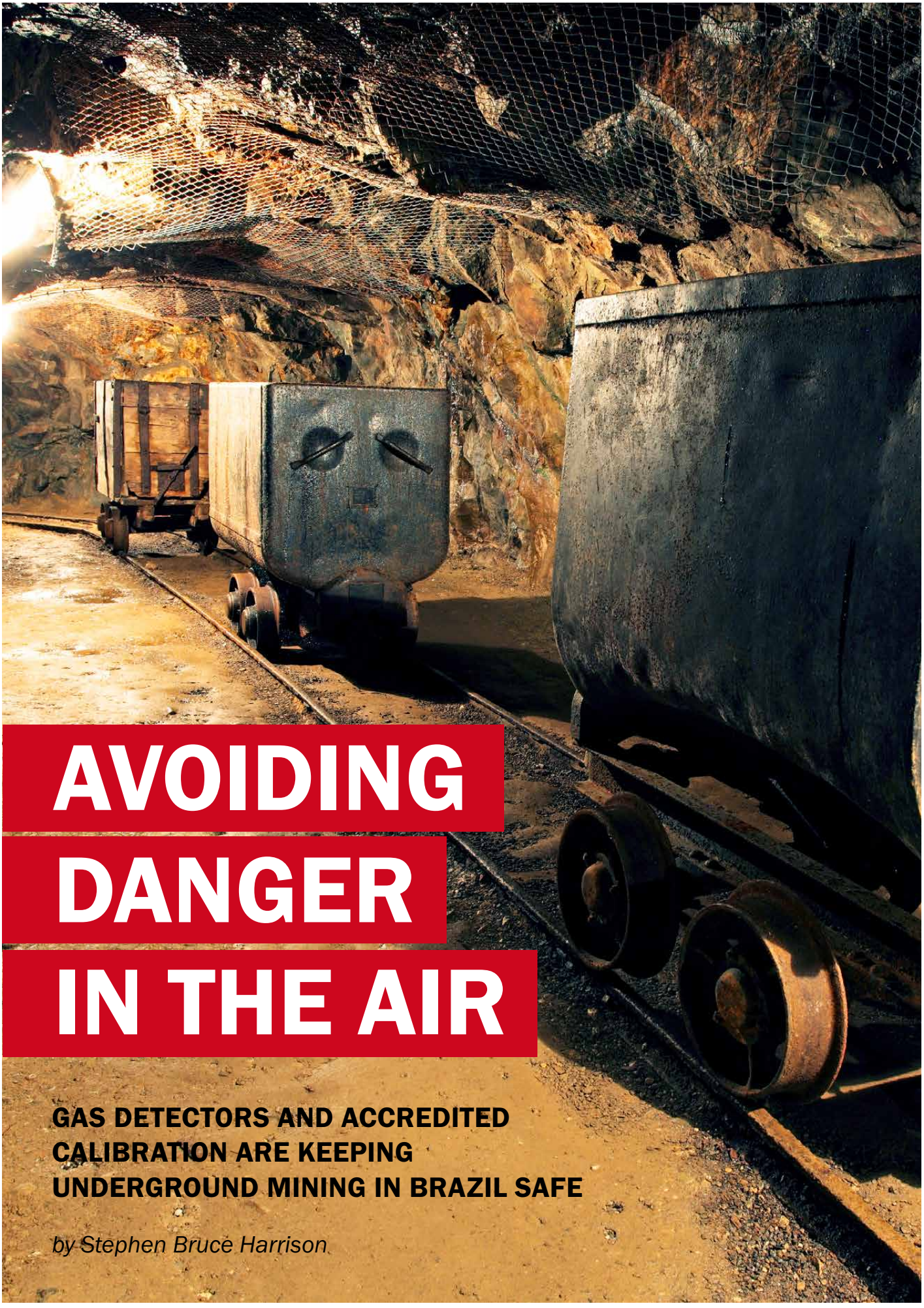


AVOIDING DANGER IN THE AIR

GAS DETECTORS AND ACCREDITED CALIBRATION ARE KEEPING UNDERGROUND MINING IN BRAZIL SAFE

by Stephen Bruce Harrison

Picture credit: MSA

Miners wearing gas detectors

Translated from the original article in Portuguese, originally published in BanasMetrologia, Brazil, July 2018

Sub-surface mining dangers can be controlled

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 Labor, the number of mining fatalities in the US coal industry in the decade of the 1990's was 32 per 100, 000 miners; in the first decade of this millennium is 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 quality of 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.

