AUTRONICA

DET-TRONICS

HYDROGEN

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INTRODUCTION

Hydrogen plays a crucial role in driving the energy transition. Over the past decade, the global production of green hydrogen, a form of hydrogen produced using renewable energy sources, has increased more than 100-fold. Similarly, the production of blue hydrogen, which is derived from natural gas with carbon capture and storage, has nearly doubled in the same period.

This remarkable growth is largely driven by the widespread adoption of clean energy technologies and the intermittent nature of renewable energy sources, which require reliable storage solutions. As a result, the hydrogen sector has attracted significant investments and has benefited from favorable policies worldwide.

Hydrogen's versatility is another key factor contributing to its rapid growth. It has a wide range of applications, including use as a fuel for transportation, in the production of fertilizers and in various industrial processes. This broad applicability makes hydrogen an essential component in the global effort to achieve a sustainable and clean energy future.

Hydrogen, in its pure form, is colorless, odorless, tasteless, and non-toxic. However, even small amounts mixed with air can become a significant fire hazard. Recent fire incidents associated with large chemical plants and hydrogen filling stations show inherent need for robust safety solutions for hydrogen applications. Hydrogen facilities must employ advanced flame and gas-leak detection technologies to maintain a safe environment for both people and processes.

AUTRONICA IN HYDROGEN SAFETY

Autronica Fire and Security is a global provider of fire and gas safety solutions and has played a crucial role in enhancing Hydrogen generation, transportation and distribution system safety. Autronica has developed a distinctive solution specifically tailored for Hydrogen application safety. Autronica is recognized for its reliability, a vital quality in this industry. Autronica's comprehensive and integrated safety solutions, personalized service, and unwavering commitment to performance and safety have solidified Autronica's global reputation, as a provider of hydrogen safety solutions.

AUTRONICA'S STRENGTHS

Global Recognition

Autronica has global presence and support capability. Our commitment to excellence has earned us recognition from industry leaders and clients alike.

End-to-End Solutions

Autronica provides turnkey solutions, from manufacturing to life-cycle support. Our holistic approach ensures seamless integration and optimal performance.

Personalized Service

Dedicated technical and commercial support staff forge lasting relationships with clients. We understand your unique needs and tailor solutions accordingly.

Performance and Reliability

Autronica's solutions set industry benchmarks for performance and reliability. Our track record speaks volumes about our unwavering commitment to quality.

Scalability

Whether you're a small business or a global enterprise, Autronica adapts to your requirements. Our flexibility ensures that your investment grows with your business, from small and efficient systems to sitewide solutions.

Certified Expertise

Autronica's in-house capabilities are backed by global certifications and demonstrated expertise. You can trust us to deliver results that exceed expectations.

ROLE OF SAFETY SYSTEM

Ensuring personnel safety and maintaining the integrity of the process system is a common requirement across all hydrogen applications. Hydrogen gas, which is highly flammable, colorless, odorless, and typically undetectable by human senses, necessitates the use of combustible gas detectors. These detectors should be installed in all areas where hydrogen leaks, spills, or hazardous accumulations could potentially occur.

The hydrogen detection system needs to be compatible with other systems, such as fire detection and fire suppression systems. Detectors must be certified for performance and safety to ensure they do not serve as an ignition source. The total time for detection, data summary, transmission, and display should be minimized. Furthermore, hydrogen gas detectors must be strategically placed and regularly maintained.

In certain applications, continuous automatic sampling equipment may be required, with sample points strategically located. This equipment should be calibrated to provide a repeatable response. The detection of liquefied hydrogen cannot rely solely on observation. While a cloud of frozen air and moisture may be visible, it is not a reliable indicator of a hydrogen leak, as similar clouds of water vapor may also rise from cold, exposed surfaces in the absence of a hydrogen leak.

The number and distribution of detection points, as well as the time required to shut off the hydrogen source, should be determined within a safety case and based on factors such as potential leak rates, ventilation rates, and the volume of space in an interior location. The detection signal should also trigger warning alarms and automatically initiate shutoff where required.

For enclosed areas where a buildup of hydrogen is possible, detection and alarm at 1 percent by volume hydrogen concentrations in air, equivalent to 25 percent of the LFL, is required (29 CFR 1910.106 1996). For permit-required confined spaces, detection and alarm at 0.4 percent by volume hydrogen concentrations in air (equivalent to 10 percent of the LFL) is required (29 CFR 1910.146 1996, and 29 CFR 1910.106 1996).

Under conditions where the sensor cannot be located at a leak source, it may be necessary to conduct a gas sample through a sensing line to the sensor. The response time under such conditions depends on the length of the sensing line.

The hydrogen detection system needs to be compatible with other systems, such as fire detection and fire suppression systems.

UNDERSTANDING HYDROGEN

Hydrogen, in its molecular form H_2, is a combination of two hydrogen atoms and is the lightest of all molecules. It constitutes about 0.14 percent of Earth's crust by weight. However, it is plentifully available in the form of H_2O (water). Hydrogen demonstrates extraordinary properties due to its low molecular weight:

Light Transparency

Hydrogen is transparent to visible, infrared, and ultraviolet light for wavelengths below 1800 Å (angstroms). Its molecular weight is less than any other gas, which allows light to pass through without substantial absorption. This property makes optical methods of hydrogen detection challenging.

High Molecular Speed

The velocity of hydrogen molecules is higher than that of any other gas at a given temperature. This characteristic contributes to hydrogen's unique behavior in various physical processes. This property is used for detection of pressurized leaks using ultrasonic gas detectors.

Rapid Diffusion

Hydrogen diffuses more quickly compared to other gases. For example, the diffusion ratio of hydrogen to natural gas is more than 4:1. This property has practical applications in areas such as fuel cell technology and industrial processes. However, due to this property, hydrogen gas cannot be mixed with any odor-producing gases. By the time the odor is detected, the hydrogen concentration would reach above the LEL limit and may ignite.

