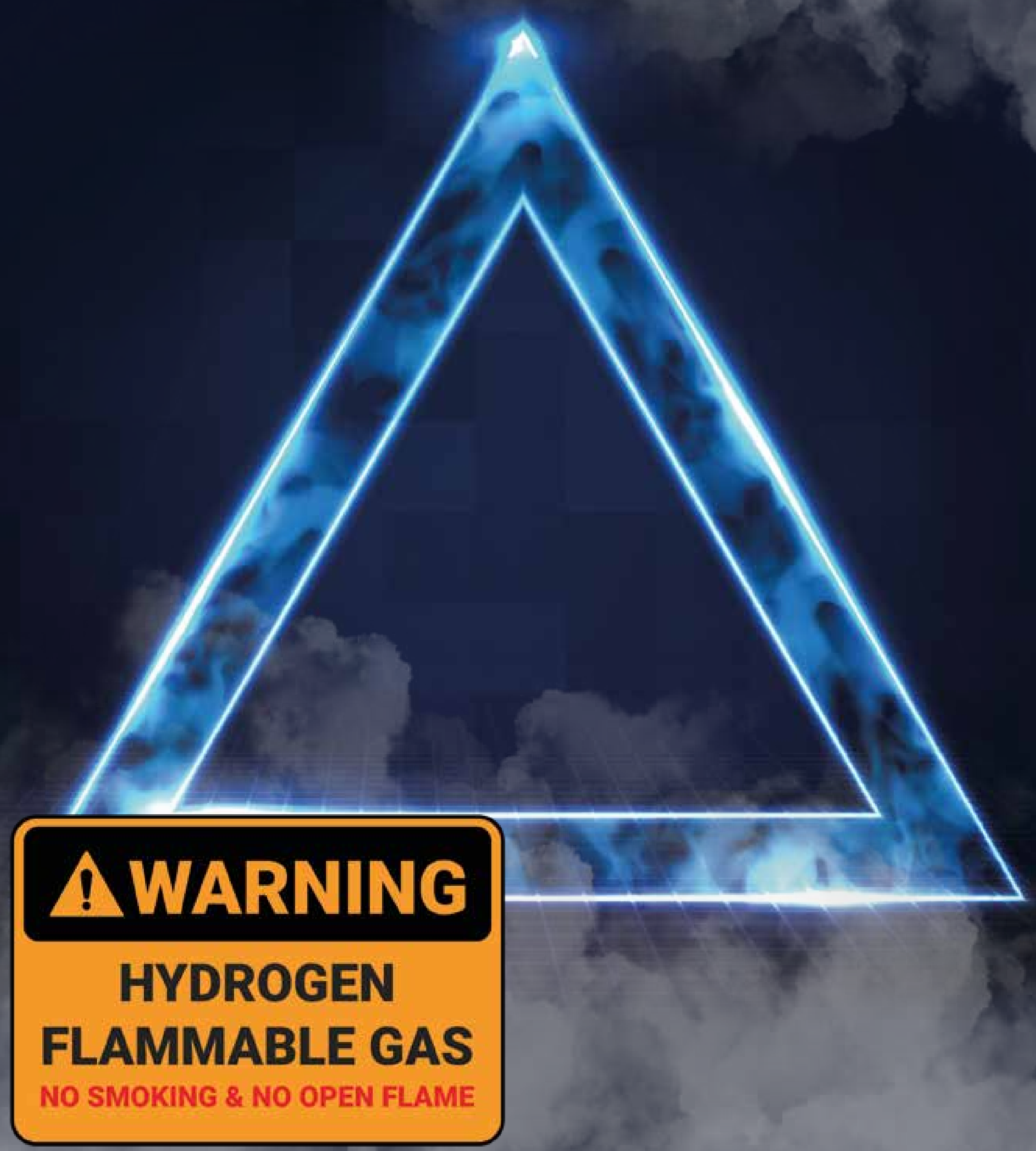
Hydrogen gas and flame detection for electrolysers and HRS

Stephen B. Harrison, from **sbh4 consulting**, outlines the best ways to enhance detection and minimise risk in HRS sector



Hydrogen is hazardous, its flammability is an inherent physical property. When handling hydrogen we must work with its physical properties and minimise the overall risk. The risk is derived from the size of the hazard and the likelihood of a hazardous event.

The size of the hazard can be reduced by minimising the inventory of hydrogen. However, there are occasions where a large amount of hydrogen is required to be stored. For example, to ensure that a fuel cell electric vehicle can drive a long range.

In the case of hydrogen mobility, reducing the risk is achieved in many ways, for example by using robust gas storage tanks. Modern fuel cell electric vehicles transport hydrogen gas in extremely strong cylinders made from carbon fibre composite materials.

The pressure of hydrogen in the tank may be up to 700 bar, but the tank itself must be tested to withstand more than 2,000 bar. This 'over-design' reduces the frequency of the tank failing.

Fixed gas and flame detection systems for hydrogen refuelling stations

The hydrogen refuelling station (HRS) is a static system. Leak points for hydrogen are most likely to be valves, connectors, and the flexible hoses. It is advisable to use fixed gas or flame detection equipment close to the most probable problem locations.

Public HRS stations are likely to be in the open air to enable the free movement of vehicles, however, the main hydrogen processing equipment is most likely to be in containerised systems, which represent a confined space. For indoor bus depots or hydrogen refuelling of indoor forklift truck fleets, gas detection is essential.

