OP01 - Pellistors (4P, 1 LEL 75 and MICROpeL)

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Document Purpose

The purpose of this document is to describe the functionality of the product, and to provide information and advice regarding the appropriate use of the sensors.

This document and the information contained within does not constitute a specification. This document should be used in conjunction with the Product Datasheet, the Product Characterisation Note (where available) and the Product Safety Datasheet.

Important Information regarding the use of Sensors in Safety Critical Applications

These sensors are designed to be used in safety critical applications. To ensure that the sensor and/or instrument in which it is used are operating properly, it is a requirement that the function of the device is confirmed by exposure to target gas (bump check) before each use of the sensor and/or instrument. Failure to carry out such tests may jeopardize the safety of people and property.

Product Safety Datasheets (PSDS), and supplementary information essential to the storage, handling, integration and calibration of sensors can be found at www.citytech.com

For help and advice on sensor selection and use, please contact a member of the Technical Sales team.

Introduction

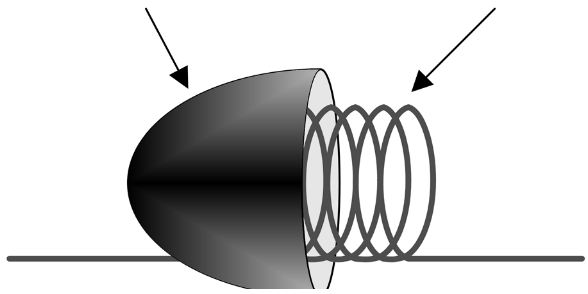
The 4P, 1 LEL 75 and MICROpeL CiTipeLs® are miniature catalytic oxidation sensors, or pellistors, designed to measure combustible gases (or vapours) in air. They operate at concentrations below the Lower Explosive Limit (LEL) of a gas, so can be used to give a warning prior to an explosive atmosphere building up.

NOTE : For the purpose of this document, the term combustible gas will be taken to include combustible vapours. Unless otherwise stated, any properties of combustible gases can be assumed to apply equally to combustible vapours.

Operating Principles

Sensors of this type consist of a matched pair of elements - *detector* and *compensator*. These elements are mounted in a planar structure, giving sensors increased shock resistance, improved orientation insensitivity and a smaller size than would be possible with conventional sensors where the beads are mounted in separate cans. The overall sensor dimensions of the 4P range match those of the complementary 4 series oxygen and toxic gas sensors, whilst the MICROpeL demensions are comparable with the miniature MICROceL toxic gas sensors.. Dimensioned drawings can be found on the product datasheets.

Each element is a coil of platinum wire embedded in a catalytic bead. When placed in opposing arms of a Wheatstone bridge circuit, a change in resistance of one element with respect to the other can be detected as an out-of-balance voltage produced across the bridge.



The electrical power of the bridge heats up the elements to about 500°C. At this temperature, the active detector element is capable of oxidising combustible gases. The compensator element has been 'poisoned', which makes it inert in the presence of combustible gases. Changes in the temperature of this element can only be caused by changes in ambient conditions. However, as both elements are exposed to identical conditions, the compensator effectively cancels out changes in the detector element caused by temperature, pressure or humidity.

With no combustible gas present, the resistance of the elements are in balance and the voltage across the bridge provides a zero gas signal. When a combustible gas is present, it is oxidised on the detector element. The heat generated causes the temperature of this element to rise, leading to an increase in the resistance of the coil. There is no corresponding rise on the compensator element, resulting in an out-of-balance signal.

At low concentrations, the resulting signal is a linear function of gas concentration. Therefore, by calibrating with a gas of known concentration, the magnitude of the out-of-balance signal can be related to the gas concontration present.

NOTE: For correct sensor operation, a minimum of approximately 8%vol. O_2 is required. If there is insufficient oxygen present, then combustion will be incomplete resulting in a low sensor output. In this case, it is likely that the beads will become contaminated with soot, resulting in a permanent loss of sensitivity.

Sensor Output and Relative Response

Detection of explosive atmospheres relies on the accurate measurement of combustible gases below the LEL 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 LEL concentration of the gas (%LEL).

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 CiTipeL gives to the same volume concentration of different gases will be different. However, when exposed to the same %LEL concentration of different gases, the variation in output is fairly small for CiTipeLs compared to other detection techniques. As safety applications are interested only in %LEL measurements, this is a major advantage.

The variation in output for the same %LEL concentration of different gases is termed 'relative sensitivity' and is quoted relative to methane.

Relative response data for CiTipeLs are available for a range of combustible gases. This data is usually determined experimentally using 50%LEL gas, based on the LEL values stated in EN 50054 (now obsolete) and EN 60079-20-1:2010.

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. The most common of these substances are: lead or sulfur containing compounds; silicones; phosphates.

