

How VESDA ECO Works

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Convention	Description
Bold	Used to denote: emphasis Used for names of menus, menu options, toolbar buttons
<i>Italics</i>	Used to denote: references to other parts of this document or other documents. Used for the result of an action

The following icons conventions are used in this document.

Convention	Description
	Caution: This icon is used to indicate that there is a danger to equipment. The danger could be loss of data, physical damage, or permanent corruption of configuration details.
	Warning: This icon is used to indicate that there is a danger of electric shock. This may lead to death or permanent injury.
	Warning: This icon is used to indicate that there is a danger of inhaling dangerous substances. This may lead to death or permanent injury.

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Scope

This document explains how the core sensing technologies used within the VESDA ECO gas detection product range work; along with any limitations of use.

Overview



VESDA ECO adds gas detection capability to existing or new installations of VESDA Aspirated Smoke Detection (ASD) systems that utilize 25mm or 3/4" BSP air sampling pipe networks.

The VESDA ECO can detect a range of flammable gases, toxic gases and oxygen deficiency. Each VESDA ECO detector houses a replaceable sensor cartridge which contains one or two gas sensors.

VESDA ECO uses the same well proven core sensing technologies that have been successfully used by the gas detection industry for many years. (see table 1)

VESDA ECO currently employs two core sensing principles: Catalytic bead (often referred to as Pellistors) for the detection of flammable gases and electrochemical cells for the detection of toxic gases and for oxygen deficiency.

It should be noted that the majority of gas sensors have a finite life (see table 1). The life of a gas sensor is linked to its internal chemistry and environmental conditions.

Manufacturing tolerances, the chemical composition and operating environmental conditions all have an effect upon a gas sensors operating life. This makes it difficult to precisely predict the end of life for any gas sensor.



To verify gas sensors continue to respond to gas and that their accuracy is within acceptable limits; it is industry practice to regularly test / recalibrate all gas detectors (typically 6 monthly) using zero gas (e.g. nitrogen or air) plus the target gas of a known concentration (Typically 50% of full scale).

The life of a toxic gas electrochemical cell is related to the working life of its internal chemistry. Oxygen fuel cells consume their internal chemistry during normal operation and their life can be measured in ppm hours based on an ambient of 20.9 % v/v.

The life of catalytic bead or pellistor based gas sensor can be many years and is directly related to the amount of catalytic poisons they are exposed to. Catalytic poisons include silicon based compounds e.g. Silicon based: furniture polish, electrical contact releasing sprays and lubricants, like WD40. VESDA ECO uses poison resistant catalytic beads ensuring the longest possible operating life.

Gas name	Chemical Formula	Detection Range	Detection principle	Typical sensor life
Carbon Monoxide	CO	0-500 ppm	Electrochemical cell	18 to 24 months
Nitrogen Dioxide	NO ₂	0-10 ppm	Electrochemical cell	18 to 24 months
Ammonia	NH ₃	0-100 ppm	Electrochemical cell	18 to 24 months
Oxygen	O ₂	0-25% v/v	Electrochemical fuel cell	18 to 24 months
Sulphur Dioxide	SO ₂	0-10 ppm	Electrochemical cell	18 to 24 months
Hydrogen Sulphide	H ₂ S	0-100 ppm	Electrochemical cell	18 to 24 months
Hydrogen	H ₂	0-2000 ppm	Electrochemical cell	3 to 5 years
Hydrogen	H ₂	0-100% LFL	Catalytic bead / Pellistor	3 to 5 years
Methane	CH ₄	0-100% LFL	Catalytic bead / Pellistor	3 to 5 years
Propane	C ₃ H ₈	0-100% LFL	Catalytic bead / Pellistor	3 to 5 years

Table 1: Gas type – sensing technology – typical sensor life

How Catalytic Beads or Pellistors Work



Catalytic beads employ catalytic combustion to measure combustible gases or vapours in air up to the Lower Flammable Level (LFL)* of the gas.

The standard sensor consists of a matched pair of elements, typically referred to as a detector and compensator (reference element). The detector comprises a platinum wire coil embedded within a bead of catalytic material. The compensator is similar except that the bead does not contain catalytic material and as a consequence is inert.

