GAS DETECTION TECHNOLOGY

The use of portable gas detectors in confined space applications

There are areas at many workplaces which have such restricted dimensions that personnel who enter them or have to work inside them are hindered in their activities or even at risk. Such areas are generally referred to as “confined spaces” if their volume is less than 100 m³, if they lack any natural or manmade system of ventilation and/or air extraction, or if they are below two metres in either length, width, height or diameter. Confined spaces are to be found not only in industrial settings (tanks, boilers, chemical apparatus, storage containers), but also in many other work areas.

For example, windowless cellar rooms, well and sewage shafts, pipelines, mineshafts, tunnels, pits, ditches, canals, double-bottom tanks in ships, bridge and crane supports, and hollow sections in machines, are also regarded as confined spaces. It is often difficult to escape from confined spaces because entry and exit is only possible through a manhole. Because of the lack of space, the presence or possible formation of harmful substances in gaseous form is of particular relevance. Before personnel enter confined spaces, it must be ensured that no hazardous gas concentrations are present. What is more, continuous monitoring of air quality is necessary the entire time work is being carried out in confined spaces. This article cites a number of practical examples to illustrate the use of portable measurement systems for air monitoring in confined spaces.

The risk posed by different gases

In principle, toxic and/or combustible gases can occur or be enriched in all confined spaces, and all confined spaces may be prone to a lack or surplus of oxygen. In almost all cases, consideration needs to be given to the following four gases:

- Methane: produced by the fermentation of organic material (shafts containing leaves and water, or sewers) or released through leaks in gas pipes (cellar rooms, trenches);
- Hydrogen sulphide: produced by rotting organic material (animal corpses, faeces) and to be found as a constituent of crude oil and oil products (chemical industry, oil industry);
- Carbon monoxide: produced by incomplete combustion, e.g. smouldering fires in cable ducts, or released through leaks in exhaust gas pipes or as exhaust fumes from heating systems or motor vehicles;
- Lack of oxygen due to the consumption of oxygen during the decomposition of organic material, during smouldering fires or when oxygen is displaced by gas leaks (e.g. methane from gas pipes). Danger of suffocation at oxygen concentrations below 19.5 % by volume.
- Oxygen surplus (caused by leaks in areas where personnel work with oxygen) means that substances – including protective clothing of low flammability in normal atmospheres – burn more easily, more quickly, and at higher temperatures.

Explosive fires can be caused. These hazards can certainly be expected at oxygen concentrations in excess of 23.5 % by volume.

Depending on the local circumstances, and the work being carried out, other gases may occur, e.g.:

- ammonia in refrigeration systems or in agriculture;
– nitrogen oxides during welding work or as a constituent of diesel exhaust fumes; 
– sulphur dioxide during burning of fossil materials; 
– chlorine resulting from leaks in water disinfection applications (waste water, cooling water, drinking water, swimming pools); 
– hydrocyanic acid in the production of noble metals and in galvanization; 
– mercaptanes as odorants in natural gas.

The gases listed above are either toxic and can affect the lungs, cause illness or poisoning – depending on their mode of action and concentration – or are combustible, meaning that there is a risk of explosion in combination with the oxygen contained in
Use of portable measurement systems
First, we can distinguish between short-term and continuous measurement systems. A classic example of a short-term measurement system is the Dräger Tube. The advantage of this method of measurement lies in its level of flexibility. Dräger Tubes represent an extremely low-cost option, and can also be used to measure exotic substances. However, the period of measurement lasts only a few minutes; to ensure proper monitoring of the atmosphere inside the confined space, many individual measurements would have to be carried out. In this context, continuous measurement systems are the obvious choice, particularly for personal measurements.

As mentioned above, the presence of combustible substances (methane), carbon monoxide, hydrogen sulphide or a lack or surplus of oxygen cannot be ruled out with any degree of certainty in most cases. A four-gas detector would therefore be the measurement system to choose here. Continuous portable measurement systems normally work with sensors. Combustible substances are measured using a catalytic Ex sensor, for example, while toxic substances and oxygen are measured by substance-specific electrochemical sensors. These four sensors are used in multigas detectors such as the devices of the Dräger X-am family, allowing the aforementioned substances to be measured all at once on a continuous basis.

The user is alerted by a visual, audible and vibration alarm the moment one or more limit values of the substances to be measured is reached or exceeded.

Confined spaces: what are the key characteristics of the measurement systems used?

