Hydrogen Safety and Detection

Frequently Asked Questions

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The Safety Company







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Summary

Gas Properties and Sensors	1	What are the primary safety concerns associated with hydrogen in industrial and commercial applications?
	2	How is hydrogen leakage and fire detected with available technologies?
	3	What common sensing technologies are not applicable for hydrogen gas and why?
Detection System Requirements	4	How do hydrogen detection systems work, and what types are most effective?
	5	What are the standards and regulations that govern hydrogen safety and detection in various industries?
	6	How often should hydrogen safety systems be tested and maintained for reliable operation?
	7	What role does ventilation play in hydrogen safety in facilities?
Detection Advancements and Effectiveness	8	How have advancements in technology improved the effectiveness of hydrogen detection and safety systems?
	9	What should be considered for detector selection and placement?

1. What are the primary safety concerns associated with hydrogen in industrial and commercial applications?

As growing numbers of industries embrace the use of hydrogen it is important that the hazards of working with this fuel are understood, and the right safety measures and systems are put in place. While hydrogen is safer in some ways than some other commonly used fuels (in that it disperses quickly in air and is not toxic), it is still highly combustible and is an asphyxiant gas. Its unique properties also pose special challenges. Specifically:

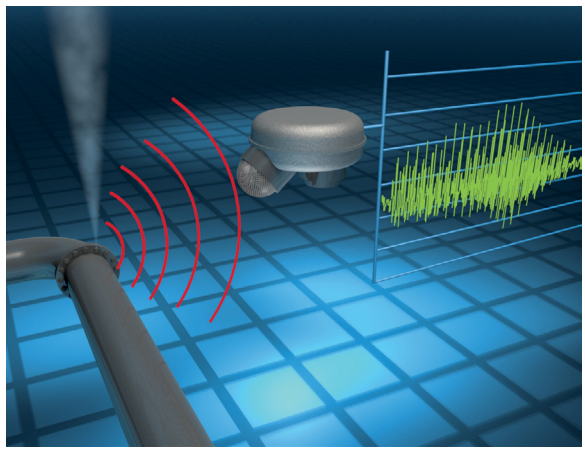
- Hydrogen gas is not visible to the human eye and has no odor, making it undetectable by human senses. Industry odorants (added to make hydrogen detectable by smell) may not be effective; many odorants can react with hydrogen or metal surfaces in the hydrogen storage and delivery system. Hydrogen can cause odorants to degrade or interact with other materials, compromising their effectiveness. Finally, high-purity hydrogen, often required for fuel cells and other applications, cannot tolerate impurities like odorants.
- Hydrogen is lighter than air. It is commonly understood that in confined areas it will rise upwards to ceiling level, displacing oxygen. However, hydrogen is difficult to detect in open spaces where accumulations cannot occur. And pressurized hydrogen gas leaks can be hard to detect as the gas jet direction can be unpredictable, making detector positioning difficult.
- When mixed with air, hydrogen gas is highly combustible and can ignite and spread rapidly. A pure hydrogen flame is very pale and almost invisible in daylight and fails to register with traditional heat detectors due to low thermal radiation.

The main areas of risk associated with handling hydrogen and its specific properties include:

Propensity to leak	Propensity to ignite	Fire consequences	Human related
• Small molecular size and permeation properties • Extremely high diffusivity	• Very low ignition energy • Fast detonation • Wide flammability range	• Invisible flame with low thermal radiation • High flame temperature	• Small molecular size and permeation properties • Extremely high diffusivity
H2 is 8 times smaller than Methane 7% of the density of air	Ignition Energy 0.02 mJ LEL 4Vol% - UEL 77Vol% Autoignition @ 560°C	UV radiation @ 185-260nm IR radiation @ 2.95µm Flame temp. 2,210°C	19.5Vol% O2 required for normal breathing 0-3Vol% O2 death in 4

