GAS MONITORING : SELECTING THE MONITORING SYSTEM BEST FOR YOUR MINE

Michael Lang
Ass Dip Marketing
Drager Australia Pty Ltd

Summary

'There appears a need for mines to supplement the use of the gas detector tubes with currently available alternative instruments,....' (Moura Report pg 68)

The Moura report looked into the methods of detection of spontaneous combustion and cross referencing of gas detection systems. From the report the above recommendation was released. Mines are now investigating the alternatives available to monitor the various gases that are found in underground coal mining.

Whether the monitoring system include the use of detector tubes or portable electronic instruments, the user must be trained to identify and understand the limitation when taking the final reading. Looking at a reading on a 'more accurate equipment' display is no guarantee of the true gas level, no more than a stain on a detector tube. Understanding how each system performs and the technology incorporated in the design, will ensure the operator is able to extrapolate the final gas levels in the environment.

Detector tubes.

For many years now the use of colourimetric stain tubes have proven themselves as a reliable and versatile means of detection.

Drager Tube

The sampling procedure involves the simple process of chemical crystals changing colour once reacted with a contaminant gas. The length of stain is proportional to the concentration of the contaminant present. Although the design may be simple the technology in the manufacturing of the tubes is complex. Starting with the grading, sizing and quality of the relevant chemicals , the process involves reaction testing to gas mixtures. Once the correct size, weight and mixture is confirmed then the packing into the glass tubes is performed. Depending upon the number of chemicals in the tube, the filling is either done by hand or sophisticated automation. A typical type of automation is a sonic vibration filling device, which ensures the correct filling quantity. From these filling areas the tubes are then tested under variable environmental conditions to ensure the reaction principals are correct. Calibration scales are then drawn up and placed on the batch in question. Each batch has its own scale placed on the tubes according to the reaction the chemicals have to the contaminant. Once the tubes have their measurement scales on, they are packed and serialised according to the quality program. Within the batch, samples are stored which are used at frequent intervals for retesting throughout the 2 year life. This also allows traceability of a batch if required by the customer.

- Tubes enable the user to measure a large range of gases.
- Tubes offer the user a simple but effective detection method
- Tubes offer the user a precalibrated system of detection
- Tubes offer an economical package for measurement of contaminants for a large user base.
- Most tubes do not require oxygen to react with the contaminant to allow measurement.
- Tubes can have dual scales allowing a wider range to be measured.
- Tubes offer higher gas ranges to be measured.

- Tubes systems are low in maintenance.
- Tubes do not require any power medium for operation.
- Tubes are not cross sensitive to common gases found in mining.
- Tubes are accurate.

There have been many studies which endorse the accuracy of tubes in detection of gases. The statement made in the Moura report 'The inherent accuracy of gas detector tubes' is directly related to the users not being properly trained. Infact through out the report the readings with tubes correlated directly to the tube bundle system.

A tube is calibrated to a level of contaminant to be measured. The concentration of the gases to be measured should fall within the middle of the scale to achieve the best results. This is the same in all measuring devices For example, if the range of gas to be measured is suspected to fall around the 30 ppm mark then the appropriate scaled tube would be the 2 - 60 ppm . If a tube scale of 10 - 300 was used then the stain will be harder to read as the differences between the graduations are greater than the 0 - 60 ppm scale.

The standard deviation on tubes takes into account the following errors :-

- Slight variations in the amount of filling and in the packing density of the detector tube preparation
- Various observers evaluate the indication differently (practice eyesight, colour discrimination, influence c lighting)
- Slight variations in temperature and pressure during measurement.

The longer the stain, the lower the standard deviation. Therefore selection of the tube with correct measuring range is important.

Most pumps draw in 100 ml of contaminant to react with the tubes. Calibration of the tubes take into consideration the characteristics of the pump used. Although pumps might draw in 100 ml of contaminant, they do this at different flow rates . Therefore, contrary to some beliefs, tubes from manufacturers should only be used with their respective pumps. This practice has been validated by ISO standards, and local Mine approvals in Australia.

