SERVOMEX

EXPERT PAPER

Subject: The principles of magnetodynamic paramagnetic measurement used in the Servomex OxyDetect oxygen deficiency gas monitor

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The new OxyDetect from Servomex utilises the company's world-leading position in the development and application of paramagnetic sensing technologies to produce a revolutionary non-depleting O_2 monitor: one that offers industry-leading levels of measurement stability, accuracy and reliability, as well as a host of operation and cost advantages when compared to traditional depleting electrochemical galvanic technologies.

Servomex's innovative magnetodynamic sensing technology applies principles of paramagnetic measurement first described by Michael Faraday. Michael Faraday's experimental research into electromagnetics are regarded as the precursor to modern electric motors, generators and transformers; his investigations during 1845 into the interaction of matter and magnetic forces provide the basis for the modern paramagnetic O_2 transducer.

Faraday discovered that substances such as iron, nickel, cobalt and oxygen were attracted into the intense part of a magnetic field. These groups of elements were classified as being 'Paramagnetic'. Other materials he found were repulsed from the magnetic field, and these he classified as Diamagnetic.

Servomex's paramagnetic sensors take advantage of these unusual magnetic properties displayed by O_2. This magnetic susceptibility - the effect a magnetic field has on a material – may be quantified as the magnetic susceptibility per unit volume (k).

This principle of magnetic susceptibility may be demonstrated by the Faraday method (Fig.1) Here a test body of mass m with associated magnetic susceptibility $K1$ and Volume V is placed into a non-uniform magnetic field H of gradient $\delta H/\delta x$. Under these conditions the test body will experience a force ($f2$) along the x axis described by the following equation (1).

$$f_2 = k1 v_H \, \partial H / \partial x \qquad \text{Eq.1}$$

Oxygen possesses by far the highest susceptibility of the common gases, making the measurement specific to oxygen. To illustrate, the molar susceptibility (χM x 10-6) of oxygen is 3449.00 – vastly higher than any other gas including Nitrogen (-12.00), Carbon Dioxide (-21.00), Carbon Monoxide (-9.80) and Methane (-17.40).

As this exceptionally high magnetic susceptibility is several hundred times greater than that of most other gases, this sensitivity to magnetic fields can be used for an exceptionally accurate O_2 measurement.

Servomex's Paramagnetic sensor (Fig.2) consists of a small dumbbell-shaped body made of glass and filled with nitrogen, a photodiode, a mirror, and an LED calibrated indicating unit. The dumbbell body is suspended in an enclosed test cell within the magnetic field of a permanent magnet and is mounted onto a taut band left free to rotate in the space between the poles of the magnet (Fig.3). Since the dumbbell body has negative magnetic susceptibility because of its nitrogen content, the balls of the dumbbell naturally deflect slightly away from the point of maximum magnetic field strength.

When a test sample containing O_2 is introduced into the test cell, the O_2 in the sample is attracted to the point of maximum field strength. The spheres will experience a force (f1) which is a function of the test gas volume susceptibility k2. This force may be characterised by equation (2) as follows:

$$f_1 = (k1 - k2) v_H \, \partial H / \partial x \qquad \text{Eq.2}$$

The magnitude of the force is proportional to the oxugen concentration.

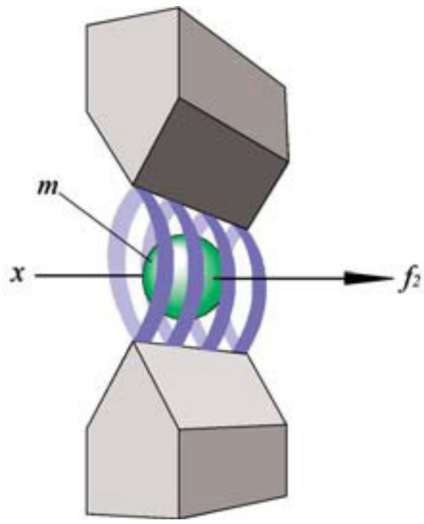

Fig.1

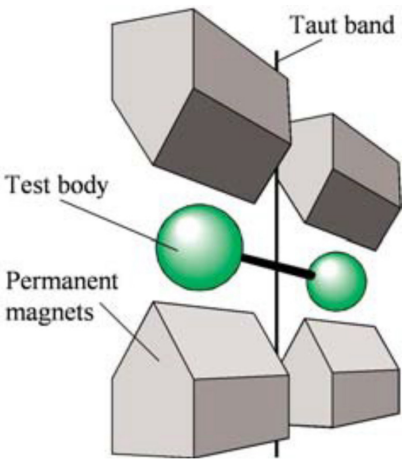

Fig.2

The industry-leading levels of linearity, accuracy and reliability delivered by paramagnetic technologies are ideal for use in life critical and life safety applications and have ensured its use as a trusted oxygen sensor for medical oxygen monitoring and process gas analysis. Paramagnetic sensors also demonstrates several important operational advantages over traditional electrochemical galvanic technologies used in Fixed Point monitoring systems, delivering users a considerably lower cost of lifetime ownership.

The non-depleting technology offers reduced calibration requirements, long life and low cost-of-ownership in comparison to other sensor technologies. Paramagnetic technology's non-consumable design ensures longevity and eliminates the costs associated with the regular replacement of electrochemical, galvanic or fuel cells, as well as the recognised problems of cell degradation when in use or kept as a stock item.

As the OxyDetect's paramagnetic measurement stability also eliminates the requirement for frequent calibration, users avoid frequent labour and downtime costs, incurred either when a traditional cell is calibrated or replaced due to anticipated expiration or sudden failure.

The first product to be launched under the new Servomex Gas Detection brand, the OxyDetect maximises all the benefits of paramagnetic technology to provide a genuine advance in the accurate and reliable monitoring of O_2 levels for life safety purposes. The robust non-depleting technology delivers both substantial cost savings and minimal maintenance requirements to make it the ideal choice for integration either into a new Fixed Point oxygen monitoring system, or as a replacement technology for existing point monitors using inferior depleting technology.

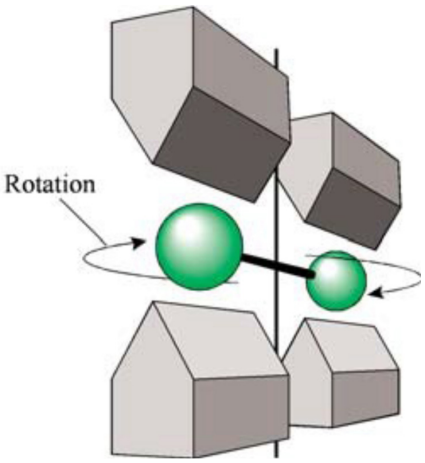

Fig.3

Find out more about the Servomex OxyDetect oxygen deficiency monitor

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