2. How is hydrogen leakage and fire detected with available technologies?

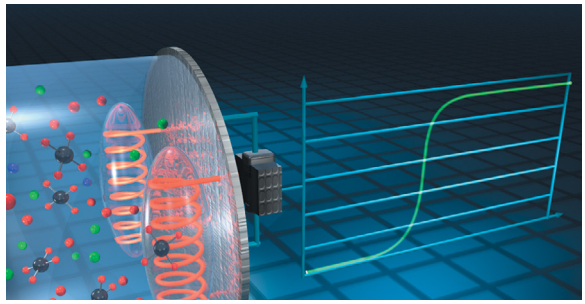
Ultrasonic Gas Leak Detection (UGLD). When pressurized hydrogen gas leaks, it generates an ultrasonic sound at the exit point. Ultrasonic monitors detect airborne ultrasound produced by turbulent flow above a predefined sound pressure level. Depending upon the level of background ultrasound and the distance from the source, a single detector can respond to even a small hydrogen leak.

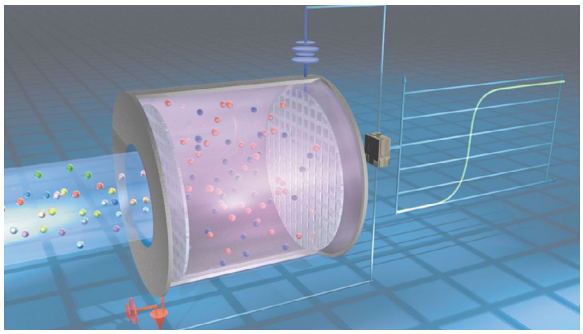


Since ultrasonic detection does not rely on a presence or concentration of hydrogen gas plume, and is unaffected by the direction of wind, it is ideal for monitoring pressurized pipes and vessels. Instruments can alarm rapidly as the time it takes for ultrasonic noise to travel from the leak source to the detector is typically at “the speed of the sound”. A time delay setting is introduced in some applications to reduce spurious false alarms.

Point Catalytic Bead. With catalytic bead gas detection, gas enters the sensor through a sintered disc (flash-back arrestor) and comes into contact with pellistors (beads) and is oxidized in the presence of oxygen.

A sensor uses a Wheatstone Bridge which converts the resulting change in resistance into a corresponding sensor signal, proportional to the amount of gas present. Results are read either locally via display on the device or remotely at a control unit located in a safe area. The operational range of these sensors is in the range of 0-100% LEL, equivalent to 0-4 Vol% range.

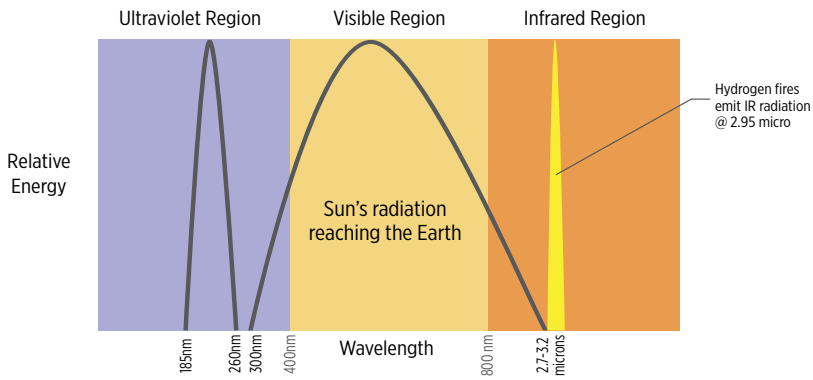




Point Electrochemical. These sensors use an electrochemical reaction to generate a current proportional to the gas concentration. The sensor chamber contains a gel or electrolyte and electrodes. The gas sample enters the casing through a membrane; oxidation occurs at the working electrode and reduction takes place at the counter electrode, resulting in ions flow which creates a current. Measurement of this current is converted into a displayed gas reading. The operational range of electrochemical cells for the detection of hydrogen is more sensitive than catalytic bead sensors - typically 0-1,000 ppm equivalent to 0-0.1 Vol% range (to convert ppm to % by volume, divide the ppm number by 10,000).

