Toxic gas detection for hydrogen derivatives and carriers

Stephen B. Harrison, sbh4 consulting explains why toxic gas detectors are essential for a safe energy transition

Hydrogen is a flammable gas and the associate hazards are clear. Gas detection can be used to track hydrogen leaks and prevent explosions. However, toxic gases are also involved in many hydrogen value chains and detection of these poisonous gases is also essential for a safe transition to climate neutral fuels and materials.

Hydrogen is notoriously difficult to store and transport as a gas. As a liquid it is not much better. These issues raise the question: will the hydrogen economy be built on hydrogen as hydrogen? Much of the green hydrogen produced in the coming decades will be converted to toxic chemicals such as ammonia to facilitate cost-effective supply chains.

Liquid organic hydrogen carriers (LOHCs) will also play a role in hydrogen storage and distribution. These are volatile aromatic organic chemicals with physical properties like liquid hydrocarbon fuels such as gasoline or diesel. Since they are flammable, and toxic, gas detection is required to use them safely.

The production of green hydrogen in the future will be based on electrolysis of water with few toxic gases present in the system. However, reforming or gasification of hydrocarbons to syngas is the dominant pathway to produce hydrogen today. Syngas is a mixture of toxic carbon monoxide and hydrogen.

So, whichever way we look, toxic gases have been, are and will continue to be part of the hydrogen story. Getting to grips with toxic gas detectors is therefore essential for a safe energy transition.

Ammonia – the carbon-free hydrogen carrier

Ammonia gas detection builds on experience in the refrigeration industry where ammonia has been used as a refrigerant gas for decades. In refrigeration applications, the EN378 standard advocated detection levels and alarms at 500 and 30,000 ppm of ammonia to protect the plant from an ammonia explosion.

Whilst these levels are appropriate to protect the equipment, employees must be protected at lower levels. For toxic detection the COSHH regulation specifies a limit of 25ppm over 8 hours and 35 ppm over 15 minutes. These are the levels that are generally built into portable gas detectors that operators wear as part of their personal protective equipment.

In the past catalytic bead gas sensors

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have been used to detect ammonia. Today, the electrochemical cell is also common. However, these sensors are easily poisoned and must be changed after exposure to an ammonia gas leak. Background traces of ammonia also desensitise the sensors over the long term.

Colin Peake, a Director at International Gas Detection (IGD) in Stockport, says that "our team at IGD has developed and commercially proven an 'Ionic cell' detector over many years of field operation." It is not easily poisoned and can tolerate percentage level exposure to ammonia with full and rapid recovery. "We back up our confidence with a two-year warranty", confirms Peake.

Peake confirms that "the Tocsin 635 and Tocsin750 are IGD's most requested control units into which signals from multiple gas detection sensor units can be fed". A control system should be mounted outside the area where the leak is expected to be. This allows the operator to safely examine the control system to understand what is happening in the room where the leak is being detected,

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Hiding in the syngas and flue gas – carbon monoxide gas detection

Syngas is produced from hydrocarbons when they are heated. The main constituents of syngas are carbon monoxide (CO), hydrogen and carbon dioxide (CO_2). Syngas can be upgraded to convert the CO to yield additional hydrogen. More than 95% of the hydrogen produced today worldwide is made this way. Syngas and the toxic CO gas molecule are unavailable hazards of the hydrogen production.

Syngas is extensively used in Hong Kong and Singapore as one of the main piped gases for heating and cooking in domestic and commercial buildings. In these grids, flammable gas detectors are the most common way to monitor for leaks. It is not common to focus on the toxic gas detection requirements.

Gas detection of carbon monoxide (CO) has been undertaken in industrial premises and commercial buildings for decades. It is common in boiler rooms for heating and steam generation where incomplete combustion of gas can result in CO poisoning due if the flue gas leaks.

Portable gas detection devices can be fitted with sensors to detect CO in the atmosphere and contribute to the protection of personnel. However, "In the Hierarchy of Safety Engineering Controls, fixed gas detection is regarded as a higher level of safety than portable gas detectors which are categoriesed as personal protective equipment. Fixed gas detection removes the human element", says Peake.

"Portables must be taking into a potentially unsafe area by the person. On the other hand, a fixed gas detector is continuously monitoring in the zone 24 hours a day, seven days a week".

Fixed gas detection systems can be connected to the wider process control network to provide automated responses to alarms, for example they can shut down plant equipment or activate forced ventilation. Portables rely on a human to react, and if they have been overcome by toxic fumes, they may not be able to.

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CO is also a flammable gas

The toxic risk posed to personnel for the limited time that they are present in the boiler house. However, the flammable hazard of the CO and other boiler room gases such as methane, or hydrogen in the future poses a 24 / 7 risk of explosion with the potential for collateral damage. Many heating system boilers are in the basement of high-rise buildings.

