New Vented Oxygen Sensor Moves Reliability, Stability and Performance to a New Level

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More than 95% of City's oxygen sensors are installed in personal life safety equipment, giving security and peace of mind to individuals whose duties involve entering the potentially hazardous environments to be found in numerous diverse different industries. When working in the oil and gas industry, wastewater treatment, the marine sector, civil engineering, chemical manufacturing or any other industry where reduced oxygen content is a potential hazard, people must be provided with reliable and accurate equipment that will warn them instantly if the oxygen level is reduced. Obviously, the performance of the detection instrument depends on the performance of the sensing element, so the stability and reliability of the gas sensor is of fundamental importance.

Can utopia be achieved?

"I have seen the future, and it works.", so said Lincoln Steffens in 1921. Originally said in a very different context, Steffen's words could now be applied, with total veracity, to the more esoteric world of the electrochemical oxygen sensors that are at the heart of today's portable gas detection instruments.
City Technology designs, develops and manufactures gas sensors for personal life safety equipment. City makes a considerable investment in research and development every year in order to bring to market new products that offer instrument manufacturers and end users enhanced performance and benefits to improve the functionality, reliability and effectiveness of PPE.
The introduction of 4OXV, the new oxygen sensor, is a major advance for the life safety industry.
Bringing the benefits of advanced technology, automated manufacturing, extensive testing and impeccable quality, 4OXV consigns to history the issues that currently cost both OEMs and end users a considerable amount of time and effort.
City research shows that the key issues concerning manufacturers and users are:

Warranty returns

Industry-wide, anecdotal evidence suggests that up to 15% of oxygen sensors are returned for replacement under warranty. City's actual rate for safety oxygen sensors is slightly less than 5%, significantly better than the industry average, but, nevertheless, in itself an unacceptably high figure.

Reliability

Plagued by false alarms and premature failures, end users regard gas detection instruments with an understandably jaundiced eye.

Certainty

The majority of oxygen sensors are sold with the promise of a two-year operating life. Regrettably, a significant proportion will fail to function before the end of the expected lifetime.

Capability

Required to operate in some of the most inhospitable environments to be found on the planet, all too often the oxygen sensor cannot cope with extremes of temperature, humidity and pressure, failing to perform both in steady state and rapidly changing conditions.

Cost

The various shortcomings enumerated above have a significant cumulative cost to end users. There are the on-site costs of responding to failed or false readings from instruments; in safety-critical environments, alarms cannot be lightly dismissed, so replacement units have to purchased and held in stock to cater for on-site outages. The ultimate scenario is a partial or full plant shut-down as the result of a false reading from a gas detection instrument. Technological utopia would be a state where instruments never fail prematurely in use; where warranty claims are, to all intents and purposes, non-existent and where routine sensor replacement at the end of the two-year life cycle is the norm, but in the real world this is unachievable.
However, although the cost consequences to the end user, being infinitely variable, cannot be realistically quantified, improved performance by the oxygen sensor will significantly reduce the costs of premature failure.

To paraphrase: "I have seen the future: it works and it's called 4OXV."

4OXV

Extensive analysis of the main causes of oxygen sensor premature failure shows that they fall into three main areas:

- lead exhaustion
- electrolyte leakage
- inappropriate response to environmental variability - false alarms

4OXV has been developed to overcome these issues: exhaustive testing has proved the point. It is the culmination of a five year, multi-million dollar, multi-disciplinary development programme. A 20+ strong team of scientists and engineers have been involved in the design and development, and more than 9500 hours of extended testing has proven that their

efforts have succeeded. 4OXV is the largest and most complex new product introduction ever undertaken by City and the results show that the return on investment in time and money is far more than could have been expected at the outset of the programme.
4OXV has an all-new design, in which City's field-proven and highly successful vented technology has been improved and extended with further enhancements; 4OXV exhibits significantly increased levels of stability and reliability over the preceding design. Its enhanced performance enables it to be installed with confidence in detectors that will be deployed in some of the most inhospitable environments in the world without fear of infant mortality, incorrect readings or false alarms.
The new design brings performance improvements in three key areas: a minimum of 24 months life across all anticipated operating environments, outstanding output stability in both steady state and rapidly changing atmospheric conditions and increased reliability through the elimination of external and internal electrolyte leakage.
The sensors are mechanically and electrically compatible with previous generations of the 4OX family, so OEMs should not have to incur the expense of re-certification and the consequent delay in bringing their new generation detectors to market.
In addition, the new design offers an increased operating life, enabling OEMs to have full confidence that the sensor is unlikely to exhibit premature performance degradation or failure before the end of its stated design life.