UV/IR Hydrogen Flame Detection. These flame detectors simultaneously monitor infrared (IR) and ultraviolet (UV) radiation at different wavelengths.

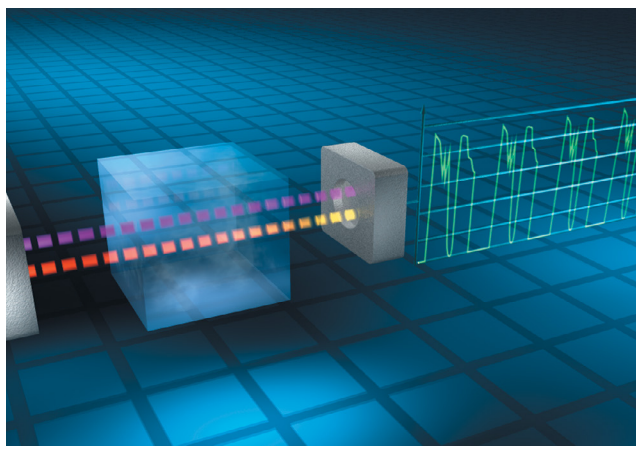
When hydrogen burns, radiation is emitted in the infrared spectrum by hot water molecules or steam created by combustion. An algorithm that processes IR radiation modulation reduces false signals caused by hot objects and solar reflection. The UV sensor is typically a photo discharge tube that detects deep UV radiation. This combination of IR and UV detection detection improves speed of response and reduces false alarms, while producing detectors that can detect even small hydrogen fires.



3. What common sensing technologies are not applicable for hydrogen gas and why?

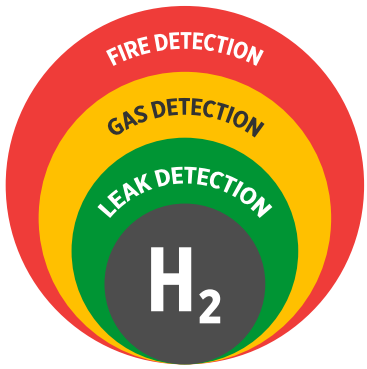
Hydrogen gas is colorless, odorless, and transparent to infrared radiation (unless it is burning, as noted for UV/IR Hydrogen Flame Detection technology).

Infrared sensors work by detecting the absorption of specific wavelengths of infrared light by molecules in the gas. However, hydrogen does not have a significant IR absorption band in the mid-infrared range (which is where many gases, like carbon dioxide or methane, are detected). This makes IR sensors ineffective for hydrogen gas leak detection.



4. How do hydrogen detection systems work, and what types are most effective?

A system that combines several layers and various hydrogen gas and fire detection solutions can provide reliable protection within each unique plant layout. All the detection solutions provide specific advantages depending upon application environments, and all have limitations. Detection layers reduce the incidence of hazard propagation, helping to prevent hazards from escalating into catastrophic consequences.



The latest generation of gas and fire detection systems employ a comprehensive layered approach that mimics human senses. Ultrasonic sensors "hear" gas leaks, conventional sensors "sniff" gases, and optical sensors "see" flames. The detectors utilizing these sensing technologies are connected to certified controllers which can automatically execute the user's approved sequence of safety actions needed in the event of a leak or fire within complete gas and flame detection system.

5. What are the standards and regulations that govern hydrogen safety and detection in various industries?

Fire and explosion are the main safety considerations associated with handling hydrogen, especially considering wide flammability range of 4% to 77% of volume in air. Explosion protection is currently governed internationally by the **IEC/EN/ISA 60079** and **ISO/IEC 80079** standards, with many regions adopting similar standards locally. Additionally, specific international standards for hydrogen facilities are also available, for example:

ISO 22734 - Hydrogen generators using water electrolysis — Industrial, commercial, and residential applications: requires manufacturers of electrolysers to perform a risk assessment. Depending on the final placement location of the equipment, plant owners/operators may need to perform their own additional assessment on the hydrogen generator, applying zone classification using IEC 60079-10-1 or an appropriate national standard.