Inhibition

Certain other compounds, especially H_2S and halogenated compounds, 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.

Most compounds fall into one of these catagories, although some will exhibit both mechanisms to a greater or lesser extent. In applications where either poisoning or inhibition are likely to be present, CiTipeLs should be protected from exposure to any compounds to which they do not specifically exhibit resistance.

CiTipeL Options Available

The following sensors complement the 4 series range of toxic and oxygen sensors. Detector and compensator elements are mounted on a patented ceramic head, housed in a stainless steel case with integral steel sinter. With North American and European flameproof standards approvals and a compact, lightwieght design, these sensors are ideal for use in portable instruments and fixed monitoring installations. Compared with traditional combustible gas sensors, these miniature sensors feature improved shock resistance and much reduced orientation sensitivity.

4P50 Lowest power consumption - ideal for battery powered applications.
Has a high degree of resistance to H_2S inhibition.

4P75 Very low power device - ideal for battery powered applications.
Also has good resistance to poisoning by H_2S.

4P90 Low power device - ideal for battery powered applications.
Also has good resistance to poisoning by H_2S.

1LEL75 Very low power device - ideal for battery powered applications.
Also has good resistance to poisoning by H_2S.

In addition, the MICROpeL 75 is a miniature, low profile device which compliments the MICROceL toxic range.

Selectivity and Filters

The 4P series and MICROpeL 75 pellistors are available in three versions, each version being increasingly selective in what they will respond to.

Standard (4P50, 4P75, 4P90, 1LEL75 and MICROpeL 75)

All standard types contain an acetate filter to prevent H_2S getting to the beads, therefore improving H_2S poison resistance. It also has the effect of filtering other sulfur containing compounds, some of which may be combustible.

C-Filtered (4P50C, 4P75C, 4P90C, 1LEL75C and MICROpeL 75C)

All C-filtered versions contain the standard acetate filter to prevent H_2S getting to the beads, therefore improving H_2S poison resistance. It also has the effect of filtering other sulfur containing compounds, some of which may be combustible.

Additionally, a silica filter is utilised to prevent silicones reaching the beads, hense improving silicone poison resistance. This filter also has the effect of filtering out larger hydrocarbons.

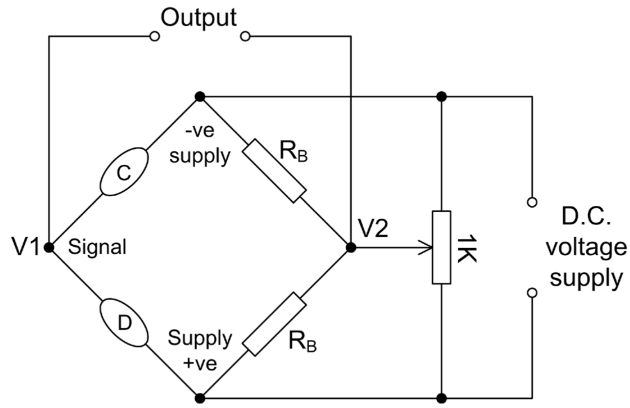
M-Filtered (4P50M, 4P75M, 4P90M, 1LEL75M and MICROpeL 75M)

All M-filtered versions contain the standard acetate filter to prevent H_2S getting to the beads, therefore improving H_2S poison resistance. It also has the effect of filtering other sulfur containing compounds, some of which may be combustible.

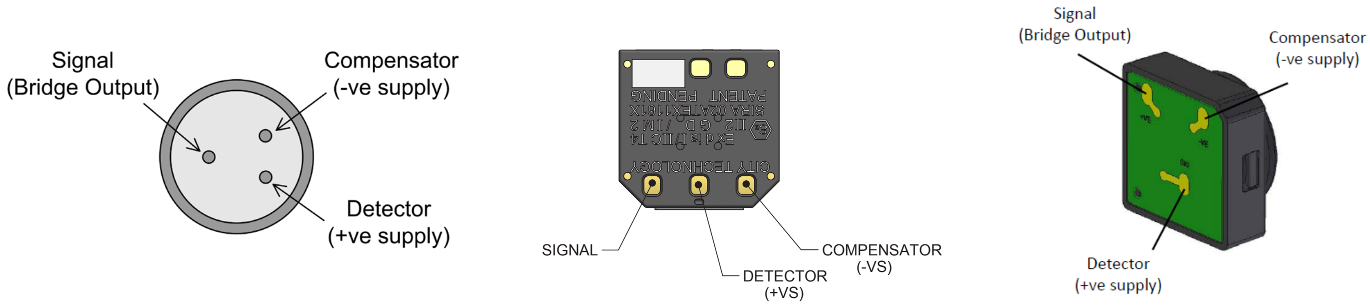
Additionally, a carbon cloth filter is used to prevent silicones getting to the beads, improving poison resistance considerably more than the silica filter. This also filters out most combustible gases except for hydrogen and methane.

