Selection And Use of Portable Gas Detection Technology
FOR PROTECTION OF WORKERS IN CONFINED SPACES

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Confined space entry is the most hazardous working environment for an operator because poor ventilation means the greatest chance of a build up of hazardous gas. Sometimes, in utility and construction industries for example, the operator is working in a cramped underground area that is wet, dirty, contaminated with pollutants and prone to changes in humidity and temperature.

Portable gas detectors are small, lightweight, battery powered devices that can be worn by those who perform their job in hazardous areas where there is potential exposure to flammable and toxic vapours. The devices use chemical sensing methods to sample the air in the environment and raise early warning alarms that alert the user to the presence of three major threats: flammable gases; toxic gases and the diminution of breathable oxygen.

Selection criteria

The ideal portable gas detector is of robust design, waterproof, lightweight, has a long battery life, detects and alarms hazardous levels quickly and is able to respond to all the likely hazardous gases (including hydrogen) whilst remaining immune to other species that could contaminate or adversely affect the actual reading of the target gases.

Especially with large fleets of gas detectors, selection criteria may also include overall cost of ownership and technical features that reduce the cost of maintaining the devices in calibrated, full working order.

Principally, users of gas monitoring equipment are concerned that the detector is always available for gas detection and is not impaired in any obvious (e.g. battery dead) or undetectable (e.g. a sensor grille is blocked) way that would lead to workers not being protected. Health and safety legislation and standard operating procedures do not allow entry into confined spaces without such sensing protection. The consequence of the unit not being operational is often expensive down time for the operator or contractor.

Portable gas detection technologies

Modern portable gas detectors use a range of sensing technologies that are now commercially available for inclusion in portable devices. This review is focused specifically on the demands of confined space entry in aggressive working environments and how well the available technologies compare with one another.

Catalytic bead technology

Modern catalytic bead (pellistor) gas detectors are small, lightweight, low power consuming and shock resistant. They are a proven, low cost, low maintenance option for detection of % LEL (lower explosive limit) presence of all types of combustible gas in aggressive confined space environments.

The technology is based on the use of two coated-filament wires (beads) connected to a Wheatstone Bridge electronic circuit; one in the sample air and one a reference environment. The electrical changes in the sample area are compared to those in the reference circuit and a direct signal is generated that is proportional to the gas concentration.

Pellistors detect the largest range of flammable hydrocarbons, including hydrogen, regardless of molecular weight, concentration or mixture. They are ideal for use with the higher alkane and aromatic products that are the components of petroleum and diesel based fuels. Moreover modern pellistors are exceptionally resistant to vibration, and withstand the aggressive drop test and ingress protection requirements usually demanded by companies who have large fleets of detectors that are constantly used in underground trenches and other difficult to enter applications.

The simple, elegant circuitry of the catalytic sensor detects any damage to the cell (such as open circuit or short circuit) and the user is alerted via the portable display that the sensor is in error and needs service attention.

Catalytic beads are proven designs that are resistant to the common contaminants such as silicones and sulfurous based biodegradation products common in sewer and utility trenches for example.

These sensors are cheap to replace; easy to calibrate and have the shortest lead-time for manufacturing and delivery logistics.

Electrochemical cells

Electrochemical cells (EC) consist of a pair of electrodes immersed in a special chemical solution or electrolyte that is sealed with a semi-permeable membrane that allows the passage of the target molecules into the electrolyte. Various chemical reactions can take place within the cell canister that produce a raw electrical signal between the electrodes that is proportional to the actual gas concentration. The signal is electrically amplified within the portable gas detector and used to display the gas levels.

Unlike other electrochemical cells, oxygen sensors are designed to generate a continuous signal, and so lend themselves to fail-to-safe modality. As the metal catalyst and chemicals are consumed during the continuous presence of

oxygen, the raw output signal decays appropriately and can be used to raise warnings on the portable device that the cell is approaching an unacceptable level of electrical output and should be replaced or inspected for damage.

In the event of sudden (mechanical) damage to the sensor, the signal suddenly increases much higher than normally expected. This can be used to trigger a warning that the cell has failed.

All other types of electrochemical cells, such as carbon monoxide, ammonia, hydrogen sulphide, etc. generate an electrical signal only when the target gas is present. In otherwise 'clean' ambient air the cells do not generate any electrical output and so have no built-in means with which to provide any direct means to alert the operator of impending failure mode.

Each cell decomposes and consumes its materials at a unique rate dependent on its individual exposure levels. Certain cell types can even fail into an open circuit mode without the electronics detecting any change in the cell output.

Software algorithms can be applied that aim to provide a basic 'watch dog' observation of the detector performance, but these mathematical models are very approximate and experience has shown that it is essential, not to rely on them as the primary test modality for electrochemical cells. Moreover aggressive pulsing of the cells with electronic signals to test them has been shown to actually deteriorate the overall cell lifetime if not adversely affect the sensor's drift over time. This is an area of active research but arguably not yet an area with practical conclusions for the rigors of confined space, portable gas detection.

Infra red portable cells

Infra red is a good technology to measure many of the common flammable gases found in industrial applications, but its deployment in a portable device for use in a harsh confined space environment however is questionable. It is ideal for, and is used widely, in expensive, sophisticated fixed-point gas detection systems and has the advantage of not requiring routine calibrations.