ISO 19880 - Gaseous hydrogen — Fueling stations: requires that sites must be inspected in accordance with the IEC 60079-10-1 standard or sufficient national regulations. This includes zone classification and ignition protection methods to IEC 60079, ISO/IEC 80079 and NFPA 2.

Both ISO 22734 and ISO 19880 standards also specify requirements for risk mitigation with gas detection system as one of the methods to prevent accumulation of ignitable gas mixtures. However, these standards do not give detailed guidance about selection or installation of gas detectors. Organizations often choose to follow the more specific guidance in the **IEC/EN/ISA 60079** series of standards, to help ensure that their fixed hydrogen gas detection systems are properly specified, installed, and maintained to enhance safety in hazardous environments.

6. How often should hydrogen safety systems be tested and maintained for reliable operation?

Guidance for service and maintenance is provided in product manuals. In addition, users can refer to **IEC/EN 60079-29-2** for Gas detectors — Selection, installation, use and maintenance of detectors for flammable gases and oxygen.

Routine maintenance of any flammable gas detection system is an extremely important factor affecting the reliability of the units. The following inspections and tests help to maintain the reliable operation of the gas and flame detectors:

	Ultrasonic	Catalytic/Electrochemical	Optical Flame
Inspection	Regular visual checks are required for the microphone and its cover	Regular visual and response checks to define if recalibration is required	Regular checks are required with a tool providing sufficient energy for sensors response
Maintenance	Periodical sensitivity checks, if required by plant regulations, also to define if calibration is needed	Operating time, conditions of use and exposure to gas or other substances will dictate calibration frequency	Regular cleaning for optics and checks of mounting bracket stability and adjustment of alignment

Frequency of these activities will ultimately depend on the specific circumstances of the application.

Inbuilt self-testing capabilities can help in providing the information when maintenance is required. Examples:

UGLD: The Observer® i from MSA features the patented Senssonic™ self-test function. This self-test checks the device's electrical integrity and microphone every 15 minutes to confirm that the detector is operational. The microphone and the microphone windscreen are frequently monitored, helping to ensure that the detector has optimal sensitivity and detection coverage.

Flame Detectors: The FL500-H2 from MSA is equipped with Continuous Optical Path Monitoring (COPM), a check of the device's optical path and related electronic circuitry every 2 minutes. If the optical window is blocked by unwanted objects such as ice, dirt, or debris for two consecutive checks, the device activates the fault output.

7. What role does ventilation play in hydrogen safety in facilities?

Ventilation and air movement serve two primary purposes as per IEC 60079-29-2 standard:

- Enhancing dilution and promoting dispersion to limit the extent of hazardous gas areas.
- Preventing the persistence of explosive atmospheres, which could influence the hazardous area classification.

The ventilation rate must be evaluated in comparison to the expected flammable gas leakage rate under various operational conditions. This relative comparison determines how flammable gas detection systems and ventilation should operate together. Detailed guidance on assessing ventilation efficiency and availability is provided in IEC 60079-10-1, Annex B.

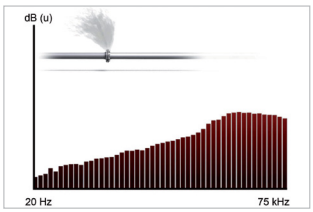
The safety functions implemented through gas detection and corresponding actions can include:

- Disconnecting non-explosion-protected equipment if gas levels exceed the alarm threshold.
- Increasing ventilation rates to prevent gas concentrations from exceeding the defined level at the equipment location.

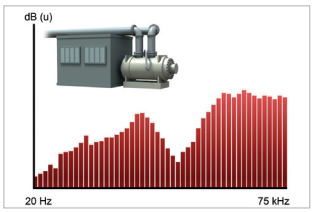
Additional requirements are outlined in standards such as ISO 22734 and ISO 19880. These standards address specific safety, reliability, and performance aspects of hydrogen production, storage, and distribution systems.