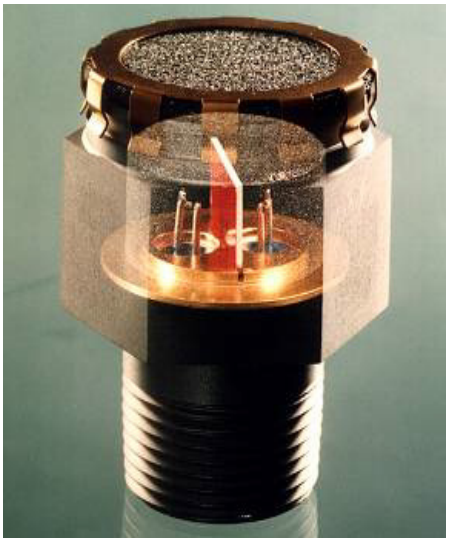
Relative Density

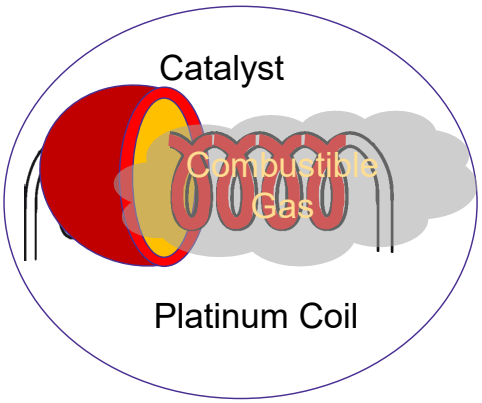
Under standard conditions, hydrogen, being one of the most lightweight elements in nature, has a density of 0.0899 kg/m^3, in stark contrast to water's density of 1000 kg/m^3. The relative density of water to hydrogen is approximately 11,000.

Fire Risk

Hydrogen is inherently highly flammable and ignites at gas to air concentrations ranging from 4% (The LFL) to over 75% (The UFL) . On the NFPA 704 flammability scale, hydrogen is rated a four out of four, indicating substances that vaporize rapidly or disperse in air and readily burn, such as gasoline and hydrogen gas. Even when combined with ordinary air in small proportions, hydrogen becomes combustible. Ignition can occur at a volumetric ratio of hydrogen to air as low as 4%, due to the simplicity and chemical characteristics of the reaction. Hydrogen forms an explosive mixture with oxygen at a ratio of 2:1. Notably, the burning of hydrogen does not produce any hazardous gases.

GAS DETECTORS - FIRST LINE OF DEFENSE





DET-TRONICS CGS DETECTOR

Industrial firms that utilize hydrogen can benefit from gas detectors and flame detectors working in tandem to swiftly pinpoint a gas leak or a subsequent flame. Given that hydrogen gas is invisible, odorless, and tasteless under normal conditions, it's crucial to deploy a gas detection system to alert staff of a leak before it ignites. These systems can be seen as the primary defense against a hydrogen release. Quick detection can halt a leak before it leads to a fire or explosion.

Two prevalent technologies for detecting combustible gas are infrared (IR) and catalytic bead point gas detectors. An IR gas detector responds to gases that absorb IR radiation, such as methane and propane that are hydrocarbon-based. However, since hydrogen doesn't absorb IR radiation, IR gas detectors won't detect hydrogen and are thus not recommended. This makes catalytic bead detectors the preferred choice for detecting hydrogen at lower flammable limit (LFL) levels.

A catalytic bead sensor can detect any combustible gas that reacts with oxygen to generate heat. If the gas can combust in air, this sensor will detect it. The catalytic gas sensor typically comprises a matched pair of platinum wire-wound resistors, one of which is encased in a ceramic bead. The active catalytic bead is coated with a catalyst, while the reference catalytic bead remains untreated. This matched pair is then enclosed behind a flameproof sinter, or porous filter.

During operation, the beads are resistively heated. When a combustible gas contacts the catalytic bead surface, it is oxidized, and heat is released, causing the wire's resistance to change. The reference (or passive) bead maintains the same electrical resistance in clean air as the active bead but does not catalyze the combustible gas. The sensor detects gas by comparing the currents. If they differ, the detector can trigger an alarm. If there is no gas cloud, both beads will have the same current, and no alarm will occur.

Catalytic bead detectors have limitations. They are vulnerable to poisoning, which can cause them to fail from exposure to silicones and other chemicals common in industrial environments. In these cases, the porous filter gets clogged, causing the active bead

to behave similarly to the reference bead, which may affect the system's accuracy or possibly prevent the detector from sensing gas.

If the active bead in a catalytic detector cannot sense gas, the operator in the control room will be unaware of it. Therefore, periodic bump or proof testing with calibration gas is necessary to ensure proper sensor operation.

When installing these gas detectors, users should remember that hydrogen, being the lightest gas, rises quickly and disperses. Therefore, installers should ensure the gas detector is positioned close to and above a location where a leak might occur or hydrogen gas might accumulate — just above a valve stem, for example. Consideration should also be given to potential pressure and direction of any leak.

Det-Tronics Catalytic Gas Sensor (CGS) provides for hydrogen detection at 0-100% (LFL/LEL). It utilizes established catalytic bead technology and is designed as a single unit with an integrated thermal barrier. The sensor features a sinter-bonded flame arrestor that offers excellent protection against electromagnetic interference (EMI).

The sensor's housing is made of 316 stainless steel, providing excellent resistance to impact and vibration. It operates over an extended temperature range of -55ºC to +125ºC.