To examine the topic of ventilation in underground mining in Brazil, let us turn to 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 notes that "the National Mining Agency (ANM) is responsible to regulate all mining activities in Brazil. However, it is not directly responsible to regulate gas emissions. Regarding the Brazilian legislation, there are some safety standards defined by the Ministry of Labour and Employment: the standard NR 22 is responsible for Health and Safety in Mining; while the NR 15 is responsible for potentially Unhealthy Activities and Operations."

Specifically, 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 dilute flammable gases and dust. Avelar continues, "in working areas, the oxygen in the air must not be lower than 19 % in volume. In coal mines the air flow must be at least 6 m^3/min/person, while in other mines the air flow must be more than 2 m^3/min/person. The threshold limit values of several chemical substances are defined by the NR 15, and these values are the same for open pit and underground mines. Therefore, the proper ventilation in underground mines are extremely important and necessary to ensure a safe work place."

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 % 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.

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 (Sulphur Dioxide) are commonly associated with metallic ores in underground mines and the threshold limits values are respectively: 12 ppm, 8 ppm, 8 ppm and 2 ppm." 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.

Keeping portable gas detectors serviceable on a dailly basis

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 some input on this topic of gas detector servicing, consider the comments of Alexandre Sa, Technical Director at Enesens in São Paulo who is a specialist in this field. He says, "there is a local standard, NBR 33, which confirms the safety procedures for confined space permit, entry and work. This standard recommends, in relation to atmospheric risks, that at least LEL, oxygen, CO and H_2S must be checked before entry and during the execution of the work. If there are additional risks known, they must be also monitored. NBR-33 states that a bump check must be made before working with the detectors. So, usually, the bump check is made in the beginning of every shift."

To make this functional test, or "bump test" as it is often described, 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 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 underground space.

Gas detector selection

MSA and Dräger are some of the companies that sell products related to gas detection safety in various industries, such as mining, construction and oil & gas. Alexandre Sa adds, "there is no specific approval for the gas detectors to be used in underground mines, but there is a local approval that applies to any instrument to be used in classified areas - ordinance INMETRO No.179 – and compliance with this approval is mandatory."

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 ALTAIR® 5X from MSA or 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. In coal mines, at a minimum, this would typically involve simultaneous measurement of methane, CO, H_2S and oxygen. The device must also be intrinsically safe and thereby avoid creating ignition risks. In metal ore mining operations gas detectors are in general geared towards Diesel and blast emissions like CO or NOx. 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 6 gas detector available on the international market today".

Picture credit: Dräger

Gas detector maintenance and sensor calibration

The sensors used in the gas detectors generally 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 functional and whilst the functional 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.

Coming back to Alexandre Sa of Enesens, he adds "concerning calibration, there are some differences in the way that manufacturers, calibration laboratories and NBR-33 see the requirement for calibration frequency. But, what is clear is that traceable calibrations are necessary and the calibration by internal or third parties associated with the RBC (Brazilian Calibration Network) must be recorded. Furthermore, it is usual to have, a third party calibration with the issue of a „Calibration Certificate" for the gas detector at least once a year. To ensure an unbroken chain of traceability, this gas detector calibration certificate will make reference to the analysis certificate on the calibration gas mixture that was used to conduct the test."