8. How have advancements in technology improved the effectiveness of hydrogen detection and safety systems?

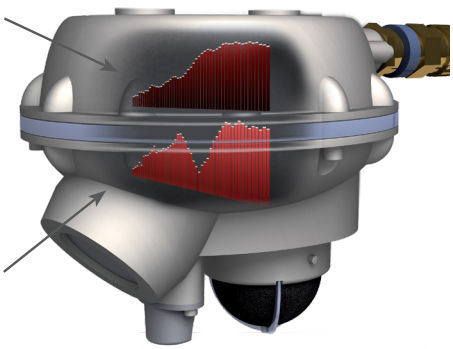
The latest, third generation of ultrasonic detectors feature **Artificial Neural Network (ANN)** algorithms to detect compressed hydrogen leaks. Using advanced sound processing, the detector can discern between a gas leak noise event and unwanted background noise, matching omnidirectional acoustic readings with data recordings amassed over years from both onshore and offshore facilities in the field. In contrast to earlier generations of ultrasonic detectors listening only at frequencies over 25 kHz, the detector can monitor down to 12 kHz while ignoring unwanted background noise. This lower frequency range significantly increases the detection radius while maintaining a reduction in false alarms.



Gas leak noise
Recognized by the detector



Background noise
Rejected by the detector



Observer-i ANN has been pretrained with gas leak noises and background noises

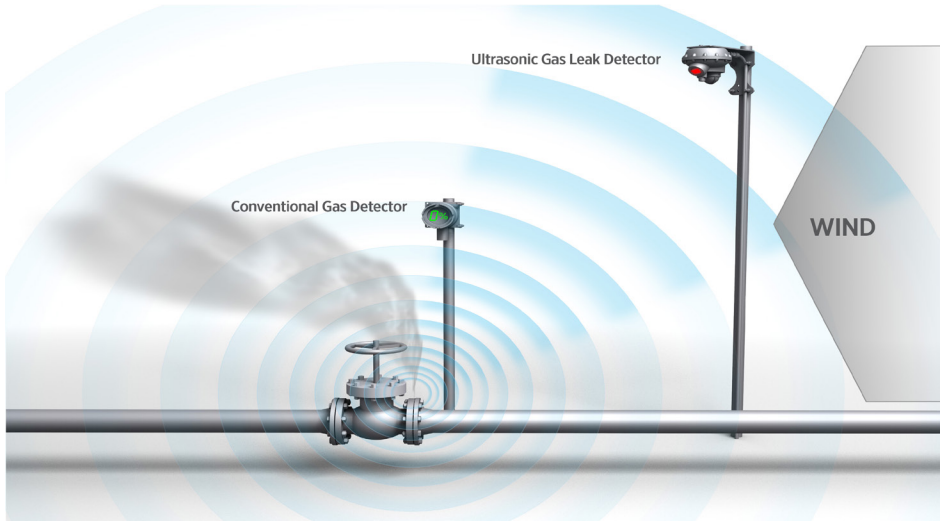
The Observer® i, which is MSA's latest third-generation UGLD, requires no alarm set points or trigger levels to be configured, and no time-consuming "training" sequences before installation. For dependable operation, a patented self-test function, Senssonic™, runs integrity checks every 15 minutes. The unit provides accurate identification and detection of hydrogen gas leaks from 2 bar (29 psi) pressure, from distances up to 28 meters, at the speed of sound.

