WHITE PAPER

The Challenge of Detecting Hydrogen Gas

Hydrogen is set to play a vital role in producing cleaner energy. Specifically, within the UK, where the government has set a target to make the country a thriving hydrogen economy by 2030. Seen as a greener way of living, countries such as Japan, South Korea and China are also on course to make significant progress in hydrogen development with targets set to match the UK for 2030. Similarly, the European Commission has presented a hydrogen strategy in which hydrogen could provide for 24% of the world's energy by 2050.

With the shift to hydrogen as a clean fuel, and the emphasis on its usage globally, it is important for the relevant people, within industries that utilise hydrogen, to gain a full awareness of the dangers and impact of this shift. Therefore, this white paper will explore this matter in more depth and focus on the challenges of detecting hydrogen gas.

CROWCON
Detecting Gas Saving Lives

Introduction

As mentioned above there is a collective global sustainability focus to decarbonise the fuel, we use by 2050. To achieve this, decarbonising the production of a significant fuel source like hydrogen, giving rise to green hydrogen, is one of the key strategies. This is because the production of non-green hydrogen is currently responsible for more than 2% of total global CO2 emissions.

During combustion, chemical bonds are broken, and constituent elements combined with oxygen. Traditionally, Methane gas has been the natural gas of choice with 85% of homes and 40% of the UK's electricity depending on natural gas. Methane is a cleaner fuel than coal, however, when it is burnt carbon dioxide is produced as a waste product which, on entering the atmosphere, starts contributing to climate change. Hydrogen Gas when burnt only produces water vapour as a waste product, which has no global warming potential.

Hydrogen classification

Green hydrogen uses electricity to power an electrolyser that separates hydrogen from water molecules, producing oxygen as a result. Using electrolysis excess electricity can be used to create hydrogen gas which can be stored for the future. Green hydrogen is discernible through the electricity used to power the electrolyzers. If they originate from renewable sources such as wind, solar or hydro, or from nuclear power – fission or fusion, then the hydrogen produced is green. This is because the only carbon emissions are from manufacture of the generation infrastructure, and no carbon emissions result from the hydrogen generation process.

Electrolyzers have great significance in the creation of zero-carbon hydrogen fuel using renewable energy, or green hydrogen, and this type of hydrogen is important in the drive to decarbonize heavy industry.

As it does not emit polluting gases through the combustion or production process, green hydrogen is 100% sustainable. It is easily storable, as well as easy to convert into electricity or synthetic gas for a variety of domestic, commercial, industrial or mobility purposes.

Green hydrogen also can be mixed with natural gas up to a concentration of 20% without the need to alter gas main infrastructure or gas appliances.

In 2021, members of The Green Hydrogen Catapult (GHC) coalition announced their mission for 45 GW of electrolyzers to be developed with secured financing by 2026 with additional targeted commissioning for 2027. With a goal to enhance and encourage the development of green hydrogen the group of leaders see it as an opportunity to not only ensure decarbonization across a range of sectors, but also as an extensive business opportunity.

Unfortunately, this type of hydrogen is costly compared to fossil fuels as it is more expensive to produce, and the overall production requires more energy than some other fuels. Therefore ironically, unless the electricity required to produce hydrogen comes from a renewable source the entire process of production may be counterproductive.

Like the methane it replaces, hydrogen is also a highly flammable gas, and so extensive safety measures are essential to prevent leakage and explosions.

Production of hydrogen using non-renewable energy sources, but still not requiring the release of greenhouse gases in the steam reforming process (SMR) are characteristics of blue hydrogen, and why it is known as 'low-carbon hydrogen'.

The SMR process is a very common one, used worldwide for bulk hydrogen production. Unfortunately, this way of creating hydrogen does create carbon dioxide as a by-product, and therefore carbon capture and storage (CCS) is required to ensure no carbon is released into the environment. This high pressure carbon dioxide can cause a hazard during the production process.

As blue hydrogen can be produced without the need to generate electricity (as is the case for green hydrogen) this source could help to conserve land. Blue hydrogen is also less expensive than green hydrogen at present, and will remain so until the trend in renewable energy cost continues enough to make that untrue.

However more methane needs to be extracted in order to make blue hydrogen, and the passing through reformers, pipelines, and ships, means there is more likelihood for leaks. The transport also uses energy lessening the overall efficiency.

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Dangers of Hydrogen

Although it is clearly a cleaner fuel source, there are still dangers inherent with the use of hydrogen, which all relevant individuals coming into contact with it need to be both aware of, and protected from.

Hydrogen is non-toxic, but in indoor environments like battery storage rooms, hydrogen can accumulate and theoretically cause asphyxiation by displacing oxygen. Theoretically, because the likelihood is such build ups would result in explosions – especially when confined within the same volume as electrical battery charging equipment. Colourless odourless gases can, however, build up without those in the environment knowing about it. This danger can be offset to some extent by adding odorants to hydrogen fuel, which provide an artificial smell to alert users in the case of a leak.

Hydrogen is also a highly flammable and volatile substance which combusts at low concentrations. Explosions can happen from a single spark or increased heat. As it is highly reactive, hydrogen has been recorded as combusting even a wide variety of ignition sources even at low temperatures. Its reactivity and flammability mean it can be highly dangerous if not managed, stored and measured correctly.