The sensor comes with thread types of ¾-inch NPT, 20 mm, or 25 mm, and wire lead lengths of 6 inches (150mm) or 30 inches (760mm). The CGS is compatible with all Det-Tronics combustible gas transmitters and controllers.

Det-Tronics transmitters are available equipped with digital LCD that displays the gas level and provides for maintenance. Options include features such as a backlit, heated, five-color display that allows for easy, non-intrusive configuration and calibration. These transmitters have 0-20mA and relay outputs, with selectable operation modes.

If the active bead in a catalytic detector cannot sense gas, the operator in the control room will be unaware of it.

The device is certified to be explosion-proof. They offer 3-port, ¾" NPT, M25, or M20 thread options and are available with aluminium or stainless steel. The CGS Model is specifically incorporated with a CGS conditioning board. The transmitter is capable of operating within a wide temperature range, from -55 degrees Celsius to +75 degrees Celsius.

HYDROGEN FLAME DETECTION

DET-TRONICS X3302 MIR DETECTOR FOR HYDROGEN APPLICATIONS

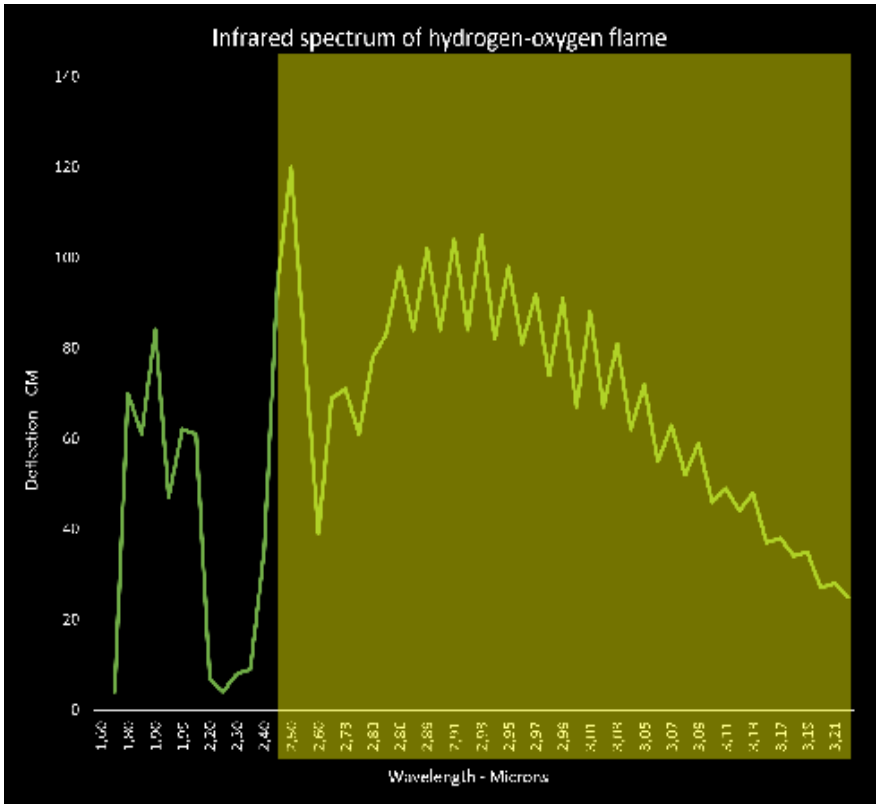
Hydrogen flames emit low IR radiation which is not sufficient to trigger a thermal heat detector alarm. While thermal heat detectors are beneficial, their correct placement is the most significant challenge. An alternative solution is to use an optical flame detector capable of detecting a hydrogen flame. Unlike hydrocarbon flames, hydrogen flames emit minimal visible light. However, technologies exist that can detect hydrogen flames, including those that sense non-visible IR and ultraviolet (UV) radiation.

UV flame detectors employ anode/cathode Geiger-Mueller-type vacuum tubes, a technology that dates back to the early 20th century, to sense UV radiation emitted by a flame. UV radiation enters the vacuum tube through a quartz window and hits the cathode. The energy from the UV photon releases a photo electron, creating an electrical impulse as it travels to the anode.

As hydrogen flames primarily radiate energy in the UV band, UV flame detectors are excellent at quickly detecting hydrogen flames. However, UV flame detectors are sensitive to arcs, sparks, welding, lightning, and other UV-rich non-flame sources. These UV emitters can trigger false alarms in UV flame detectors, which can lead to costly consequences and desensitize people to real potential dangers.

As hydrogen flames primarily radiate energy in the UV band, UV flame detectors are excellent at quickly detecting hydrogen flames.

Therefore, UV flame detectors are best suited for locations isolated from sources of false alarms, such as enclosed rooms. Even in these settings, the problem may not be completely eliminated, as most enclosed rooms have ventilation ducts that can reflect UV from lightning and welding, potentially causing a UV flame detector to alarm.



Detectors that utilize both ultraviolet and infrared (UV/IR) technologies exist. These detectors require both UV and IR signals to be present to trigger an alarm. This provides better false alarm rejection capability compared to just UV detection alone. However, UV/IR detectors are still vulnerable to combinations of false alarm sources.

Multi spectrum infrared (MIR) flame detection has emerged as the preferred choice for detecting hydrogen flames in most indoor and outdoor settings due to the false alarm challenges faced by UV and UV/IR flame detectors. These flame detectors use a combination of IR sensor filters and software algorithm to both detect flames and reduce false alarms.

Some MIR flame detectors have been specifically designed to detect the low-level radiation from hydrogen flames using a unique set of IR filters. These specialized devices offer a very good detection range; with the optimal IR filter set, some MIR flame detectors can detect hydrogen fires at approximately double the range of a UV flame detector. MIR flame detectors also offer a good response time and do not trigger false alarms when exposed to arcs, sparks, welding, and lightning. Additionally, they provide solar resistance and are insensitive to artificial lights and most blackbody radiation, factors that may negatively affect other detection technologies.