Overview

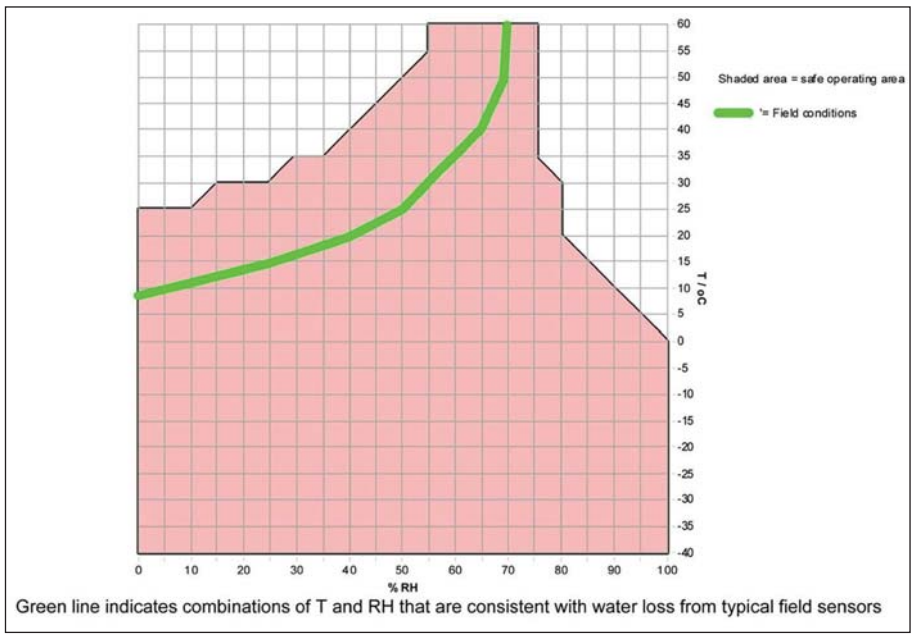
Superficially, an oxygen sensor might appear to the untrained eye to be no more than a simple can with two electrodes.
In fact, nothing could be further from the truth. 4OXV consists of more than 20 individual components, which are manufactured to exceedingly tight tolerances and assembled to create the finished product on an automated assembly line.
Each component performs a specific purpose to ensure the product's performance throughout its anticipated two-year life.

Critical Performancy Benefits

Various elements of the design address and overcome the three key issues: lead exhaustion, electrolyte leakage and false alarms.

False alarm glitches

The effect of rapid temperature change, experienced, for example, when taking an instrument from a temperature controlled internal environment into desert or arctic conditions, is a corresponding rapid rise or fall in the volume of air entering the device through the capillary tube, a condition known as "bulkflow".
Without a suitable correcting mechanism, the rapid change in pressure on one side of the sensing electrode will cause a spuriously low or high signal to be generated because the rate of diffusion though the electrode will be artificially changed, potentially causing the instrument in which the sensor is installed to indicate an alarm condition. When the pressure differential across the sensing electrode normalises, the glitch in the output level disappears as equilibrium is re-established and the diffusion rate is not artificially raised or lowered. To avoid a false output, control of any potential pressure gradient across the sensing electrode to negate the effects of rapid temperature changes is the most critical factor affecting the linearity of the output.
City's field-proven and highly successful vented liquid electrolyte technology used in the mechanically larger 7 Series of sensors has been successfully migrated to the smaller 4 Series form factor. The pressure equalising vented design ensures that the sensor remains in equilibrium during pressure and temperature transients, eliminating false alarm glitches.
An internal anti-bulkflow mechanism eliminates false alarms and further dampens the response to transient pressure changes. The design also minimises threshold drift in slow temperature and pressure variations, providing the maximum possible headroom between the quiescent state and alarm outputs. More than 1000 sensors, both new and artificially aged to the equivalent of 24 months life, have been tested under strenuous conditions with no glitches observed.
Humidity changes are another significant cause of false alarms. 4OXV features an integrated moisture protection membrane to prevent the ingress of humid air into the chamber.



Green line indicates combinations of T and RH that are consistent with water loss from typical field sensors

