Avoiding danger in the air

Gas detectors and calibration gas mixtures keep miners safe around the world. Stephen B. Harrison, sbh4 consulting, describes how improvements in technology is saving lives

It is a sad fact that underground mining is one of the more dangerous civilian professions that has existed since the onset of industrialisation. However, the good news is that great strides are being taken to improve the safety of miners all around the world. For example: according to data published be the United Stated Department of Labour, the number of mining fatalities in the US coal industry in the decade of the 1990s was 32 per 100, 000 miners; in the first decade of this millennium it fell to 27 fatalities and for the seven full years of this decade the average has reduced to 17 fatalities per year per 100,000 miners.

So, what is behind this tremendous increase in mining safety? Firstly, we must consider the main causes of mining fatalities and they are twofold: problems with the air quality in the mine caused by excessive heat, toxic gases, a lack of oxygen or a build up of flammable gases; secondly incidents related to the use of explosives for rock blasting or collapses caused by drilling. With regard to air quality, there are two main preventative measures that have made a positive impact on mining safety. They are improvements in the ventilation systems that bring fresh air into the mine and the increased use of highly reliable gas detectors that miners use when working underground.

In 2015, we saw the closure of the last underground mining operations in the UK at Kellingley colliery in North Yorkshire. We must therefore turn our attention abroad to understand current practices in this industry. So, to examine the topic of ventilation in underground mining, let us consult Barbara Corrêa Avelar, a mining engineer who studied in both Canada and Brazil and has experience at Prospec Jr mining consultancy and Brio Gold Inc at the Pilar mine in Goiás. She says that "specifically, here in Brazil, with regard to ventilation in underground mining, air moving equipment is required to continuously renew the air and thereby provide the right amount of oxygen and to dilute flammable gases and dust. In working areas, the oxygen in the air must not be lower than 19 per cent in volume. In coal mines the air flow must be at least 6m³/min/person, while in other metalliferous mines the air flow must be more than 2m³/min/person."

GAS DETECTION IN THE MINE

In the mining industry oxygen deficiency and CO_2 build up are common. Additional hazards also exist, for example Methane is released from gas pockets that are intersected during excavation and can build up to explosive levels. If there is a source of ignition present the ensuing explosion can cause untold damage to the mine, often resulting in fatalities. H_2S is created in the mine due to the breakdown of acid mine water. In some regions of the world it is released directly from freshly exposed coal faces. So, we can conclude that methane, CO_2 and H_2S gas detection in the mine would be essential to save lives.

Oxygen levels fall in the enclosed mine environment because underground machinery and explosives consume oxygen in combustion processes. Only a small reduction from the standard level of 20.9 per cent oxygen in air is regarded as "oxygen deficient" and hazardous. Oxygen deficiency is one of the most notorious and invisible of all mining hazards. In addition, carbon monoxide (CO) is a by-product of internal combustion engines used in mines and of explosives detonations. These by-product gases from internal combustion engines, or explosions, containing CO are often referred to by miners as afterdamp.

KEEPING PORTABLE GAS DETECTORS SERVICEABLE ON A DAILY BASIS

Coming back to Barbara Avelar, "Different gases can be tested in a mining environment, usually CO, CO_2 and methane, are the most common. Additionally, the gases NOx (The combined quantity of nitric oxide and nitrogen dioxide), NH_3 (ammonia), H_2S and SO_2 (sulfur dioxide) are commonly associated with metallic ores in underground mines." What this adds up to is a requirement for a sophisticated range of gas detection sensors to be used in fixed or portable gas detection equipment in mining operations. And, to ensure that the equipment remains functional in the harsh, dusty and damp underground atmosphere, regular testing of the gas detectors is required to ensure the safety of mine workers.

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Gas detectors are one of the most important safety devices that a miner uses. His helmet and his lamp would also rank in this 'must have' category. Before entering the mine, the lamp can be tested for functionality with a visual check. But how can we ensure that the gas detectors are working? For them, a functional test is also conducted at the beginning of every working day, or even every shift. To make this functional test, or 'bump test' as it is often described, specialty gas mixtures containing low levels of the gases to be detected are passed over the sensors in the gas detector. This simulates the real life danger scenario and should trigger the audible and visual alarms on the device. Only when the miner is satisfied that the detector has reacted appropriately to these simulated conditions may they proceed into the confined space underground.

