Honeywell

Introducing…

THE NEXT GENERATION OF ELECTROCHEMICAL TOXIC GAS SENSORS

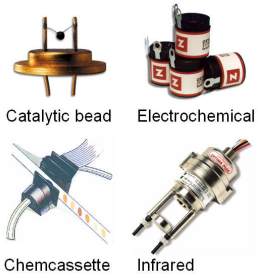
Surecell™ *from Honeywell Analytics*

Honeywell Analytics manufactures flammable, toxic and oxygen gas sensors for use in a wide range of markets. From low cost carbon monoxide detectors for domestic and commercial applications through to high specification infrared point and open path flammable solutions for the oil & gas industry Honeywell Analytics covers the widest possible range of sensing technologies coupled with state of the art manufacturing techniques. Catalytic bead (flammable), electrochemical (toxic & oxygen), infrared (flammable) as well as Chemcassette™ paper tape (very low level toxic) technologies are used to monitor over 100 different gases. This document focuses on the innovations within the electrochemical based toxic gas sensing technology.

Introduction

Toxic gases may be monitored by a variety of different sensing technologies; these include semiconductor, colorimetric paper tape, spectrophotometer and electrochemical. Some examples are shown in Figure 1 below. Electrochemical sensors have proven most popular due to their low power requirement, small physical size and relative low cost.

Figure 1 – Different Sensing Technologies



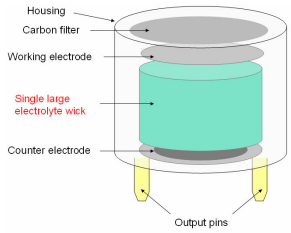
Due to the availability of a wide range of chemistries within electrochemical sensors they are used throughout the world in a very wide range of applications. Ideally suited to monitoring toxic gases at Occupational Exposure Levels (OELs) the sensors can be found in both portable and fixed gas monitoring equipment measuring gases such as hydrogen sulfide and carbon monoxide; two of the most common 'industrial' gases found in the world.

Such toxic gases are used throughout the world. Due to their geographic locations or industrial applications expected operation in extremes of temperature, humidity as well as gas level exposure varies greatly. Not all electrochemical sensors are able to handle such a wide range of environmental conditions… until now. The Surecell™ is an evolution of electrochemical technology coupled with state of the art manufacturing techniques that now puts electrochemical cells at the forefront of the market in detecting toxic gases such as hydrogen sulfide.

'Traditional' Electrochemical Sensors

Figure 2 below shows a simplified view of a traditional electrochemical sensor comprising a housing, filter and large electrolyte volume between two electrodes. Some sensors incorporate a third electrode (known as a reference electrode) which is not shown for simplification purposes. The housing is 'filled' with the electrolyte that reacts with the target gas to produce very small currents that are 'picked up' by the electrodes, amplified and then 'displayed' via the instrument being used.

Figure 2 – 'Conventional' Electrochemical Cell



Such electrochemical sensors were used in harsh environments. The most extreme being found in the Middle East or Asia Pacific regions of the world. Extreme temperatures (55°C in the shade) or very high humidity levels (>95%RH) are not untypical for significant portions of the year in these areas.

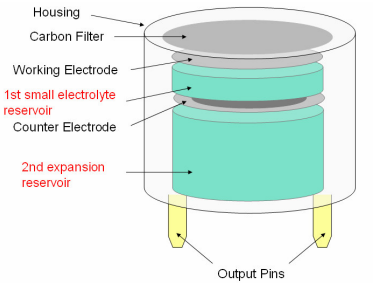
Early electrochemical sensors 'failed' routinely in such environments for two reasons. First, in high humidity levels water was absorbed by the electrolyte causing the unit to 'swell' and 'expand'. This coupled with low free volume, and poor seal integrity caused by manual assembly production, often resulted in 'weaknesses' in the housing and ultimately cell failure when cells burst.

Market Leading Surecell™ Design

Several manufacturers have improved upon the 'basic' cell construction to try and improve performance in harsh environments. However, Honeywell Analytics took a more radical approach by re-designing the cell construction from the 'ground up' and implementing the worlds first automated production line thereby removing random errors in manufacturing. By doing so the Surecell™ has proven itself in real life applications to have addressed the basic and fundamental problems faced by other electrochemical sensors.

Consider the radical new design of Surecell™ shown in Figure 3.