To add to this from the voice of our mining operations expert, Barbara Avelar, "Gas detector quality can be assured by an Ex Certificate of Conformity, issued by INMETRO (The National Institute of Metrology, Standardization and Industrial Quality). This institute is responsible to certified products and laboratories that perform equipment calibration and maintenance. To obtain the certificate of conformity, the equipment and laboratory must follow some standards elaborated by ABNT (Brazilian Association of Technical Standards), that were written based on the International Organization for Standardization (ISO).

Picture credit: Coregas

To assist with the recording and documentation of gas detector calibration and testing, many companies are now turning to digital technology. According to Christph Feyerabend of Dräger, "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 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 paper-less documentation and management of clearance measurements."

Gas detector calibration gas mixtures

The availability of functional test gas mixtures in Brazil is generally high. Many major industrial and 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 Guide 34 calibration gas mixtures which are the recommended choice for gas detector calibration is, on the other hand, not such a simple matter.

According to Jackson Machado the Brazil National Service Supervisor at MSA Brazil, "bump test gases can be sourced in Brazil from well known suppliers such as Portagas and Calgaz but, the regulations that we must follow means that we must use a primary standard reference material for the gas detector calibration. To source that level of gas mixture, we have chosen to import products from Coregas in Australia. Their certified ISO Guide 34 reference material gas mixtures contain the components that we need at the required target concentrations. And, most importantly for the calibration, they meet the highest metrological standards as required by Cgcre, the agency that accredits laboratory operations in Brazil."

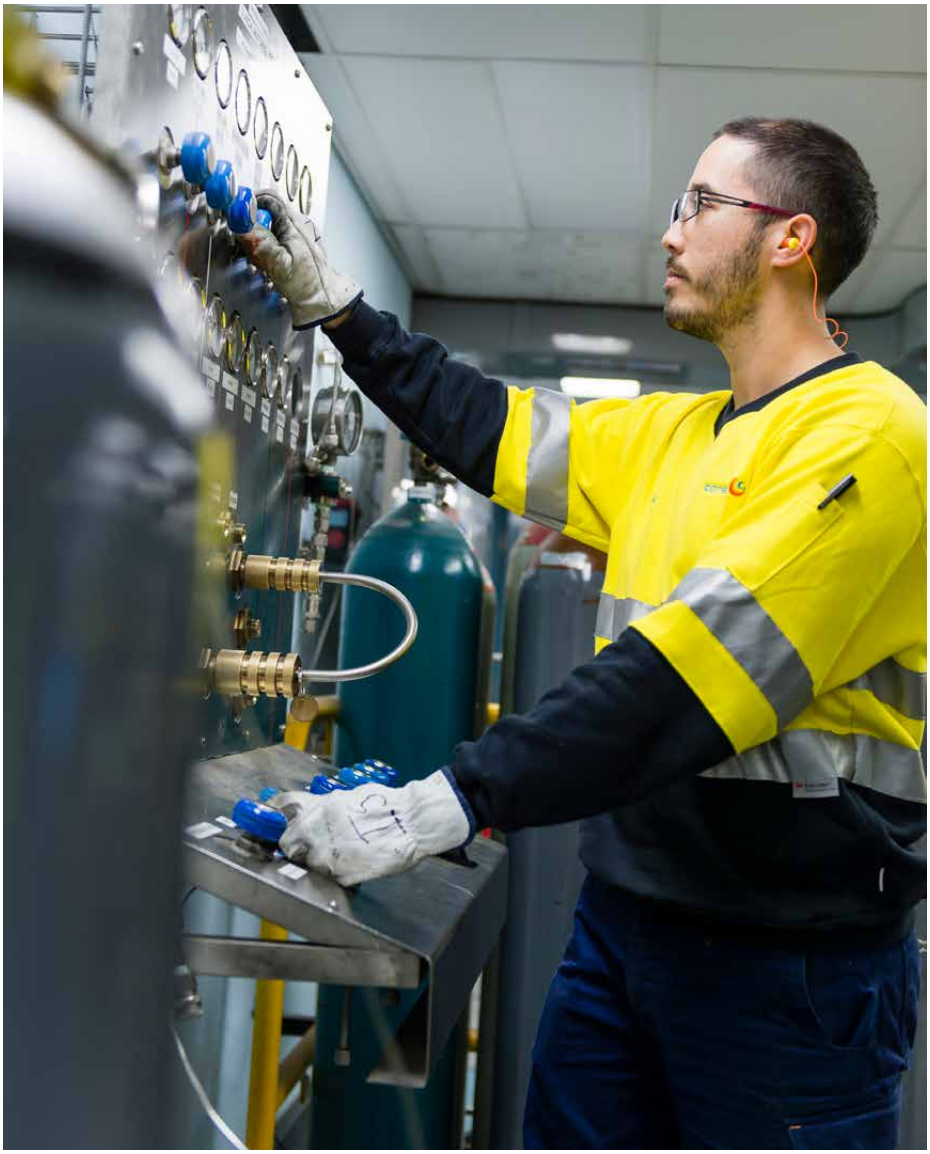
Mark Qin, the Specialty Gas & Quality Control Manager at Coregas Pty Ltd in Australia comments on his experience with accredited specialty gas mixtures. "Our specialty gases accreditation journey began in 1997 when we achieved ISO 17025 accreditation as a calibration laboratory for calibration gas mixtures. Subsequently, Coregas achieved ISO Guide 34 accreditation in 2002 which made us the first accredited gases reference material producer in Australia. Furthermore, the updated version of ISO Guide 34 which is called ISO 17034 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 our Australia. Their reputation is worldwide and in addition to working in Australia, NATA also engages in accreditation widely in Asia.