Reliability

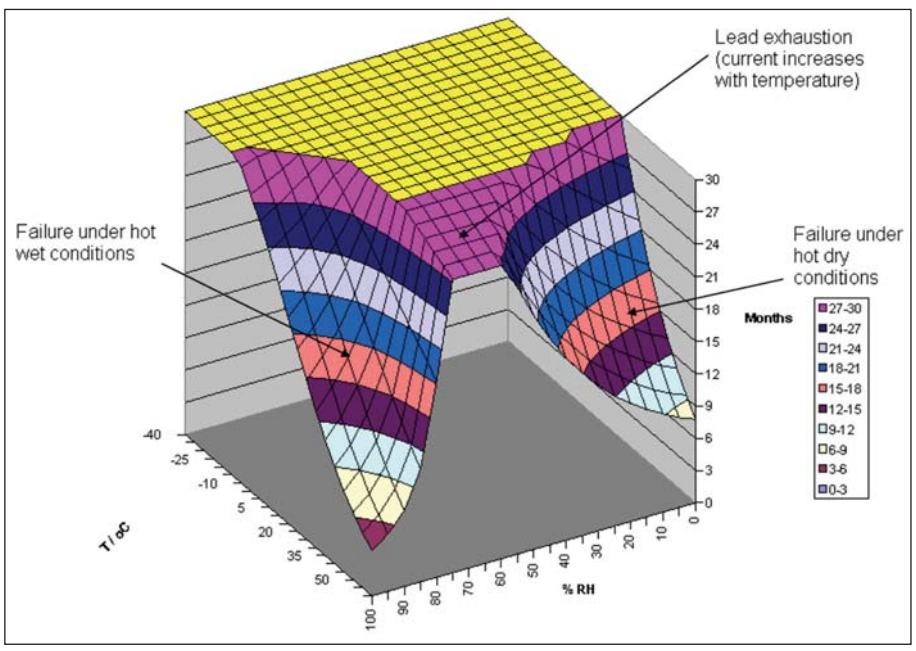
The 4OXV has improved pin retention and O-ring sealing to prevent electrolyte leakage. It also has enhanced sealing between the internal membrane upon which the catalyst is mounted and the liquid electrolyte, preventing seepage into the internal plenum chamber and possible blockage of the input capillary. Internal electrolyte leakage will potentially cause the instrument to fail because air cannot enter through the capillary. External leakage where electrolyte seeps though the seals between the pins and the unit's body can, apart from the obvious failure of the sensor itself, result in irreparable damage to the instrument's PCB.

Lead exhaustion

By the nature of the electrochemical reaction upon which the sensor's operation is based, the lead anode is oxidised over time. The anode assembly in 4OXV has a fused base, guaranteeing connectivity with all the lead strands from which it is made and the current collector is deeply embedded in the structure, ensuring good connectivity with the output pin.
The anode's design ensures that lead exhaustion will not occur prematurely before the end of the sensor's 24-month design life.

4OXV Product Overview

The 4OXV offers full mechanically and electrically compatibility with previous generations of the 4OX family, so OEMs should not have to incur the expense of re-certification and the consequent delay in bringing their new generation detectors to market. In addition, the new design offers an increased operating life, enabling OEMs to have full confidence that the sensor is unlikely to exhibit premature end-of-life degradation or failure before its stated design life.
The new 4OXV device provides outstanding stability and linearity across wide extremes of temperature and humidity.
In environmental testing, the output of the 4OXV was stable when exposed to the most demanding and severe thermal shock and humidity tests, demonstrating the efficacy of the advanced technology used in the sensor. In addition, the improved pin sealing technology, used in more than 500,000 7OXV devices already deployed in the field without a single failure, has been enhanced to ensure that even when used under the most challenging operating conditions, pin leakage, and the consequent possible PCB damage and premature instrument replacement requirement will not be an issue.
Various other design improvements have made their contribution to ensuring that 4OXV is the most stable and false alarm free unit ever produced by any manufacturer. It moves the technology of electrochemical oxygen sensing to a new level.
The greatest variable, which cannot be controlled by either the sensor or the instrument manufacturer, is the operating environment in which the gas detector will be used.
Extensive testing has predicated the expected lifetime under the complete gamut of potential operating environments.
The above graph depicts the expected typical operating life of the 4OXV across a wide range of temperature and relative humidity combinations.
As expected, very hot environments combined with either low or high humidity proved the most challenging environments for any oxygen sensor; the 4OXV has been developed to provide market leading life performance at the extremes of typical field usage.
It is helpful to present selections of the complete data to give OEMs and end users a clear indication of the operating conditions in which the sensor will perform to its stated 24-month operational life.



Conclusions

The introduction of the new 4OXV is the latest development in the evolution of the capillary oxygen sensor for use in life safety equipment. A major improvement in stability when the unit is subjected to rapid temperature or humidity changes significantly improves the operational reliability of the sensor, giving instrument manufacturers the confidence that false readings will not be generated when the unit is subjected to rapid environmental changes.
Improved reliability through enhanced sealing reduces premature failures and consequently builds user confidence in the detector.

Full mechanical backwards compatibility, identical output voltage ranges and temperature and linearity coefficients that are extremely close to the previous generation will facilitate upgrading to the latest generation of 4OXV capillary oxygen sensors. The 4OXV is the result of a multi-million dollar investment in product design, manufacturing capability, test equipment and quality procedures, ensuring that the oxygen sensor, the component critical to the performance of the detector, provides the repeatability and stability needed for those involved in the personal protection life safety industry.
To summarise: 4OXV will reduce warranty failures to less than 1%; it will eliminate false alarms, improve the field reliability of the instruments to which it is fitted and rebuild customer confidence.

By taking oxygen sensor technology to new heights, 4OXV will enable OEMs to build enhanced trust in their products and brands, enabling them to take market share and increase profits.