Entering confined spaces
An all-clear measurement has to be performed before personnel enter a confined space to make sure that no combustible or toxic substances are present, and to ensure that there are acceptable concentrations of oxygen available. For the purposes of the all-clear measurement, the multigas detector is fitted with a pump and an extension hose; the extension hose is then fed into the confined space — through the entrance opening, for example. Ideally, the multigas detector will feature an integrated pump — this is the case with the Dräger X-am 3000 (four-gas detector) and the X-am 7000 (five-gas detector). An extension hose up to 20 metres in length can be used with the X-am 3000 — in the case of the X-am 7000 the hose can be as long as 45 metres. In both devices the internal pump is activated automatically when the pump adapter is fitted. If the extension hose becomes blocked or obstructed for any reason (e.g. if it is kinked), the user will be alerted by the devices. The gas concentrations are displayed on the device’s screen in a clear and easily comprehensible manner so that personnel can decide on the basis of the measurement result whether and which measures need to be taken before entering the confined space.

Working in confined spaces
When working in confined spaces, it is important to remember that concentrations of harmful substances can also change while work is being carried out. This may be due to inflowing contaminants (e.g. leaks in gas pipes), or indeed the work process itself (e.g. organic substances being released during cleaning processes). Given that this is the case, personal measurements should be performed during work in confined spaces. The X-am 2000 is a small and lightweight instrument which allows measurement of combustible substances, oxygen, carbon monoxide and hydrogen sulphide. The X-am 2000 is the first multigas detector to feature miniaturized Dräger XXS sensors and, besides its compact dimensions and low weight, also offers extremely quick response times and a high level of water tightness. In the event of hazardous gas concentrations, the X-am 2000 also alerts the user with a visual, audible and vibration alarm, allowing the area to be exited or appropriate protective clothing to be donned in case of alarm.
Measuring combustible substances: Cat Ex, IR or PID sensor?

Different types of sensor can be used to measure combustible substances. In the percentage by volume or LEL (lower explosive limit) range, catalytic Ex sensors (Cat Ex) or infrared sensors (IR) can be used. In the LEL concentration range, the Cat Ex sensor works on the principle of catalytic oxidation on a pellistor element of the combustible gas to be measured. This type of measurement requires at least 10 % oxygen to be present. In the case of the aforementioned Dräger detectors, a Cat Ex sensor error is given at oxygen concentrations below 10 %, thereby clarifying the situation for the user. At even higher concentrations of combustible gases (percentage by volume range) and therefore even lower oxygen concentrations, the sensor switches to a thermal conductivity measurement and the measurement result is displayed in percent by volume. The IR sensor does not require any oxygen in order to measure organic combustible substances because the sensor functions according to the principle of IR light absorption. In other words, if organic combustible substances need to be measured at very low oxygen concentrations, the use of an IR sensor is recommended. What is more, the IR sensor cannot be influenced by hydrogen sulphide or other (Cat Ex) sensor poisons. It needs to be remembered, however, that the IR sensor, unlike the Cat Ex sensor, cannot measure hydrogen, so a combination of Cat Ex and IR Ex sensor may make sense, depending on the particular application to be carried out. The X-am 7000 allows these two sensor types to be used in combination. Both sensors can be replaced by the user and store the necessary data, such as limit values and calibration data, in the sensor’s EPROM (plug and play). This means that no repeat calibration needs to be performed after a sensor has been replaced.

If organic substances need to be detected in the ppm range rather than the explosive limit range, the use of a PID (photo ionization detector) is recommended. Measuring these substances in the lower concentration range makes sense to the extent that different organic substances have toxic relevance in the ppm range. PIDs are available both as stand-alone devices (e.g. Multi PID 2) and as sensors integrated in multigas detectors (PID sensor in the X-am 7000). When a PID sensor is integrated in the X-am 7000 multigas detector, an Ex and PID sensor can be used in combination.

Flexibility by combining electrochemical sensors

While certain multigas detectors (X-am 2000, X-am 3000) are equipped with defined combinations of sensors, other multigas detectors like the MiniWarn and X-am 7000 allow the use of other electrochemical sensors. This means that the aforementioned sensors needed for special applications (e.g. for ammonia, nitrous gases, sulphur dioxide, chlorine, hydrocyanic acid, mercaptanes) can be used in these devices. These sensors also require no previous calibration. Calibration data and alarm limits are transmitted to the measuring instrument when the sensor is changed.

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Conclusion

Multigas detectors, thanks to the features they offer such as alarms and flexibility, are predestined for use in confined space applications. The user should focus on aspects such as ease of operation, sturdiness and modularity. Recent developments in sensor technology have paved the way for miniaturized measuring instruments and, therefore, straightforward personal measurements. As for all-clear measurements, devices with an integrated pump are the best choice so as to make actual use of the detector as simple as possible and to largely rule out potential measurement errors. The measuring instruments described in this article can be used to store and download the obtained measured data; together with a user-oriented analysis software (such as GasVision) it is possible then to evaluate and store the measurement results in graph and tabular form.