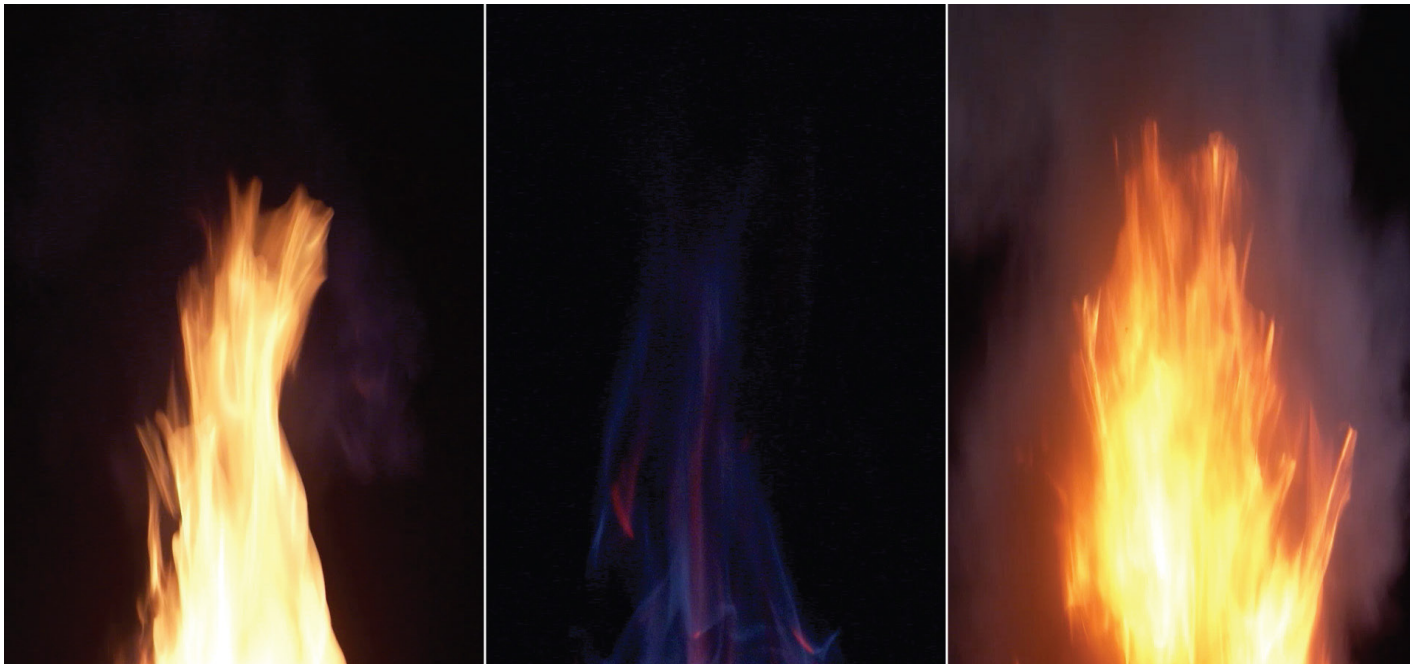
On the downside, the range of MIR flame detectors is reduced by the presence of water or ice on the lens. To address this issue, some detectors are equipped with lens heaters that melt ice and accelerate the evaporation of water.

The Det-Tronics X3302 is certified as SIL2. It offers maximum false alarm rejection and an extended detection range. The device is optically calibrated automatically and has built-in FDT/DTM and HART capability.

It sets the new standard with a detection distance of 100 feet (30.5m) for a 75 cm/10 SLPM hydrogen plume, offering the lowest cost of coverage. It has the ability to detect smaller fires earlier, ensuring low maintenance costs and reliable fault diagnostics. The device is explosion/flame proof (Ex d) or suitable for increased safety installations (Ex d e) in hazardous locations.

The X3302 is insensitive to artificial lighting and lightning, and resistant to solar and blackbody radiation. It offers multiple output configurations such as Relay, Relay/0-20mA, Relay/0-20mA/HART, Modbus RS485, and Eagle Quantum Premier LON/SLC. The Automatic Optical Integrity (oi) feature provides a warning when detection is impeded.

The device comes with housing options of copper-free aluminum or stainless steel. It features microprocessor-controlled heated optics and built-in data logging.



HYDROCARBON VS. HYDROGEN FLAME DETECTION

Optical flame detection technology needs to be compatible with the type of fuel it is expected to detect. To confirm the presence of a flame, a flame detector must be able to detect one or all of the flame's components. For a flame fueled by a hydrocarbon source, these components include carbon dioxide (CO_2), carbon, water, and heat (IR). However, not all fires are identical. For instance, a hydrogen fire does not emit CO_2.

The flame detection technologies commonly used today are based on ultraviolet (UV) and infrared (IR) sensors. Given that hydrocarbon-based fires emit strongly in the IR spectrum, single and dual-IR detectors are appropriate for their detection. Combination UV/IR detectors have also been popular for detecting hydrocarbon-based fires due to their ability to reduce false alarms.

In contrast to hydrocarbon flames, hydrogen flames primarily radiate energy in the UV and water bands. As a result, UV flame detectors could be sensible choice for detecting hydrogen flames.

Indeed, UV flame detectors respond well to both hydrocarbon and non-hydrocarbon fires. However, UV, UV/IR, and single and dual-IR detectors are being replaced by multispectrum IR (MIR) detectors. MIR technology often provides superior performance, fewer false alarms, and a lower cost of coverage than its conventional detection counterparts in many applications.

The flame detection technologies commonly used today are based on ultraviolet (UV) and infrared (IR) sensors.