GAS DETECTOR SELECTION

There are two broad types of gas detectors: portable and fixed. According to Barbara Avelar, "portable gas detectors are more commonly used in the mining industry, because as the mine goes deeper the adjustment required for this equipment is minimal, while using a fixed detector would require more maintenance and changes in the equipment at various locations". Fixed gas detection systems are more common in surface operations, for example in the oil and gas industry and they are often used to detect various gases. For example, the Dräger Polytron 8100 EC can detect a range of toxic gases and oxygen. Regarding the portable gas detectors, there are single, two gas or multi-gas detectors. Avelar continues, "for underground mining operations in Brazil it is most common to use a multigas detector, such as the X-am 5000 from Dräger".

When choosing a gas detector several criteria must be met. Firstly, the gases to be detected must comply with the local safety legislation and fit the hazards encountered in the particular mine. Beyond that, many factors come into play such as the sensor performance, robustness of the unit, its size and weight, the ease with which the functional test can be performed, data capture for audit purposes and serviceability. Christoph Feyerabend, marketing manager for gas detectors used in the mining segment at Dräger added, "the pace of innovation with gas detectors is stunning. It is highly likely that this has been one of the factors contributing to improvements in mine safety in recent decades. The X-am 5000 from Dräger can measure up to five gases typically encountered in mines. To go one step beyond that, we have introduced the X-am 5600 which also detects a sixth component, CO_2, by means of a dual infra-red detector, providing a highly accurate measurement performance and long service life."

The inclusion of additional sensors is no great technological challenge, but with each addition sensor the size, weight and battery consumption of the gas detector can increase and the challenge is to bundle all of that together in a practical and portable design. Feyerabend goes on to say, "the extension of the gas range was something that our customers in the mining industry were particularly keen to see and we are experiencing a general trend across other industries such as petrochemicals processing for a wider range of sensors to be built into our detectors. Our X-am 5600 is, we believe, the most compact six gas detector available on the international market today".

GAS DETECTOR MAINTENANCE AND SENSOR CALIBRATION

The sensors used in the gas detectors often rely on electrochemistry and many of the sensors require calibration or replacement at prescribed intervals to avoid the problems of 'drift' in the measured result. This calibration event is more precise than the daily 'bump test' and whilst the bump test generally occurs at the mine pit head, the calibration generally takes place at an off-site service laboratory. Alternatively, the detector can be returned to the manufacturer's service facility for a general overhaul which may also involve replacement of some of the sensors contained in the gas detector.

The frequency of testing the gas detectors depends on three layers of rules or standards. Feyerabend expands on this point, "in Australia, NSW Resources legislate the frequency of detector testing. In Germany, there are strict codes of practice such as the T021/T023 from the BG RCI (the trade association for raw materials and chemical producers) that are rigorously adhered to. And, in addition to these rules the manufacturers of the gas detection devices will provide usage instructions based on field experience and best practices." These rules ensure that safety standards are met and mean that mining operators can comply with requirements made by insurance companies which underwrite mining operations. The authorities that write these rules are also engaged in compliance validation to ensure that the gas detectors have indeed been tested appropriately. Feyerabend again, "of course, electronic documentation with a calibration and testing system such as our Dräger X-dock can make life a lot easier to maintain accurate records. This enables periodic inspection and ensures that the required data is available in the case of an investigation after an incident."