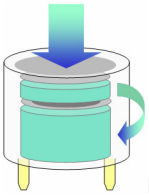
Figure 3 – 'New' Surecell™ Design



Still incorporating two or three electrodes (subject to chemistry and sensor type) the new design incorporates two electrolyte reservoirs. The first, between the two electrodes shown, has a 'high' capillary action that draws the electrolyte from the second expansion or reservoir. In a similar fashion to an old fashioned oil lamp the first reservoir never runs dry in low humidity applications. In areas of high humidity, moisture absorbed by the electrolyte is 'pushed back' into the second expansion reservoir.

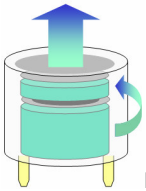
The 'take up' and 'loss' of moisture by the electrolyte is akin to the sensor 'breathing' such that its lungs never 'burst' or 'dry out'. Such an effect is much slower than that of breathing of course; however, the ability of the sensor to operate in environmental extremes is vastly superior to any other electrochemical device on the market.

Figure 4 - High Temperature / High Humidity



Moisture 'Absorbed'

Figure 5 - Low Temperature / Low Humidity



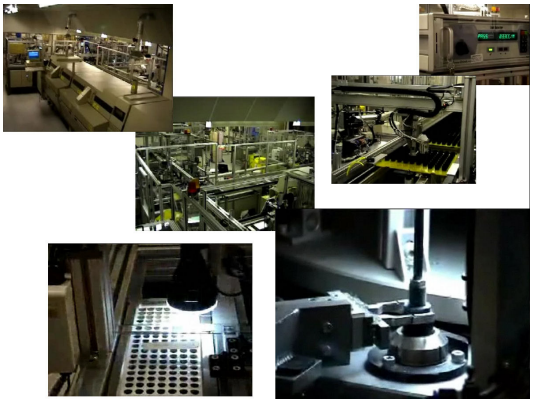
Moisture 'Released'

The simplified plastic cell construction also uses 360° ultrasonically welded seals rather than gasket compression seals as in 'old' cells. The overall design reduces potential internal pressure due to moisture absorption while ensuring the mechanical housing is strong enough to withstand any pressures that may build up.

Automated Manufacturing is Key to Success

Consider the 'traditional' cell manufacturers manual assembly process making 1000's of sensors per day. Complex sensor designs with multiple seals and gaskets that are all assembled by potentially different 'shift' workers at different times of the day. It is inevitable that such labor intensive approach will lead to 'random errors' in manufacturing. This 'hit and miss' approach can lead to undiagnosed batch issues such as imperfect seals (leaking cells) or worse premature cell failure in the field. Again, Honeywell Analytics lead the field in implementing the worlds first automated manufacturing facility to remove the 'random error' and enable optimization of the process while minimizing controllable 'systematic errors'. *'It's not always what you do; it's the way that you do it'.*

Figure 6 – Automated Sensor Production Line



The Surecell™ production line is the world's first fully automated production line for electrochemical sensors with over 2.5 million cells produced to date. Sensors are used in both Honeywell Analytics products and by OEM customers and are recognized for their high quality and reliability with less than 0.001% returns from the field due to incorrect manufacturing; quality that is second to none in the industry.

While cost reductions and increased volume potential are important the key benefit is the 'spread' in performance and operation is tightened and controlled through the elimination of 'human error'. With ALL sensors 100% tested, with gas, a database is used to record each and every one of 21 tests that take place during the manufacture of any one cell; that's over 300,000 tests per day that are fully traceable to each and every bar coded sensor produced on the line.

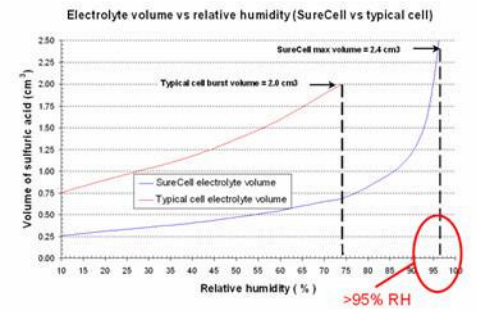
The Real Benefits of Surecell™

The real benefits of the unique dual reservoir design, simplified cell construction and automated production process of the Surecell™ electrochemical sensors is shown in Figures 7 though 9. Fundamentally, through exacting controls in manufacturing at Honeywell Analytics any 'systematic' or 'process' deviations can be monitored. Where necessary corrections to process parameters can then be adjusted to ensure sensor performance is consistent from 'cell to cell' and 'batch to batch'.