LISTENING TO HYDROGEN LEAKS - ACOUSTIC DETECTORS

The process of storing, transporting, and distributing hydrogen typically involves high pressures. The detection of hydrogen leaks through acoustic methods offers a distinct advantage as the gas is not required to make direct contact with the detector. Instead, the acoustic detection method identifies the ultrasonic acoustic sound that originates from the source of a pressurized gas leak.

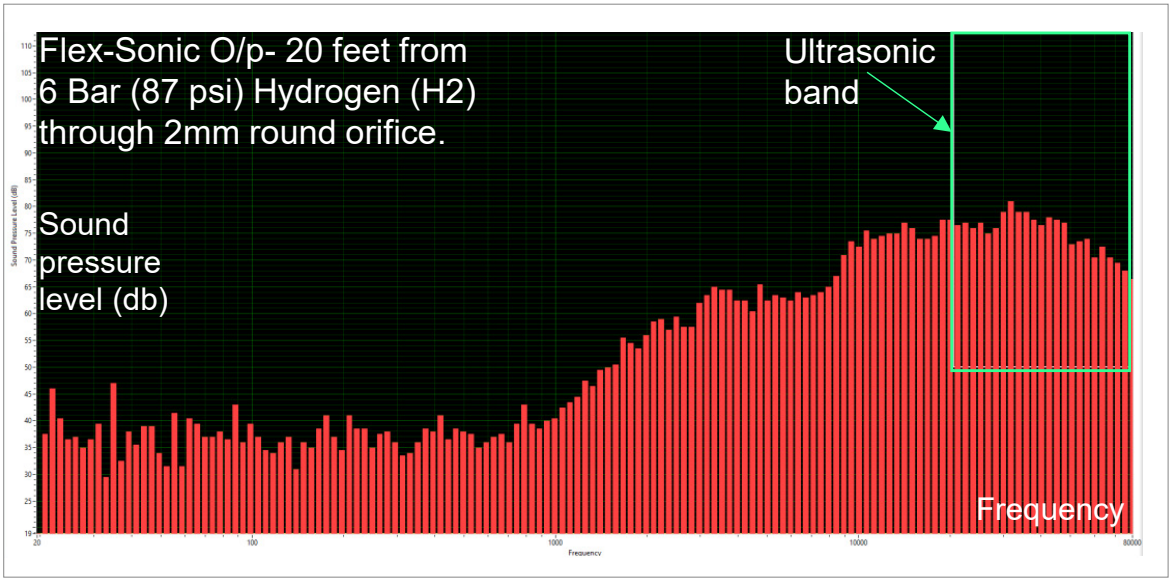
DET-TRONICS FLEXSONIC ACOUSTIC DETECTOR

When there is a breach in the containment of pressurized gas, the gas molecules transition from a state of high pressure to a state of lower atmospheric pressure. The difference in pressure at the source results in turbulent flow as both sides of the leak strive to achieve equilibrium. This turbulence generates sound in both audible and ultrasonic frequencies. Acoustic gas leak detectors utilize the sound pressure level (volume) of ultrasonic frequencies to trigger alarms.

Typically, to generate ultrasound, the pressure on one side of the leak orifice needs to be double that on the other side. The level of ultrasound emanating from a leak source can also be influenced by other factors, including the shape of the orifice, background ultrasonic noise sources, and the distance from the source.

Traditional acoustic gas detection technology offers limited user options, such as a single value amplitude alarm threshold level, alarm delay, and detector position. However, advanced Multi-Frequency analysis technology in acoustic gas detection not only provides the same options as traditional technology but also allows for the configuration of frequency ranges, the number of frequency bands, alarm threshold type, alarm recovery, and alarm sensitivity.

The level of ultrasound emanating from a leak source can be influenced by several factors, including the shape of the orifice, background ultrasonic noise sources, and the distance from the source.



The Det-Tronics FlexSonic acoustic leak detection technology offers an extra layer of protection. This detector has been evaluated and found to be more responsive to pressurized hydrogen leaks compared to natural gas. It is designed with a fail-safe mechanism and includes built-in testing functionality. It offers coverage for areas within Hydrogen facilities. The detector has the ability to learn about its environment to enhance its coverage. The FlexSonic detector offers the advantage of active listening over passive waiting. Instead of waiting for the gas to reach the detector, FlexSonic proactively listens for the acoustic signatures of a hydrogen gas leak. This approach allows for an immediate response to potential leaks, thereby reducing risks.

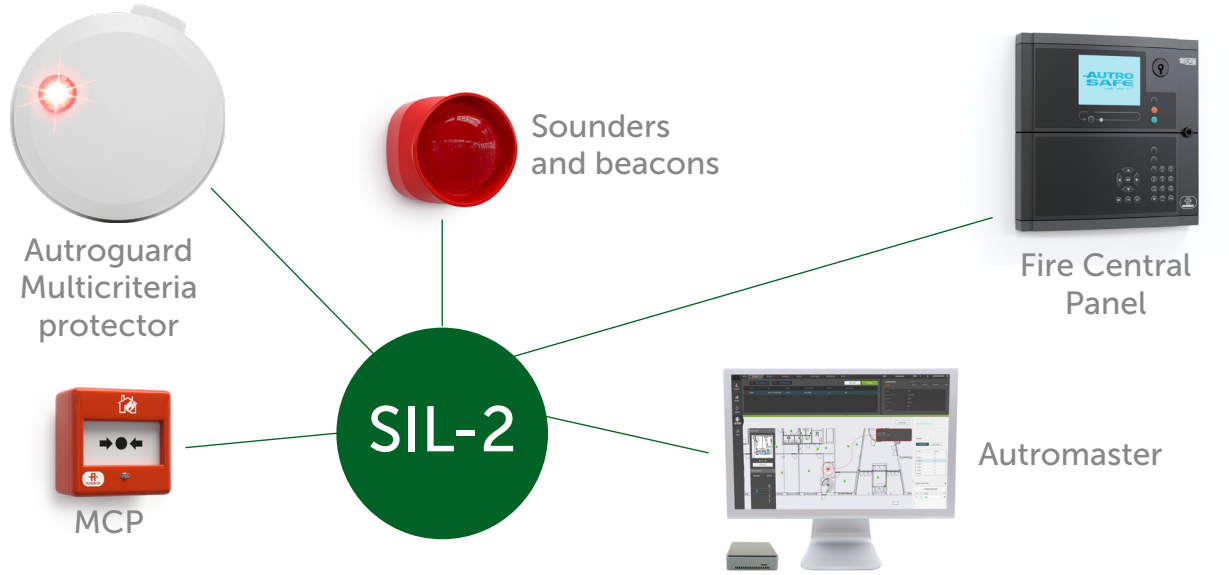
The sound of a gas leak naturally spreads in all directions, allowing FlexSonic to provide 360-degree coverage. The detector doesn't have any blind spots and isn't dependent on wind speed , direction or the location of the leak.

