Gas Sensing Technology Improves Mine Safety

Gas in Mines: an Omnipresent Hazard

An underground mine is an inhospitable place in which to work. Gas poisoning and explosion is a major hazard, with many different types of gas commonly present in mines. Black damp, a mixture of carbon dioxide and nitrogen, is formed as the result of corrosion in enclosed spaces so removing oxygen from the atmosphere and potentially causing suffocation. Fire damp mainly consists of methane, a highly flammable gas that explodes at concentrations between 5% and 15% or, if it does not explode, at 25% concentration it causes asphyxiation. Methane ignition can trigger the much more dangerous coal dust explosions because the shock wave raises coal dust from the floor of the mine galleries to make an explosive mixture that is highly susceptible to spontaneous combustion. Stink damp, so called because of the rotten egg smell of the hydrogen sulphide gas, can explode and is also very toxic. Carbon monoxide, toxic even at low concentrations, is another major hazard.

> *"Without doubt, today's sophisticated gas detection technology has saved many lives in what is still one of the world's most dangerous industries."*

Gas sensors are the critical operating component of all gas detection instruments. They transform a gaseous concentration, typically measured in ppm, into a change in electrical voltage or current that provides a reliable, stable and repeatable input for the detection instrument. With so many different gaseous hazards potentially present, effective gas detection is critical in protecting life and equipment underground.

Apart from gas-related hazards, underground mining dangers include suffocation, gas poisoning, roof collapse and gas explosions, while open cut hazards are principally mine wall failures and vehicle collisions. Most risks are greatly reduced in modern mines, and multiple fatality incidents are now rare in most parts of the developed world. However, according to the Bureau of Labour Statistics, mining remains the second most dangerous occupation in America, with 30 deaths in a typical year due to mine accidents.

The Beneficial Impact of Modern Technology on Fatality Rates

Modern technology employed in mines throughout the developed world, has dramatically improved safety. Improvements in mining methods such as automated longwall mining, effective hazardous gas monitoring, gas drainage, better electrical equipment and improved ventilation have reduced many of the risks of rock falls, explosions, and unhealthy air quality. In less developed and developing countries, many more miners continue to die annually, either directly as the result of accidents in mines, or indirectly as the result of illnesses contracted from working under poor conditions. China's coal mining industry is the world's largest; unfortunately, it also has the worst fatality rate amongst its workers. Thousands of people die every year in the Chinese coal pits, compared with 30 per year in the USA. Coal production in China in 2007 was 2.7 billion tons, 40% of world production and twice that of the US. However, such volumes come at a high human cost. The number of coal miners is around 50 times that of the US, making deaths in coalmines in China 108 times more frequent per unit output than in the US. China has taken significant steps to improve safety in its mines, and although the absolute number of fatalities is still very high when compared to other regions, the number of deaths is on a strong downward trend, despite the dramatic increase in coal production over the recent past.

Gas Sensors Improving Mine Safety

As the world's leading manufacturer of gas sensors used in personal gas detection equipment, industrial safety systems and residential gas detectors throughout the world, City Technology has made a significant contribution over the years to improved safety in mines. Operating from four main facilities in the UK, Germany, the USA and China, over 300 different sensors, based on electrochemical, pellistor and NDIR (non-dispersive infra-red) technologies, are manufactured. They respond to 28 common and exotic gases with excellent response linearity and high immunity to cross-contaminants. City's sensors are approved to the demanding specifications issued by the mining industries in emerging regions and the established markets of North America and Europe.

The Challenges Facing Gas Sensor Manufacturers

In deep coalmines, extreme temperature changes, rapid humidity variations and significant pressure changes are experienced as miners travel down from the surface. In both deep and open cast coal mines methane gas is an ever-present hazard. City's methane and other flammable gas sensors have extensive approvals to the various global mining specifications. Specific regional issues are a further complication, for example, in South African mines, hydrogen cross-sensitivity is a particular concern. One of City's key strengths is a strong new product development programme, and the most recent product introductions have been specifically designed for mining applications. 4OXV, the latest oxygen sensor, is highly stable under rapid pressure change, and the

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latest carbon monoxide sensor, 4CM, offers the fastest response and recovery times in the industry. City's Pellistors are robust, poison-resistant and offer outstanding shock and vibration immunity, a critical requirement for the mining industry.

Superficially, a gas sensor might appear to the untrained eye to be no more than a simple small cylinder, 20mm in diameter and 17mm high, with two or three electrodes. In fact, nothing could be further from the truth. Such an unremarkable looking component is the operating heart of all gas detection equipment, which saves countless lives and prevents damage to property worth billions of dollars.