Things to look for when incorporating Gas Detection Tubes in mine monitoring systems,

- Time of test, not the stroke number ,but the time it takes to perform test
- Colour changes in the tubes, are they defined and clear
- Scale on the tubes, is there a multiscale which allows more economical use (less tube variations required
- The packaging of tubes (quantity, protection , information and dated correctly)
- Accuracy of the tube (deviations are small and known)
- Humidity and temperature range of tubes is correct for application
- Cross sensitivities are known
- Storage temperature is manageable
- Technical and training assistance is available
- Tracking of batches is available

Gas Detection Instruments

Instruments comprise seven major components. These include the electronics, sensors, display, signal outputs, alarm outputs, power supply and enclosure. These components will differ from unit to unit or manufacturer to manufacturer, and some may even be absent. But the basic function will remain the same for all gas detection equipment.

Sensor

The sensor is the cornerstone of the gas detection instrument. The sensor is a transducer that provides an electrical signal proportionate to the amount of gas to which it is exposed. Accuracy and specificity dictate the use of electrochemical sensors for the detection of most common toxic gases. In use, the chemical reagent in the sensors produce an electrical response when the reagent reacts with the toxic gas in the sampling area.

- Sensors differ in their reactions to environmental variables. Due to the nature of the chemical process, sensors can be effected by humidity which can either dilute or increase the water content in the electrolyte.

- Sensors can be effected by pressure differences, especially oxygen cells. Pressure differences cause partial pressure sensors to either increase or decrease readings , dependant upon the fluctuation in pressure from atmosphere.

- Sensors are also be effected by temperature variations which cause the gas to expand or contract therefore changing the sampled gas compared to what the sensors were calibrated to read.

- Sensors have cross sensitivities to other gases and are poisoned by others. The cross sensitivities are commonly found in underground coal mining , NO2, H2S, CO2, Ethylene, Hydrogen, and other hydrocarbons are but a few. The degree of sensitivity can be reduced by using selective filters. The most common cross sensitivities are NO2 (decreases readings) and H2S (increases readings) which effect the CO sensor.

- Hydrogen Sulphide can inhibit methane catalytic sensors, which therefore reduces the accuracy and longevity of the sensor. Build up of carbon on the surface of the catalyst when high concentration of combustible gas for long intervals can reduce the capacity of the catalytic sensor . This is called carbonisation.

- The oxygen sensor can be poisoned by CO2 by turning the electrolyte into an acid thus killing the sensor over a short period of time. One manufacturer , by changing the electrolyte to an acidic base, has reduced this effect.

Recent developments have allowed sensors to be precalibrated and actually reprogram the instrument upon installation to determine which gas is to be monitored.

Technological advances in sensors, have reduced the environmental effects and increased working life. Some these advances are :-

Problem	Solution
Humidity and dry air reducing the capacity of the sensors electrolyte	The use of hydrophobic filters with the sensors
Partial pressure O2 sensors giving false readings when underground	Volumetric Sensors, not effective by partial pressure
Temperature differences changing the composition of gases	Temperature compensators built in the sensors and circuit boards.
Cross sensitivity to other gases	The use of selective filters and biasing the sensor
Inhibition of catalytic sensors by H2S	The introduction of Infra red sensor technology
Poisoning of oxygen sensors by CO2	The introduction of different electrolyte sensor
Low ranges of CO2 measurement	The introduction of Infra red sensor technology

In general the larger the electrolyte the longer the life of the sensor. The average life of current sensor technology should be 2 years. Ofcourse exposure to high concentration of gases will shorten this due to the excessive exposure of the electrolyte. Once again, larger electrolyte sensors have a higher tolerance to resist high spikes of gases levels.

Instrument

A portable instrument allows the simultaneous measurement of multi gases. Generally most handheld instruments were made for Occupation, Health and Safety. This means that the sensor ranges are within TLV and STEV values and alarm points are set accordingly. They also work on the concept whereby if the oxygen content is below 19, 18, or 17 % then the worker should not be in the area, and the instrument will repeatedly remind the operator of this fact by a latching alarm.