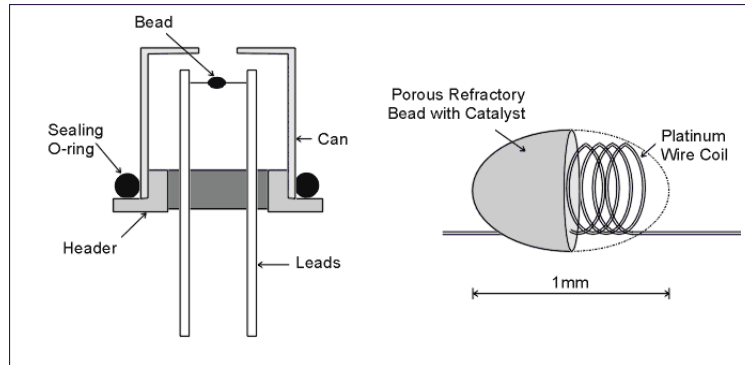


Figure 1 – Catalytic beads / Pellistors

Both elements are normally operated in a Wheatstone bridge circuit, that will produce an output only if the resistance of the detector differs from that of the compensator.

The bridge is supplied with a constant dc voltage or current that heats the elements to 500-550°C. Combustible gases are oxidised only on the detector element, where the heat generated increases its resistance, producing a signal proportional to the concentration of combustible gas. The compensator helps to compensate for changes in ambient temperature, pressure, and humidity, which affect both elements equally.

Most catalytic based detectors have their pair of elements housed in separate metal cans. In a complete gas detector the cans will normally be mounted inside an enclosure consisting of a metal sinter and housing. This enclosure allows gas to reach the sensor whilst ensuring that the hot sensor elements cannot ignite an explosive gas mixture.

Detection and alarm of flammable gases relies on the accurate measurement of flammable gases below the LFL concentration. Safety applications, therefore, are not generally concerned with measuring the volume concentration of gas. Measurements are more usually expressed as a percentage of the LFL concentration of the gas (%LFL).

Most combustible gas detection techniques are designed to detect a wide range of gases. Ideally the output of a sensor will be independent of the gas being measured. In reality, however, the variation in physical properties affects the output. Catalytic oxidation sensors are no exception, so the response a catalytic bead gives to the same volume concentration of different gases will vary. However when exposed to the same %LFL concentration of different gases, the variation in output is fairly small compared to other detection techniques. As safety applications are interested only in %LFL measurements this is a major advantage.

The variation in output for the same %LFL concentration of different gases is termed 'relative sensitivity'. Tests have been carried out to determine the experimental values of relative sensitivity for the catalytic beads used within the VESDA ECO to a range of combustible gases.

Catalytic Poisons

Certain substances are known to have a detrimental effect on catalytic sensors. There are two mechanisms by which this can occur:

Poisoning

Some compounds will decompose on the catalyst and form a solid barrier over the catalyst surface. This action is cumulative and prolonged exposure will result in an irreversible decrease in sensitivity. Typical poisons are organic lead and silicon compounds.

Inhibition

Certain other compounds, especially H₂S and halogenated hydrocarbons, are absorbed or form compounds that are absorbed by the catalyst. This absorption is so strong that reaction sites in the catalyst can become blocked and normal reactions are inhibited. The resultant loss of sensitivity is temporary and in most cases a sensor will recover after a period of operation in clean air.

In applications where either poisons or inhibitors are likely to be present, the VESDA ECO should be tested on a more frequent basis to ensure its' ability to respond to gas.

Limitations of Use

Catalytic beads are designed to detect flammable gases within a background of ambient air and require the presence of Oxygen to operate. Catalytic beads will not detect flammable gases in a background of inert gas e.g. Nitrogen or Helium.

Cautionary Note Regarding ASD Pipework Installations

To ensure ease of maintenance, VESDA ECO must not be glued into ASD sampling pipework. It should be noted that some glues used to permanently join ASD sample pipework and fittings contain solvents which may result in a positive response on catalytic bead based detectors. Gas commissioning procedures should only be carried out after these glues have fully cured.

*LFL Note: The LFL of a gas is the minimum concentration of that gas in air at which an ignition source will cause an explosion.

How Electrochemical Cells Work



Electrochemical toxic gas sensors are micro fuel cells, designed to be maintenance-free and stable for long periods. They have a direct response to volume concentration of gas rather than partial pressure.

The simplest form of electro-chemical toxic sensor comprises two electrodes: sensing and counter, separated by a thin layer of electrolyte. This is enclosed in a plastic housing that has a small capillary to allow gas entry to the sensing electrode and includes pins which are electrically attached to both electrodes and allow easy external interface. These pins may be connected to a simple resistor circuit that allows the voltage drop resulting from any current flow to be measured (figure 2). Gas diffusing into the sensor is either oxidised or reduced at the sensing electrode and, coupled with a corresponding (but converse) counter reaction at the other electrode, a current is generated through the external circuit. Since the rate of gas entry into the sensor is controlled by the capillary diffusion barrier, the current generated is proportional to the concentration of gas present outside the sensor and gives a direct measure of the toxic gas present.