Both the ISO 17015 and the ISO 17034 accreditations are important and they have some differences: ISO 17025 is for testing gases as a calibration laboratory and ISO 17034 is for reference material production, so it is focused on traceability, stability, homogeneity and measurement uncertainty. Qin adds, "preparation for a new ISO Guide 34 accreditation takes approximately one year to gather sufficient quality data and prepare the relevant processes. Then, the preparation of the documentation for the assessment will typically take us an additional 3 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 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 ISO Guide 34 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 Mark Qin at Coregas, "there are four members of our Specialty Gases laboratory team who are NATA signatories for our accredited ISO Guide 34/ISO 17034 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 years of combined experience as NATA signatories for gas testing".

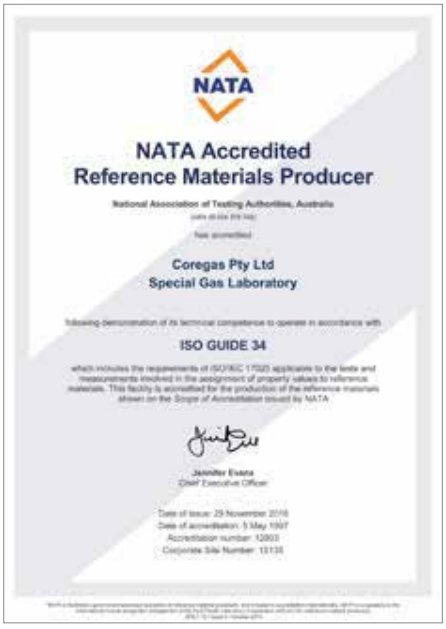
Qin continues, "I have personally been involved with the NATA accreditation process for more than 18 years. At Coregas, our pedigree has grown from serving mining customers in Australia.



Picture credit: Coregas

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 local gas detection equipment servicing companies in Brazil"

Stephen Bruce Harrison is managing director at sbh4 consulting


NATA

NATA Accredited
Reference Materials Producer

National Association of Testing Authorities, Australia

Coregas Pty Ltd
Special Gas Laboratory

ISO GUIDE 34

Jennifer Evans
Chief Executive Officer

Find out more:
Coregas: coregas.com.au
Dräger: draeger.com
MSA: br.msasafety.com
sbh4 consulting: sbh4.de