Effect of Humidity

The unique 'breathing' cell design enables Surecell™ to operate in the widest humidity ranges possible for any electrochemical cell in the market. At humidity levels >95%RH actual laboratory measurements of humidity are difficult and inaccurate. As part of on-going life tests sensors are exposed to continuous near 100% RH environmental conditions to push the sensors to the limit. 'Conventional' sensors routinely fail in environments slightly above 75%RH proving the Surecell™ dual reservoir approach offers significant advantages to other leading cell manufacturers.

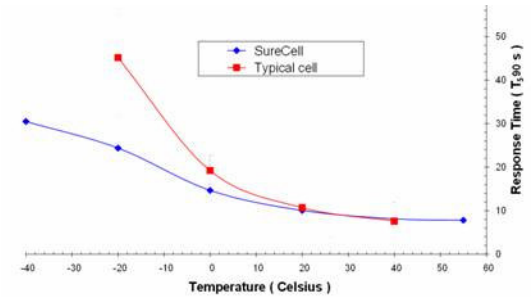
Figure 7 – Effect of Humidity



Speed of Response & Temperature Performance

The cell construction with the two electrodes separated by a smaller reservoir with high capillary acting 'wick' for the electrolytes also improves the sensors response to gas and the effect of temperature on the unit. This is shown in Figure 8 below.

Figure 8 – Response Time & Temperature Performance

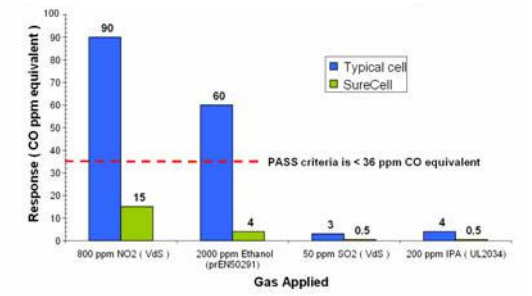


Consider the time for a sensor to react to the target gas. The T90 (time for the sensor to reach 90% of the target gas concentration) is shown above. At 20°C both 'conventional' and Surecell™ sensor designs react in about 10 seconds. However, an electrochemical reaction is taking place and charge transfer of both electrons around the circuit and ions through the electrolyte are affected by temperature. Generally, as the temperature is reduced the internal resistance of the electrolyte increases. However, the 'size' of this effect is reduced when using Surecell™ as the distance for the ions to diffuse between the electrodes is much shorter than for previous cell designs. The variation seen across the entire operating range of a cell is reduced. Improved manufacturing techniques also limit this variation from cell to cell thereby enabling consistent and accurate correction in software of the final instrument the cell is used in.

Reduced Cross Interference

While re-designing the sensor construction Honeywell Analytics also took the opportunity to introduce new and improved cross interference filters. These new and improved filters ensured that sensors are as specific as possible to the target gas being monitored thereby reducing nuisance or unwanted alarms.

Figure 9 – Reduced Cross Interference



Different filters are used in different sensors. Figure 9 shows the results for a carbon monoxide sensor.

Summary

This document set out to demonstrate the marked improvements in electrochemical sensing technology as employed by Honeywell Analytics in its wide range of commercial and industrial gas detectors. Surecell™ electrochemical sensors are used in various product ranges such as Sieger, Neotronics, Lumidor, Sixth Sense, SF Detection, Zareba and MDA Scientific. Fixed and portable gas detectors are used throughout the world in many of the harshest environments be that due to environmental conditions (temperature and humidity for example) or the process being monitored.

As owners and innovators of the core sensing technologies, Honeywell Analytics is committed to supplying the best technology packaged appropriately for our customers' applications. Understanding those applications is part of an on-going 'Customer Partnership Program' where all parties benefit from shared knowledge and expertise. If you would like to know more about the partnership program please contact steve.forrest@zelana.co.uk.

Finally, Honeywell Analytics believes that ***'better sensors make better products'***.

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About the Author:

Steve Forrest is currently employed by Honeywell Analytics as their Business Development Director for Fixed Systems. Having worked within the gas detection industry for over 14 years he has been involved in pre-sales, after sales, new product development and strategic planning of both portable and fixed gas monitoring solutions. He strongly believes in the 'right product for the right application' having experienced a wide range of end user applications, which in turn means the right sensor, for the right product, for the right application.