Simply speaking, infrared gas detectors count the number of gas molecules present that pass between a source of infrared radiation and a solid state detector of the radiation. A measurement is made of ratio in signal change between the sensing chamber and the reference chamber which is blocked from sensing the actual gas. The relative change in transmitted light energy in the sample beam is compared with that from the reference source and this is converted into a signal proportional to the actual gas concentration.

IR cells compensate for the gradual decay of the light source within the cavity of the sensor body and other optical effects caused by the build up of debris by using separate sample and reference channels. In an ideal environment if the light source fails the reference also detects this loss of transmitted light and a failure alarm is yielded.

However, in a typical dirty, wet, confined space environment, there is real risk of the detector becoming blocked by direct cover from clothing or some other surface, or build up of mud, grease or condensation. In this highly dangerous scenario the infra red detector could appear to be operating correctly, when it is actually measuring only the air inside its own canister leaving workers unwittingly unprotected.

The infra red sensor does not necessarily adapt well to the rigours of portable device applications for a number of reasons. First, and an important point to realise when selecting portable gas detection technology, is that infra red cannot measure hydrogen because the hydrogen molecule does not have a strong enough infra red absorption band. Hydrogen is a highly flammable gas that can build up in confined spaces and should not be ignored when selecting a single flammable sensor in a multi gas portable device. Users must be completely confident that hydrogen will not be present in their uncontrolled environment.

Other arguments against infra red as a portable technology are its relatively slow response time (more than 30 seconds) and the need for heated optical surfaces to drive off moisture that can condense on the sensitive optical surfaces. This requires relatively high power demand and is not therefore a practical feature for portable gas detectors where long battery lifetime is a practical necessity.

Photo ionization detectors

Photo ionization detectors (PIDs) are solid state devices that can detect a range of toxic and flammable gases. They use a powerful light source to ionize the molecules and a special detector that picks up the transport of charged molecules and converts this into a proportional signal output.

These specialist tools are usually deployed for the broad band detection of certain molecules that may be found in a chemical emergency such as spill or open air monitoring, chemical storage and transportation integrity detection purposes.

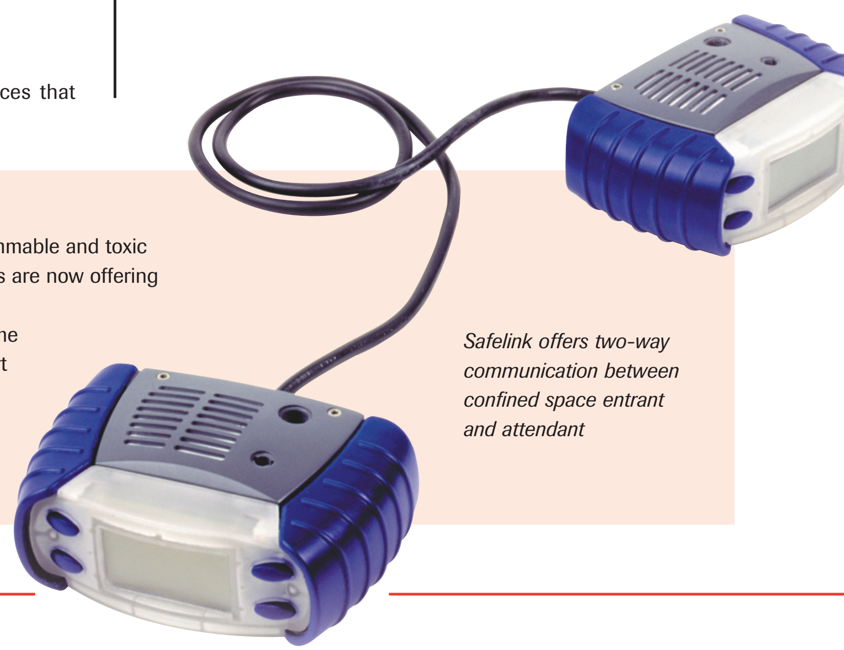
PID cells are expensive to purchase and relatively complex to maintain. They require frequent calibrations to generate 'correction factors' as they are highly cross sensitive to many other molecules. New lamps are required on a routine basis.

The fact that these cells are very sensitive to the presence of water vapour needs to be considered when both calibrating (ultra dry gases are required) and more importantly when monitoring in humid confined space applications. PIDs are also highly sensitive to methane and this reduces their availability to detect the presence of other hydrocarbon gases. PIDs are not recommended for deployment in zones that are prone to the presence of high levels of natural gas such as gas utility trenches and petrochemical storage tanks.

Conclusion

Catalytic bead and electrochemical cells continue to provide reliable, affordable, fit-for-purpose gas detection of the major flammable and toxic gases in robust portable devices that operate safely in the rigors of confined space applications. Although some manufacturers are now offering infra red cells in portable detectors, the technology is not totally proven for applications as confined space entry.

There is intensive research being carried out by sensor manufacturers into practical technology that can prolong the lifetime of the sensor or forewarn of the sensor's unavailability to detect gas. The potential for sensing devices that can proactively alert the user if they have failed is an attractive design goal. However, there are already practical gas testing methods routinely executed by users of portable gas detectors which, when used correctly, do meet global health and safety requirements and best practice guidelines, and afford peace of mind that workers are well protected from the risks of hazardous gas in confined spaces.



Safelink offers two-way communication between confined space entrant and attendant