An explosion in this location could result in collapse of the tower block

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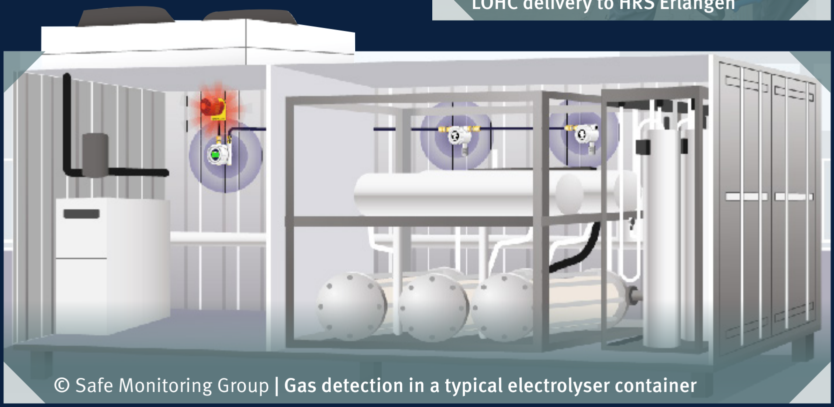

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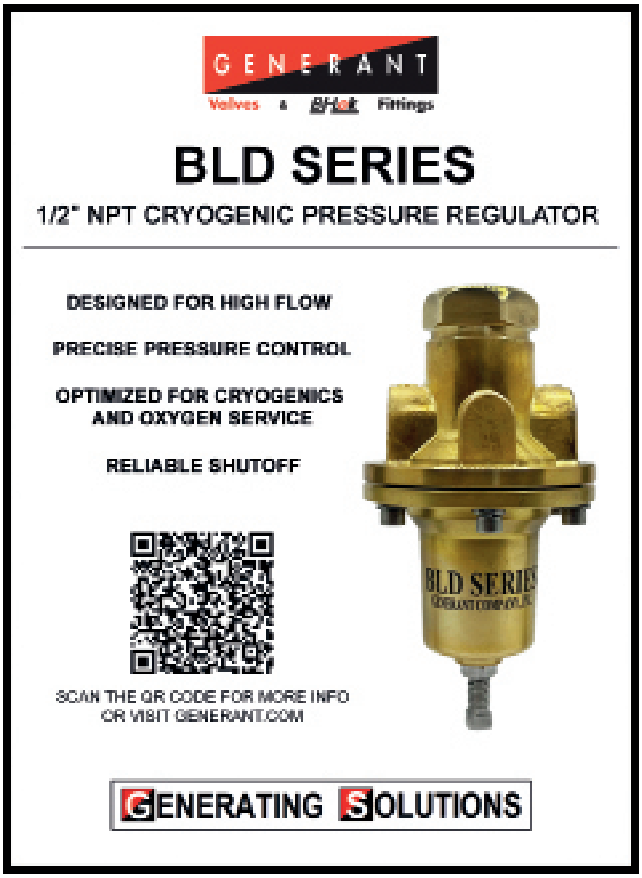
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with multiple fatalities. Therefore, the flammability risk must continuously be monitored with suitable gas detection equipment.

"IGD offers the Tocsin 750X fixed gas detectors for use in an ATEX environment", says Peake. "The equivalent unit for use in a non-ATEX location is the Tocsin 750." If the gas detection system is focused on identifying the toxic hazards of CO, an electrochemical sensor fitted in these housings would be appropriate. This is a mature, low cost and reliable sensor technology.

The generally accepted alarm levels for CO are 100ppm for a 15-minute exposure and 20 ppm over an 8-hour shift. These are commonly implemented as alarm levels in CO gas detection systems.

The most widely used LEL, or flammable gas sensor is a pellistor bead that works on a catalytic oxidation principle. The sensor is integrated into a Wheatstone bridge circuit. As flammable gases flow over the sensor, it becomes hot and its resistance increases. This is identified by the electronic circuit.

Pellistor sensors are low-cost, but some pellistor types suffer from drift, are influenced by poisons, and they are not considered to be fail safe devices. To overcome these issues, IR sensor technology has been introduced for CO gas detection. An attraction is that optical systems are regarded as being fail safe. However, there is still a requirement for regular calibration and cleaning of the optical surfaces. And the price tag of the IR sensor can be many times more than a pellistor.

Coming back to Peake, he adds that "IGD has continued to improve Pellistor sensors for CO and our latest MK8 shows a significant enhancement in poison resistance and detector lifetime. We believe it represents a cost-effective alternative to IR sensors."

Aromatic hydrocarbon gas detection for LOHCs

An increasingly popular mode of hydrogen storage and transportation is the use of a liquid organic hydrogen carrier (LOHC). Several aromatic organic chemicals, such as toluene, can perform as an LOHC. Hydrogenious LOHC Technologies GmbH, a pioneer in this field uses benzyltoluene as their chosen LOHC molecule.

Hydrogen is loaded into the LOHC using a chemical reaction called hydrogenation. The LOHC can then be shipped as a liquid. When required, the loaded LOHC can be dehydrogenated using heat and catalysts to release the hydrogen. The LOHC can then perform another round trip to transport hydrogen.

Their physical properties of an LOHC are like that of diesel – a flammable liquid at room temperature and pressure. This enables them to be used in storage and distribution equipment that has previously been aligned to refined products.

"The generally accepted alarm levels for CO are 100ppm for a 15-minute exposure and 20 ppm over an 8-hour shift"

Gas detection for vapour leaks of the LOHC can be achieved using a PID detector. However, it is likely that the main areas of concern would be a hydrogen gas leak during hydrogenation and dehydrogenation of the LOHC.

In closing, Peake states that "for this application the Tocsin 903-X5 would be a good choice. It is a stand-alone ATEX transmitter to feed signals from two detectors into a PLC control unit." For the hydrogenation and dehydrogenation facility, using a pellistor hydrogen detector in parallel with a PID detector for the LOHC would be ideal. gw

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Ammonia refrigeration system