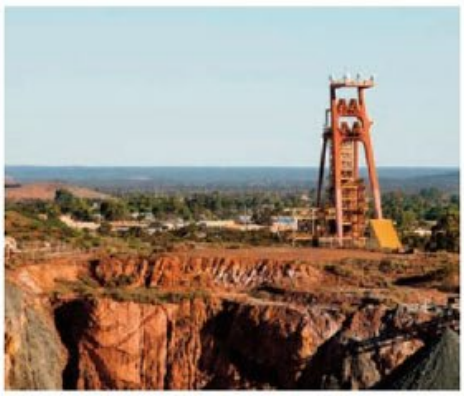
To assist with the recording and documentation of gas detector calibration and testing, many companies are now turning to digital technology. According to Feyerabend, "the X-am 8000 is very new in our range, adding even more flexibility with regards to sensors, for example a PID sensor. It also has better user guidance, an internal pump and a wireless Bluetooth interface. This is the new flagship model geared towards specialist applications for confined spaces such as mine rescue. With the Bluetooth interface it will be able to tie into the Dräger CSE Connect cloud-based software solution via a smartphone app. This will pave the way towards paperless documentation and management of clearance measurements."

GAS DETECTOR CALIBRATION GAS MIXTURES

The availability of 'bump test' gas mixtures is high. Many specialty gas suppliers around the world are able to produce cylinder gases for this purpose because the certification and accreditation requirements are relatively straight forward. The availability of accredited ISO 17025 or ISO Guide 34 (recently updated to ISO17034:2016) gas mixtures, which are the recommended choice for gas detector calibration is, on the other hand, not such a simple matter.

Victor Chim, the specialty gas business development manager at Coregas Pty in Australia comments on his experience with accredited calibration gas mixtures. "Our specialty gases accreditation journey began in 1997 when we achieved ISO17025 accreditation as a calibration laboratory for calibration gas mixtures. Subsequently, Coregas achieved ISO Guide 34 accreditation in 2002 which made us the first accredited gases reference material producer in Australia. Furthermore, ISO 17034:2016 will be implemented from 2018 and we will have the accreditation assessment soon." The accreditation authority responsible for Coregas production and testing operations is NATA, the National Association of Testing Authorities Australia which is sole accreditation body in Australia.

NATA is one of the founding members of, and currently holds the secretariat for, the



Asia-Pacific Laboratory Accreditation Cooperation (APLAC), which is a cooperation between the various laboratory accreditation bodies in Asia and the Pacific Rim. NATA is an active participant in the International Laboratory Accreditation Cooperation (ILAC) and liaises with other international bodies such as The International Bureau of Weights and Measures (BIPM), the International Organisation of Legal Metrology (OIML) and the International Organisation for Standardisation/International Eletrotechncial commission (ISO/IEC). NATA currently holds the secretariat for the International Laboratory Accreditation Cooperation (ILAC).

Both the ISO17025 and the ISO 17034:2016 accreditations are important and they have some differences: ISO17025 is for testing gases as a calibration laboratory and ISO17034 is for reference material production, so it is focused on traceability, stability, homogeneity and measurement uncertainty. Chim adds, "preparation for our new ISO 17034 accreditation has taken approximately one year to gather sufficient quality data and prepare the relevant processes. Then, the preparation of the documentation for the assessment will take us an additional three months. So, this is a highly labour and cost intensive process that requires the attention of the most expert members of our laboratory team. And, these accreditations are not just one off events, both our ISO 17025 and our ISO 17034 accreditations must be re-assessed every 18 months by NATA to ensure that our quality systems remain under control."

When it comes to gas mixtures filling it is possible to prepare general certified (non accredited) specialty gases calibration mixtures in small batches for speed and economy. However, most accredited calibration gas mixtures must be prepared as single cylinders which involves a lot more labour input per cylinder and results in higher costs of production. Coming back to Victor Chim at Coregas, "there are four members of our Specialty Gases laboratory team who are NATA signatories for our accredited ISO Guide 34 certificates. Between them, they have 38 years of experience as NATA signatories for reference material production. Beyond that, there are five NATA signatories in our team at Coregas for ISO 17025 accreditation, and they have a total of 60

Victor Chim, Coregas Pty

years of combined experience as NATA signatories for gas testing".

Chim continues, "At Coregas, our pedigree has grown from serving mining customers in Australia. In recent years, our reputation and our specialty gas cylinders have been travelling abroad and we are proud to be a supplier to many multi-national gas detection device manufacturers and gas detection equipment servicing companies overseas."

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