Recommended Circuitry

The circuit below is recommended for use with any 4P, 1LEL75 or MICROpeL CiTipeL. The bridge supply is typically 1.75 VDC to 4.25 VDC, depending on the sensor (refer to product datasheets for details).



Recommended Circuity for use with 4P CiTipeL



Pin Configurations for 4P (left) and MICROpeL (right)

Voltage V1 is set by the potential divider of the detector element (D) and compensator element (C) - when no gas is present, this is nominally half the bridge supply voltage. Voltage V2 is also half the bridge supply and is predominantly determined by the potential divider created by the balancing resistors (R_B).

The 1K potentiometer is used to fine tune V1 and V2 so that they are the same value when no gas is present and enables the bridge output to be set to zero.

When gas is present, the resistance of the sensitive detector element rises, causing V1 to decrease. The output (being the difference between V1 and V2) rises. The function of the non-sensitive compensator element is to eliminate any effects that environmental conditions may have on the resistance of the two elements. Any changes will be the same for both the detector and the compensator, and so the bridge output voltage will remain unchanged.

The recommended value of the balancing resistor (R_B) is 470 Ω for both the 4P and the MICROpeL CiTipeLs.

Calibration

The response of a CiTipeL to combustible gas will depend on the precise gas being measured. In general, a pellistor will give a similar response to similar gases if the %LEL concentration is the same (i.e. 50%LEL). In practice, however, this will be affected by the variation in diffusion rate and heat generated on combustion for different gas molecules.

The variation in response of a CiTipeL on exposure to the same %LEL concentration of a range of common gases and vapours is shown in the pellistor product datasheets. Each figure is experimentally derived, expressed as a percentage of the methane signal (=100%) and is known as the 'relative response' of the sensor.

Relative responses may be used to calibrate a sensor with a gas other than the target gas. They is, however, intended for guidance only, and for the most accurate measurements, an instrument should be calibrated using the gas under investigation.

The relationship between the calibration gas concentration and target gas reading is as follows:

$$Conc_{GAS1} = Conc_{GAS2} \times [\$_{GAS2} / \$_{GAS1}]$$

Where	$Conc_{GAS1}$	=	Target Gas Concentration (%LEL)
	$Conc_{GAS2}$	=	Calibration Gas Concentration (%LEL)
	$\$_{GAS1}$	=	Target Gas Relative Sensitivity
	$\$_{GAS2}$	=	Calibration Gas Relative Sensitivity

Example 1 - Calibrating an instrument using non-target gas.

Measurements of n-hexane with a 4P-90 are required. The pellistor will be calibrated using 50%LEL propane.

$$Conc_{GAS1} = Conc_{GAS2} \times [\$_{GAS2} / \$_{GAS1}]$$

$Conc_{GAS2}$	=	Calibration Gas Concentration (propane) = 50%LEL
$\$_{GAS1}$	=	Target Gas Relative Sensitivity (n-hexane) = 45%
$\$_{GAS2}$	=	Calibration Gas Relative Sensitivity (propane) = 60%

$$Conc_{GAS1} = 50 \times (60/45) = 67\%\text{LEL Hexane}$$

Therefore, if the instrument is set to read 67%LEL (using the propane scale), it will be calibrated for 0-100%LEL hexane.

Example 2 - Interpreting a reading from an instrument when the gas being measured is not the same as the gas it was calibrated with.

An instrument using the 4P-50 is calibrated for 0-100%LEL methane. It is used to measure ethanol and is reading 40%LEL methane.

$$Conc_{GAS1} = Conc_{GAS2} \times [\$_{GAS2} / \$_{GAS1}]$$

$Conc_{GAS2}$ = Calibration Gas Concentration = 40%LEL

$\$_{GAS1}$ = Target Gas Relative Sensitivity (methane) = 100%

$\$_{GAS2}$ = Calibration Gas Relative Sensitivity (ethanol) = 80%

$Conc_{GAS1}$ = 40 x (100 / 80) = 50%LEL ethanol

Therefore, a reading of 40%LEL on the methane scale is equivalent to 50%LEL ethanol.

Gas Flow Rates

Pellistors can be calibrated using static gas, or gas which is flowed across the sensor. Flow rates of up to 500 ml/minute are commonly utilised for calibration purposes.

Sensor Mounting

Pellistors are not sensitive to orientation and can be mounted in any orientation with no significant effect on performance.

IMPORTANT NOTE: Sensor pins must not be soldered to, as excessive heat may damage the sensor. Connectors are available to assist in mounting the sensors to PCBs. Please contact Citry Technology for further information.