Therefore in underground coal mining, where gas concentrations can be high , oxygen low, and other gases a prevalent, the portable gas detector will have its work cut out.

Factors to be taken into consideration when looking at the display of a gas detector are :-

- Radio frequency interference, RFI, especially with remote mining and communication systems.
- Electro magnetic interference, EMI, from generators and other power sources.
- Calibration specifications and intervals.

This last point is critical. Calibration is directly linked to the accuracy of the instrument. While tubes are precalibrated by the manufacturer, portable instruments require calibration at set intervals or upon changing of sensors. Calibration will ensure the unit will read to the manufacturers specifications accurately . Differences in sensor technology means there are several techniques to calibrate the sensors.

Last but not least, ensure the calibration gases are correct, that is to say :-

- It is the gas to be used to zero the sensors with correct.
- It is the correct gas to calibrate too.
- It is the correct concentration of gas.
- The gas is in date.
- The gas is certified, if required.
- The balance gas is the correct type.
- Cross sensitivities are considered when using combination gas cylinders.
- The flow rate is correct.

Fixed Systems

Underground coal mines currently use either a tube bundle or single point system, or both. Of late, new mines have opted for tube bundle systems. The rational behind this is due to the down time of the single point systems. Alternatively those who already have the single point are now implementing tube bundle gas monitoring systems.

With both of these systems, the most important facet is the sensors, and yet they are considered the least. Looking at current informational material from system suppliers will confirm how little detail attention there is to the sensors. Both these systems rely upon the sensors accurately measuring the concentrations in the defined area. Therefore the more sensors there are, then obviously the more attention is required to upkeep, or is there?

The main differences between the systems is real time monitoring versus time lapsed.

The tube bundle system, is as it describes, is a system of tubing running from underground to the surface sensors. Advantage of this system allows mines to monitor difficult to access areas , aswell as sealed areas. The disadvantage is the long distances of tubing requiring, what should be , constant investigation for leaks. Tubing also adsorbs and desorbs gases. This system does not indicate readings in realtime, delays can be as long as 20 - 40 minutes.

The single point system works from strategically placed sensors near working areas and in return airways. The diffusive sensors, once detecting a contaminant will transport this data to the surface via hard wiring. The system allows the mine knowledge of concentrations of contaminants within 20 - 30 seconds, also indicating to the user faults within the sensors or electronics.

With the emergence of sensor technology as previously discussed, single point monitoring in the underground mine environment has become a reliable system alternative with low running cost.

New sensors need only to be calibrated if indicated by the monitor, besides the 6 monthly Mining Act requirements. Also with the introduction of infra red measurement capabilities for CH4 and CO2, problems associated with real time monitoring systems have been surpassed.

Recently, this new sensor technology has been in use in what can be considered one of the most extreme forms of mining, highwall mining, at the Moura project. Pre concerns for vibration, water, dust and general mining conditions for the Infra red sensors, mounted on the cutting head, have proved needless. The new generation sensors have provided the project with accurate measurement under not so ideal conditions, and low oxygen environment.

With consideration to placement, single point measuring monitors can offer the mine an accurate portrayal of its environment. Initial upfront cost are generally less expensive than tube bundle, and, maintenance cost are lower than with the old sensor systems. That is not to say that there is no place for tube bundle systems, infac there is room for both to help the mine remain hazard free.

Conclusion

In selecting monitoring systems, limitations in the technology of the sensors and corresponding electronics, should be considered. A gas monitoring system should notify the mine of increasing contaminant levels and t trends. Due to the contrasting environmental conditions and the hazards associated with underground coal mining, electrochemical sensors can offer a manageable system. Technological advances in sensors have reduced, not solved, the problems previously experienced.

Personal monitoring can be conducted effectively with either a stain tube or multigas instrument. Each have their advantages and disadvantages, and both systems a place in underground coal mining. 'Inherent accuracy's' are associated with all systems if the user is not trained to identify and understand their limitatio

As with any product, the more knowledge, the better understanding and therefore the higher degree of confidence in operating the equipment.