Oxygen Sensors

Gas sensors are in fact complex pieces of equipment: 4OXV, the new oxygen sensor, is constructed from more than 20 individual components, which are manufactured to exceedingly tight tolerances and assembled to create the finished product on an automated assembly and test line. As an example of the technology behind the design of gas sensors, consider the 4OXV oxygen sensor that is used in portable gas detectors in mines. It features City's field-proven and highly successful vented liquid electrolyte technology, which includes a unique pressure equalising vented design. The sensor's 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 levels. 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. The implications in the mining environment are self-evident. Bump testing for personal gas detection equipment, in which the instrument is exposed to its target gas to check for correct operation, would normally take place on the surface. Descending in high speed lifts to the working levels will result in rapid increases in temperature and humidity, potentially causing the instrument to false alarm, with a consequent loss of time and confidence while the issue is sorted out. Instruments fitted with 4OXV do not suffer from such issues, improving efficiency and reducing down time.

Carbon Monoxide Sensors

"Speed is of the essence". A truism applied to many different situations, but a statement that is arguably critical in mining life safety applications, where delay can literally prove to be fatal. Carbon monoxide, a colourless, odourless, tasteless, and initially non-irritating gas is very difficult for people to detect. Exposure to 100 ppm or greater can be dangerous to human health, and as the symptoms of mild exposure include light-headedness and confusion, while larger exposures can lead to death, the provision of an effective CO detector is an imperative for personnel who may encounter it during the course of their work. CO is commonly found in mines, so a fast and effective CO detector is an essential piece of equipment.

City's new 4CM sensor meets the Chinese mining specification, AQ6205-2006, widely regarded as the most severe set of requirements to be found anywhere in the world. Since its launch in early 2012, 4CM has been specified by more than twenty major instrument manufacturers who supply detectors for use in Chinese mines; more than fifty thousand units are now in service. 4CM reacts 12% faster to CO hazards than other sensors on the market; with a typical T90 time of seven seconds, giving users critical extra time in the event of an emergency. The recovery time is equally impressive, returning to an indicated level of <2ppm in under 100 seconds, less than half the time of alternatives. Worker downtime is reduced, as they do not have to wait so long for the instrument to recover. During prolonged 50-day exposures in 50°C and 11% relative humidity, hot and dry conditions and when exposed to 50°C at 95% relative humidity for 50 days, in hot and wet environments, the 4CM continues to operate to specification.

Flammable and Explosive Gas Sensors

In addition to being used in personal gas detection equipment, City supplies sensors, typically pellistors, used to detect combustible gases, which are installed in ruggedised gas detectors positioned on walls and machinery in mines. They are frequently installed on underground vehicles where they are subject to high levels of shock and vibration during normal operation, so for reliable operation pellistors have to be mechanically robust as well as highly resistant to cross contamination from commonly occurring poison sources. The pellistor was originally developed as a far safer replacement for the flame safety lamp hitherto used as a flammable gas detector once battery lighting had replaced a naked flame as a source of illumination. The flame safety lamp itself was invented by Davy and Stephenson to replace the even more dangerous open candle flames previously used for illumination.

Meeting Global and Regional Requirements

City sensors are to be found in detection equipment used in the world's main coal mining regions. The top four regions are China, which in 2011 accounted for just under 50% of world coal production, the USA with a 14% share, India which accounts for 6% and Europe, 4%. Methane is arguably the most dangerous gas in mining, present both in the mines themselves and also in coal washeries. City has an extensive range of methane and flammable gas sensors that carry approvals from the various mining specification authorities. Some markets also have specific requirements. For example, in South Africa, hydrogen cross-sensitivity is a major issue for CO and methane sensors, in Indian surface mines H_2S is a major hazard.

The Future

Without doubt, today's sophisticated gas detection technology has saved many lives in what is still one of the world's most dangerous industries. Gas detection instrument manufacturers typically rely on gas sensors from specialist manufacturers. Typically based on electrochemical technology, the characteristics of the gas sensor itself determine, to a great extent, the instrument's performance and reliability in use. To offer their users reduced lifetime cost of ownership, enhanced performance and features that improve the functionality, reliability and effectiveness of personal and fixed gas detection, OEMs require the gas sensor manufacturers to innovate sensors that have better stability, greater resistance to cross-contamination, longer life and faster response. City has a long tradition of developing new products that make a positive contribution to life preservation, with particular emphasis on meeting the unique demands of the coal mining industry, still one the world's most hostile working environments, particularly in less developed and emerging economies.