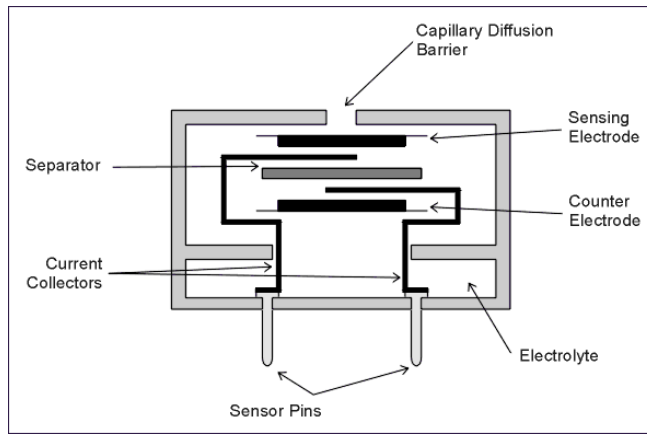


Figure 2 - Toxic Gas Sensor

The central feature of the design is the gaseous diffusion barrier, which limits the flow of gas to the *Sensing* electrode. The electrode is therefore able to react all target gas as it reaches its surface, and still has electrochemical activity in reserve. This high activity reserve ensures each cell has a long life and excellent temperature stability.

2-Electrode sensors are the simplest form of toxic gas sensors. However they have limited measuring range due to polarisation of the counter electrode. This polarisation effect can be eliminated by using a third, reference, electrode with a stable potential in the sensor design. In these sensors the sensing electrode is held at a fixed potential relative to the reference electrode (from which no current is drawn) so both maintain a constant potential. The counter electrode is still free to polarise, but has no effect on the sensing electrode and does not limit the sensor in any way. 3-Electrode sensors are the most widely used design of electrochemical sensors for detecting toxic gases.

VESDA ECO uses 3 electrode electrochemical cells.

How Oxygen Sensors Work



All electrochemical oxygen sensors are of the self-powered, diffusion limited, metal-air battery type comprising an anode, electrolyte and an air cathode as shown.

An oxygen cell can simply be considered as an enclosure (either a metal can or a plastic moulding) which holds two electrodes: a flat PTFE tape coated with an active catalyst, the cathode and a block of lead metal, the anode. This enclosure is airtight apart from a small capillary at the top of the cell which allows oxygen access to the working electrode. The two electrodes are connected, via current collectors, to the pins which protrude externally and allow the sensor to be electronically connected to an instrument. The entire cell is filled with conductive electrolyte which allows transfer of ionic species between the electrodes (figure 3).

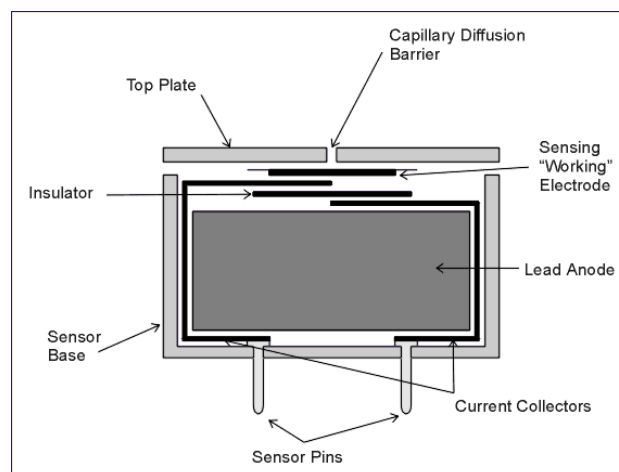


Figure 3 – Schematic of oxygen sensor.

The rate at which oxygen can enter the cell is controlled by the size of the capillary hole at the top of the sensor. When oxygen reaches the working electrode, it is immediately reduced to hydroxyl ions:

These hydroxyl ions migrate through the electrolyte to the lead anode where they are involved in the oxidation of the metal to its corresponding oxide.

As the two processes above take place, a current is generated which can be measured externally by passing it through a known resistance and measuring the potential drop across it. Since the current produced is proportional to the rate at which these reactions occur, its measurement allows accurate determination of the oxygen concentration.

As the electrochemical reaction results in the oxidation of the lead anode these sensors have a limited life. Once all the available lead has been oxidised they no longer work. Typically oxygen sensors have 1 – 2 year life times.

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