Flame detection can be used in combination with gas detectors. Using multiple gas detection devices, the operator can use a 'voting system' to escalate the system response from a visual alarm to an audible alarm and ultimately to an automated system shutdown.

The flame detector is the ultimate alarm that would invoke a complete shutdown of the HRS. This integrated approach can minimise disruptive 'false-alarms' and simultaneously ensures that a truly hazardous situation is flagged as quickly as possible.

Régis Prévost, Product Line Manager for Fixed Gas and Flame Detection and Teledyne says, "Our new range of Spyglass hydrogen flame detectors can be supplied with high-definition video recording. The benefit is that a remote operations centre can observe the situation at the HRS when an alarm is triggered and determine if it is indeed an emergency on the HRS or whether there is an innocent reason for the alarm such as hot car exhaust system."

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Video and alarm signal data from the Spyglass flame detectors and other gas detectors on the HRS can be fed to the Teledyne Gas and Flame Detection GDCloud data management system. Here it is stored for review. Digitalisation will be an essential safety enabler in the distributed hydrogen economy of the future.

High pressure is unavoidable on the HRS

On a hydrogen refuelling station (HRS) there will generally be an inventory of hydrogen at high pressure. Even with on-site hydrogen production using an electrolyser, storage of hydrogen is required to ensure that there is sufficient gas available to fill the tank of an incoming vehicle rapidly.

The role of the high-pressure hydrogen storage on the HRS is to buffer the slow steady production of the electrolyser and the intermittent high flow requirement of the refuelling operation. In the example above, if the HRS is intended to serve a fleet of 10 buses that all require refuelling before leaving the bus depot in the morning, the static storage must be able to decant 100kg of hydrogen.

The buffer storage of hydrogen must be at high pressure. The reason is that there needs to be a driving pressure from the storage to the bus. When the bus tank is 'full' it will be at 350 bar. The pressure in the storage will need to be a minimum of 400 bar to ensure a 50 bar pressure gradient to transfer the hydrogen into the bus rapidly. In essence, the static storage on the HRS is 'empty' at 400 bar.

"High-pressure hydrogen gas storage cylinders are generally located outdoors", says Prévost. "This is safer because a gas leak can be diluted rapidly in the ambient air. On the other hand, wind can blow hydrogen away from the leak detector and the safety answer is to use flame detection."

Hydrogen electrolyser gas and flame detection

Hydrogen electrolysers are often used to generate hydrogen on site for the HRS and have well defined gas detection requirements. Small-scale electrolysers are used on HRS systems are often built into a container, which is an enclosed space. This makes a combination of passive measures such as ventilation and active systems such as gas detect >>

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>> In outdoor spaces a flammable gas leak can be diluted to an undetectable level by a strong wind and flame detectors may be required. However, fixed gas detection is a lower cost solution and works very well in enclosed buildings, such as a containerised electrolyser, where there is no wind to disperse a gas leak.

The main technical standard that can be followed when considering gas detection and safety for electrolysers is 'ISO 22734-1: Hydrogen generators using water electrolysis process'. The standard makes guidance about escalating layers of protection. The first lines of defence when detecting a slight elevation in hydrogen concentration would be to implement additional ventilation.

Gas and flame detection equipment cannot avoid a gas leak, but they can reduce the hazard which results in a reduction in the overall risk. Gas and flame detection can also be incorporated into process control strategies. For example, a high-level alarm can shut down the compressor and close a pipeline valve to prevent a small leak developing into a larger one.

Detection of a more severe gas leak would trigger an emergency shutdown of the electrolyser. The electrical power supply is isolated, and a flow of inert nitrogen gas is activated. This purges the internal space of the electrolyser, and the nitrogen, oxygen and hydrogen gases are vented to a safe location outside the containerised system.

Safety management processes may specify gas and flame detection

Appropriate engineering and design of hydrogen systems requires the use of established safety processes such as Layers of Protection Analysis (LOPA), Hazard Analysis (HAZAN), Risk Assessment (RA), and Hazard and Operability Study (HAZOP).

Using these tools will call for the implementation of appropriate mitigating actions.

Many of the actions that result from these studies will be focused on avoiding leaks of hydrogen. To add to the layers of protection, gas and flame detection are also often specified. These safety devices cannot avoid leaks, but they can reduce the severity of a leak and thereby reduce the size of the hazard. This results in a reduction in the overall risk.

Gas detection, for example, can shut off a valve to prevent a small leak developing into a larger one. Stored hydrogen is generally not unsafe, hydrogen leaking into the air where it may ignite with oxygen is the problem. So shutting off the flow of hydrogen to the location of the leak can minimise the scale of the hazard.

Multiple devices improve operability and safety

"Teledyne Gas and Flame Detection use both electrochemical and catalytic sensors in their hydrogen gas detection equipment", confirms Prévost. For maximum safety, it is recommended to use two different technologies to detect any type of gas, and the same applies to hydrogen.

The benefit of doubling up detection with dissimilar technologies is stronger than duplicating the same technology. This is because there may be adverse environmental conditions which impact one of the two gas sensor technologies, but the other type of sensor may continue to function normally.

Prévost says that, "the solution we recommend is both safe and cost-effective. A catalytic bead gas detection sensor is used on the roof of the electrolyser or HRS compressor container. We locate that detector high up because hydrogen is a light molecule, and gas leaks tends to go upwards.

"Additionally, we would implement a hydrogen-specific electrochemical cell sensors in the ventilation duct where air is extracted from the containerised system. This will pick up a few ppm of hydrogen that would result from a small leak when diluted in the air being pulled through the container to act as an early warning system." H2V