Flexsonic is capable of identifying actual gas leak "signatures" based on their sound characteristics.

FlexSonic is capable of identifying actual gas leak "signatures" based on their sound characteristics. This feature helps to minimize false alarms, and its patented technology ensures accuracy. FlexSonic can detect leaks down to 6 Bar (87 PSI), providing reliable detection even at low pressures.

The detector is SIL2 Certified, ensuring a high level of safety and reliability. The Det-Tronics FlexSonic has been tested and found capable of detecting hydrogen leaks as low as 0.004 kg/s, making it one of the most sensitive acoustic detectors available in the market. This excellent sensitivity translates to enhanced safety.

PROTECTION FROM TRADITIONAL SOURCES



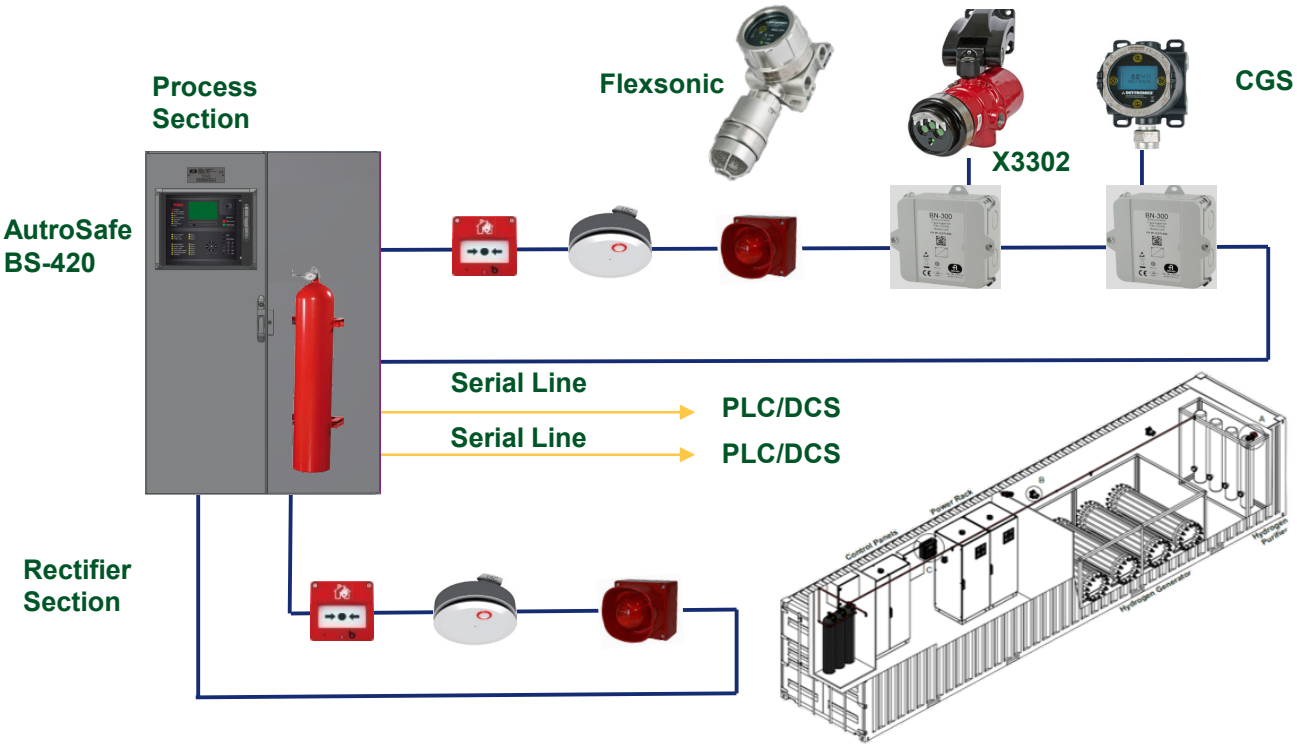
Autronica's Autroguard platform brings state of art fire and smoke detection for Hydrogen facilities.A typical solution includes smoke detectors, Manual call points, Safety switches, reset switches, Sounders and beacons, output modules for trip signals, Input modules for reset and activation functions, Interfaces to PLCs and distributed control systems

To simplify configuration, Autronica's Autroguard platform integrates multiple features—heat detection, smoke detection, sounder, visual alarm devices, carbon monoxide detector, and loudspeaker—into a single unit. Onsite installation is straightforward, with plug-and-play connection cords that even unskilled technicians can handle. Special connectors and design reduce installation time by up to 90%. The Autroguard protector operates effectively across a wide temperature range (-30°C to +70°C) and exhibits good resistance to salt, vibration, oil mist, weather, and pollution. The detectors are IEC61508 SIL2 certified and tested according to UL268 standards. An innovative chamber design makes them four times more dust-resistant than conventional detectors.

