not affected by chemical change, Servomex's non-depleting Hummingbird Coulometric sensor (Fig.3) avoids the problems associated with using galvanic or zirconium oxide sensors in reflow furnaces. Unlike other types of sensors, the Coulometric 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 sensor operates on a simple Coulometric process whereby oxygen in the sample gas is reduced in an electrochemical reaction. O_2 is reduced at the cathode to hydroxyl ions and - assisted by potassium hydroxide electrolyte - the ions migrate to the anode, where they are oxidized back to O_2 which vents out the sensor. Whereas conventional electrochemical sensors use a consumable lead anode and a silver cathode, the carbon composition of the electrodes are non-depleting: neither electrode undergoes chemical change. As a result, excellent measurement stability is achieved.

The fast speed-of-response of Coulometric sensing provides immediate indication of changes in O_2, regardless of whether they are caused by an ambient air leak or by incorrect N_2 inerting levels. In contrast to galvanic sensors which require frequent, usually bi-weekly, calibrations, the latest Servomex Coulometric sensor requires only an annual calibration, biannual addition of replenishment solution and no programmed cell replacement.

Servomex's unique Coulometric sensor technology is optimized for use in reflow furnaces by integration into the new SERVOPRO MonoExact DF150E, an advanced oxygen analyzer that offers exceptionally accurate O_2 analysis for excellent batch quality and significantly improved nitrogen consumption.

Built around the latest innovations in software and hardware, including an updated Coulometric digital oxygen sensor, DF150E brings operational and maintenance benefits that improve user control and reduce cost of ownership.

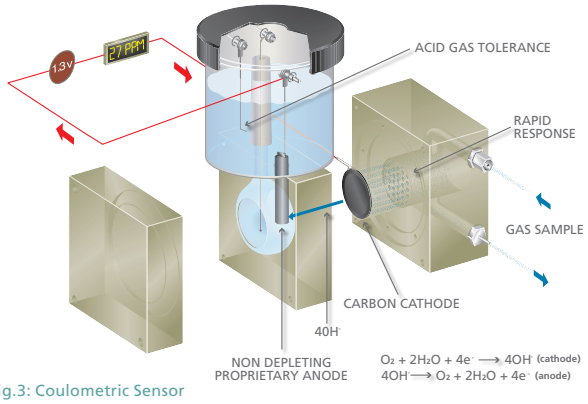

Fig.3: Coulometric Sensor

Built around Servomex's new advanced user interface, the DF150E offers immediate hands-on control via a high brightness touchscreen display. Intuitive to use, Servomex's software is optimized for a simple user journey, with the touchscreen GUI making reporting or adjusting control parameters effortless. With the standard 0-10VDC out and optional 4-20mA out and concentration alarms, the DF150E requires minimal training and maintenance to operate.

The DF150E is accurate to +/-5% of reading or 0.05% of full range whichever is larger. Concentration ranges include 0-100ppm, 0-1,000ppm and 0-10,000ppm.

As Coulometric technology ensures accuracy with no sensor drifting and no false low readings, the DF150E provides highly effective protection against inerted material oxidization. This 'no fail' performance is crucial as a false O_2 reading can waste thousands of dollars in scrapped final product, schedule disruption or cause safety issues when using N_2 or mixtures using N_2 as a blanketing gas.

The flexibility of the DF150E means it can be easily integrated into multiple zone sample systems using a manual or automatic sequencing system. This makes the DF150E ideal for OEM furnace manufacturers who supply analyzers as an option or as standard for the end-user, heat treatment contractors and on-site or laboratory processes.

And, as a direct successor to the original DF-150E, the MonoExact DF150E delivers the same precise, accurate oxygen measurement in a backwards-compatible design that integrates easily into existing systems. This ensures the MonoExact DF150E complies with existing standards and customer agreements, without the need for re-testing or re-qualification.

Every DF150E is custom configured under ISO-9001 controls to meet precise specifications and calibrated to standards traceable to NIST and is thoroughly tested to ensure flawless out-of-the-box performance.

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Hummingbird SENSING TECHNOLOGY

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