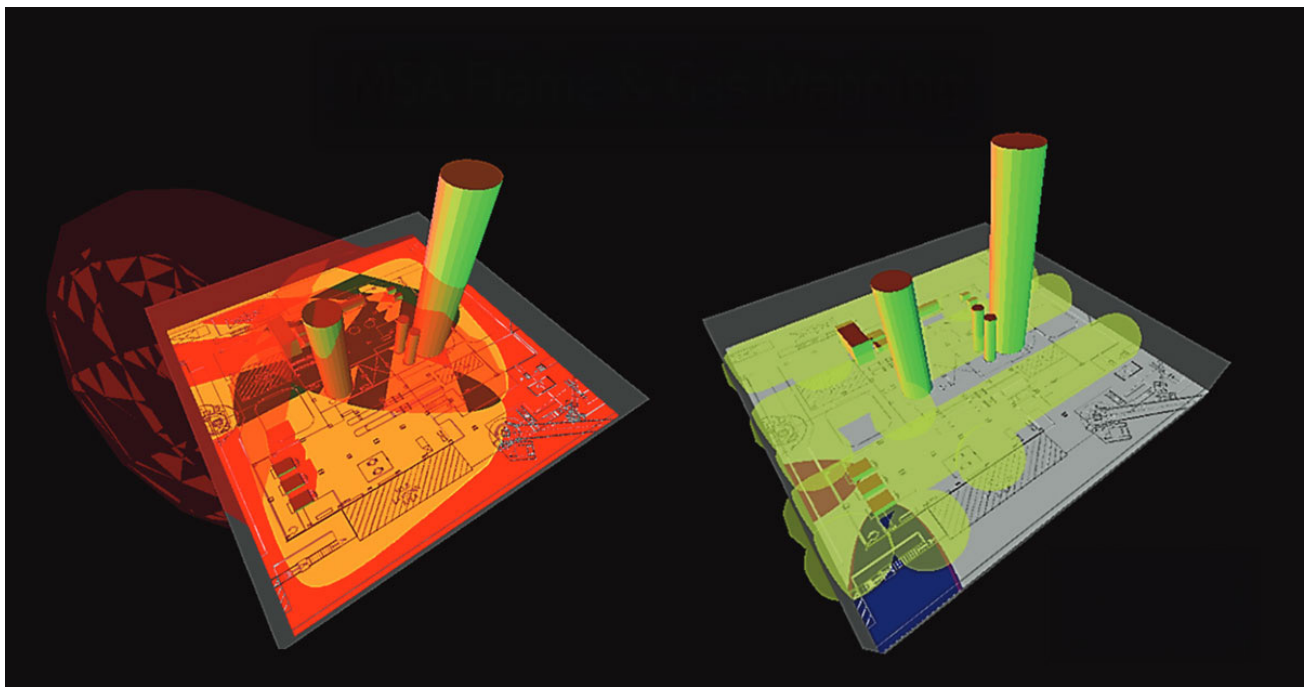
9. What should be considered for detector selection and placement?

Correct placement and utilization of multiple detector technologies increases the likelihood of early identification of hydrogen gas dispersal or fire. Presently, hydrogen detection schemes are mainly based on point gas detectors, either with catalytic bead or electrochemical cell sensors. While point gas detectors can be an important part of a layered system, they may have limited efficiency for applications in unconfined areas.

This is because hydrogen gas in processes or storage is usually under elevated pressures, and the direction of the leaked hydrogen plume is not necessarily upwards. When under pressure, hydrogen gas leaks are likely to be in the form of gas jets. The shape of these jets is typically long but narrow in width, and the momentum of release can maintain this shape for a considerable time. This increases the likelihood of the gas jet bypassing point gas detectors for a lengthy period. And, since it is difficult to know where a leak would occur, the direction of such gas jets can be unpredictable. This further increases the likelihood of delayed detection or non-detection. Positioning point gas detectors for rapid hydrogen gas detection in unconfined areas is difficult. Consequently, the likelihood of hydrogen gas detection can be much lower than realized.

Plume modelling and gas mapping software tools can be used to demonstrate the limitations of point gas detectors in hydrogen gas applications and help to show the abilities of new detection techniques, like ultrasonic gas leak detection, for more effective and combined hydrogen gas risk mitigation.





MSA—The Safety Company

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Our Mission

MSA's mission is to see to it that men and women may work in safety and that they, their families, and their communities may live in health throughout the world.

MSA: SAFEGUARDING PEOPLE, PLACES & THE PLANET.

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