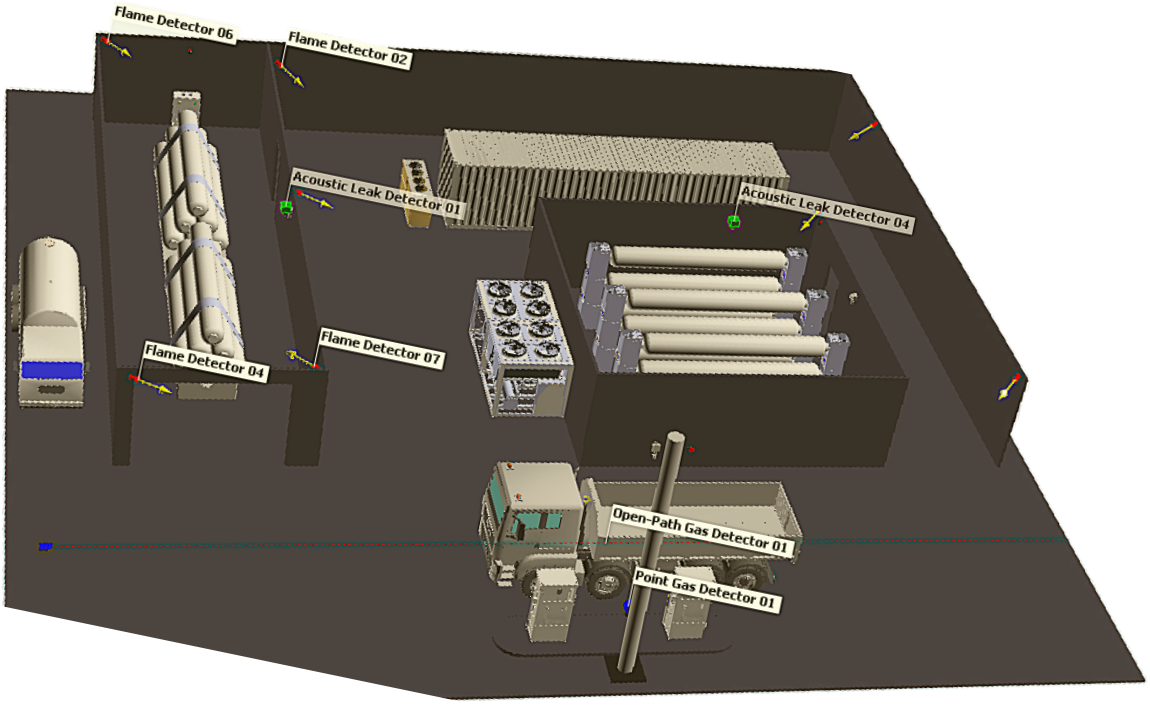
The robust design ensures an expected lifetime of over 20 years for connectors and electronics in normal environments. The self-verify functionality detects 100% of errors in the signal path and 99% of all components in the protector. Autroguard also features cover detection using infrared light. Integrated sounders produce sound at 93 dB at 1 meter output, with two sound levels and 16 standard tones. The EN54-23 approved visual alarm device operates at a frequency of 0.5 Hz or 1 Hz and is available in red or white light. Additionally, Autroguard offers a voice alarm with high-quality sound, supporting two languages and an attention-drawing signal.

Detectors include a short-circuit isolator in each base, allowing isolated operation in case of a short circuit. Automatic addressing follows the base, and wiring loops can be verified before protector installation. Mounting the protector is easy, requiring just one hand. Each address tag has a QR code for scanning and linking the physical location and protector during operation. AutroGuard® eliminates all typical nuisance alarms. It uses DYFI3D, a state-of-the-art data processing technology where up to six sensors analyze the unique signatures for each type of smoke source. Manual call points are used to provide safety at entry and exit points, with models available to withstand harsh conditions with an IP range from IP 52 to IP 66. The Flame IR flame detector serves the function of perimeter protection.