Regulations

The ISO 22734-1:2019 regulations govern the use of hydrogen generators using water electrolysis across industrial, commercial, and residential applications. Generators that use aqueous bases and acids, solid polymeric materials with proton exchange membrane (PEM) and anion exchange membrane (AEM) are referred to here.

The legislation also covers the management of generators used in outdoor residential spaces including in sheltered areas, such as car-ports, garages, utility rooms and similar areas of a residence.

In the UK, the Gas Safety (Management) Regulations 1996, state that the concentration of hydrogen that can be injected onto the UK gas network is 0.1%. Although this is currently being tested to increase the hydrogen up to 20% in a blend with natural gas.

Elsewhere in the UK, hydrogen is legislated for within the definition of "gas" in the Gas Act 1986 (the "Gas Act") and regulated as part of the gas network. In the UK the gas market is regulated by the Gas and Electricity Markets authority, operating through the Office of Gas and Electricity Markets, commonly known as Ofgem.

Therefore, anyone supplying, shipping or transporting gas, participating in the operation of gas interconnectors, or providing smart metering need a licence as required by the Gas Act. These licences govern the measures relating to the safe operation of the gas network and provisions relating to price controls.

As created and defined by OSHA, the PHMSA regulates almost 700 miles of hydrogen pipelines under the 49 C.F.R. Part 192 in the USA. These regulations focus on natural gas, but also cover hydrogen due to the inclusion of "flammable gas".

Detection technology is required for personnel and environmental safety, as well as to ensure compliance with regulations.

Importance of Detection technology

As mentioned earlier, hydrogen is a colorless, odorless and tasteless gas which makes the utlization of detection technology paramount in order to trace it within working environments. With hydrogen starting to play an important role in energy production, the implementation of robust detection infrastructure is vital to minimize the risk of a small leak becoming an insurmountable incident. Hydrogen is highly mobile and capable of exiting breaks in damaged infrastructure far faster than traditional natural gas.

Detection technology is required for personnel and environmental safety, as well as to ensure compliance with regulations, however there are also best practice processes that can be undertaken when working with hydrogen.

Workers should remain alert and listen for the sound of high-pressure gas escaping, as well listen and watch for alarms. The use of portable hydrogen detectors is recommended, as are routine checks for small leaks by applying soap bubble solutions on the surface of areas where leaks are suspected, or use of metal oxide (non-IR based) leak sensors.

Types of Technology and Products for Detection

Awareness of the different types of detection technology available enables those making decisions about the safety of their staff working with hydrogen to make informed choices.

Pellistor detectors, or catalytic bead gas sensors, have been the primary technology for detecting flammable gases since the '60s. Detection of Hydrogen has been restricted to pellistor sensor technology due to Infra-Red sensors inability to detect Hydrogen.

Crowcon's Molecular Property Spectrometer (MPS™) sensor provides a far better solution for hydrogen detection. The challenges faced with traditional sensor technology are completely removed. A long-life hydrogen sensor that does not require calibration throughout the life cycle of the sensor, without the risk of poisoning or false alarms allows users to save on total cost of ownership, whilst reducing interaction with the unit.

Electrochemical sensors are used in diffusion mode in which gas in the ambient environment enters through a hole in the face of the cell. Some instruments use a pump to supply air or gas samples to the sensor. A PTFE membrane is fitted over the hole to prevent water or oils from entering the cell. Sensor ranges and sensitivities can be varied in design by using different size holes. Larger holes provide higher sensitivity and resolution, whereas smaller holes reduce sensitivity and resolution but increase the detectable concentration range.

Electrochemical sensors can be specific to a particular gas or vapor in the parts-per-million range. The degree of selectivity depends on the type of sensor, the target gas and the concentration of gas the sensor is designed to detect. They have a high repeatability and accuracy rate, and once they are calibrated to a known concentration, the sensor provides an accurate reading to a target gas that is repeatable. It is also not susceptible to poisoning by other gases and is less expensive than most other gas detection technologies, such as IR or PID technologies.

IR sensors use infrared emitters within the sensor with each generating beams of IR light. Each beam is of equal intensity and is deflected by a mirror within the sensor onto a photo-receiver, which measures the level of IR received. The "measuring" beam, with a frequency of around 3.3µm for hydrocarbon measurement, is absorbed by hydrocarbon gas molecules, so the beam intensity is reduced. The "reference" beam (around 3.0µm) is not absorbed, so arrives at the receiver at full strength. The %LEL of hydrocarbon gas present is determined by the difference in intensity between the beams measured by the photo-receiver. This technology is however unable to detect hydrogen which does not absorb light at either 3.3µm or 3.0µm.

Crowcon provides a range of reliable gas detection technology suitable for varied environments within the hydrogen industry. The technologies already described detect lighter than air gases, catalytic sensors and IR sensors already described detect hydrocarbon gases with similar densities to air, and our PID products detect heavy gases and liquid-based fuels once airborne, as either hydrocarbons on dust particles or solvent vapours. Full coverage can be arranged by judicious use and placement of the safety technologies available. This equipment includes our Gas-Pro portable, our Gasman single gas, T3 multi gas and Gas-Pro multi gas pumped portable products, and our Xgard, Xgard Bright and Xgard IQ fixed products – each of which has the capability of detecting all the gases mentioned.

Meeting sustainability goals and being a part of the drive towards cleaner energy is important globally. However, keeping teams working with hydrogen safe is also vitally important, as the risks can be high if left unmonitored and undetected. For more information about hydrogen detection and the products available get in touch with a member of Crowcon's team.