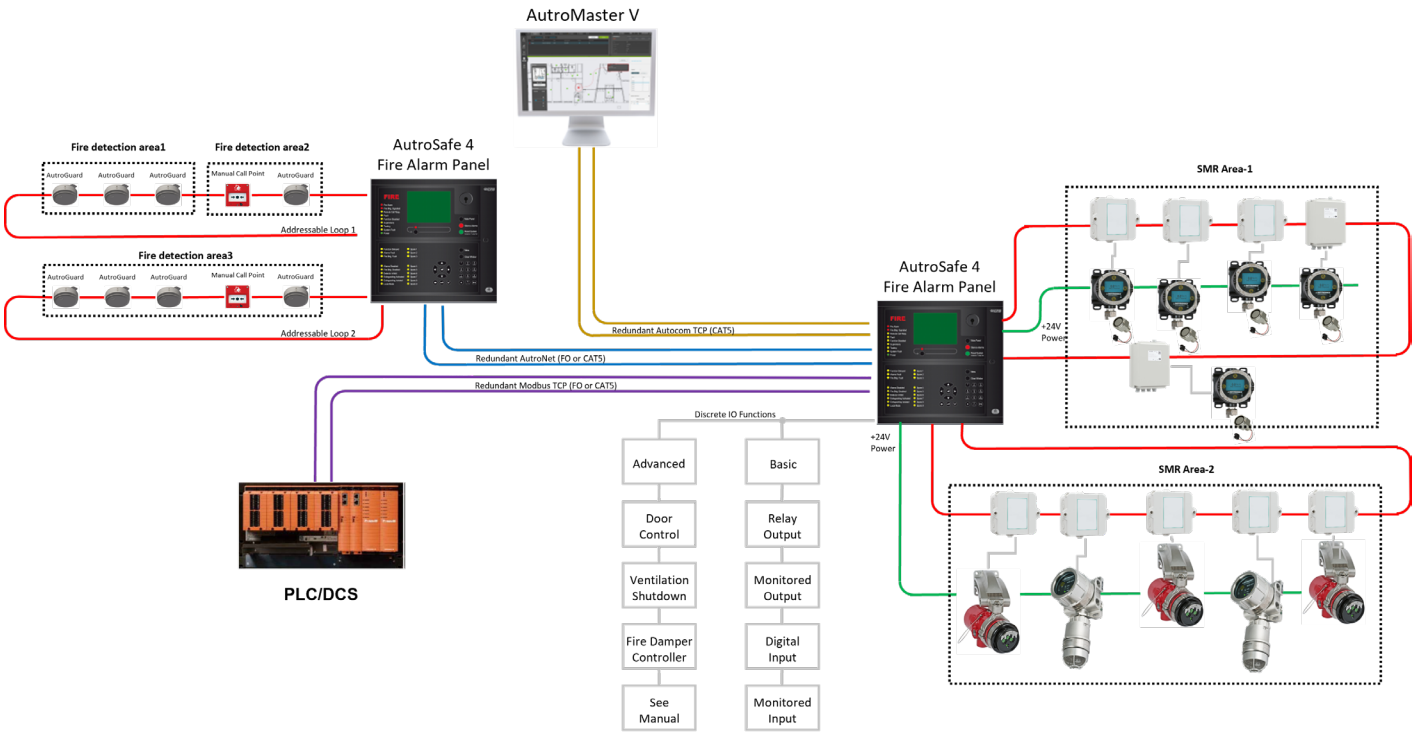
INTEGRATED SAFETY SOLUTION



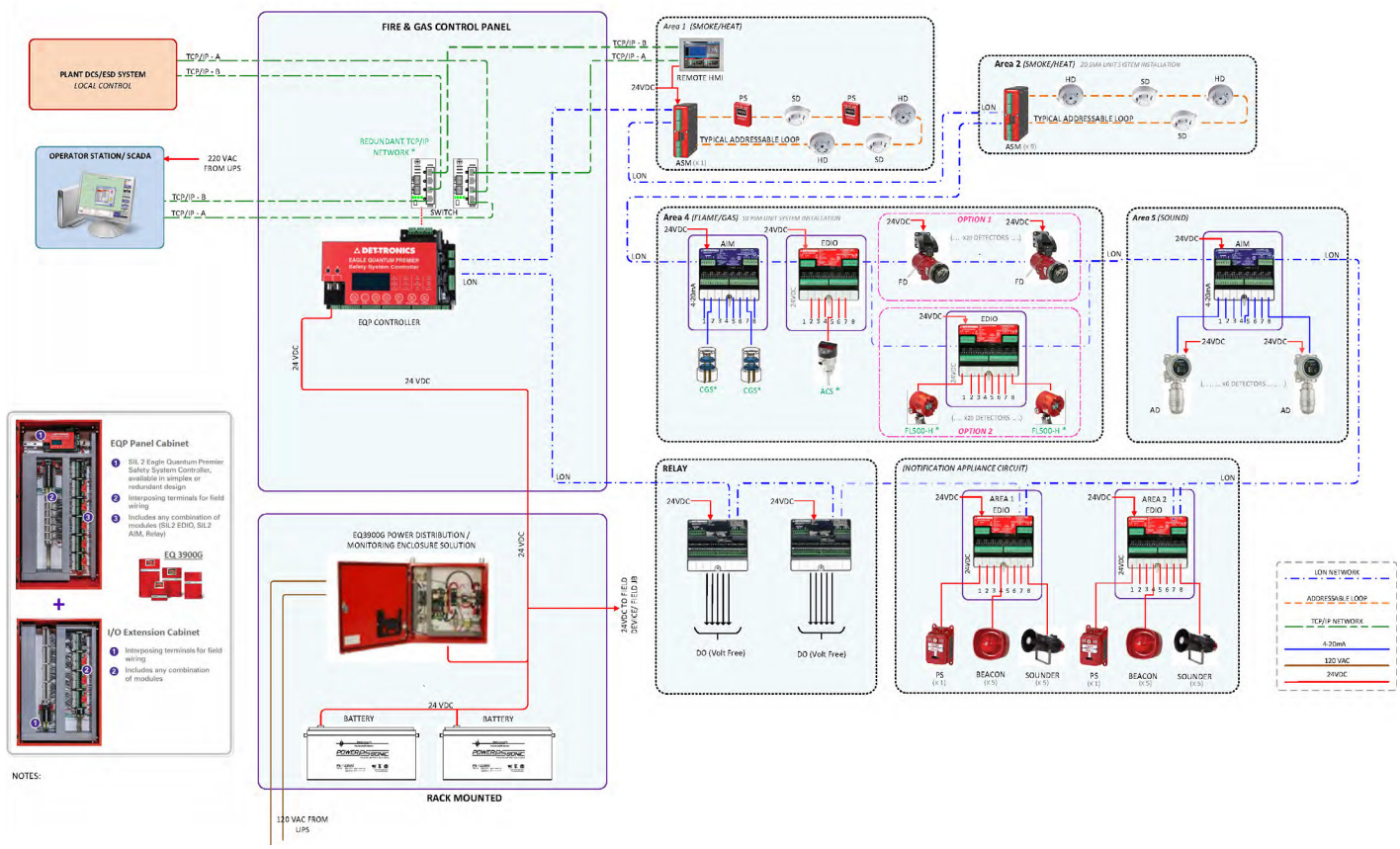
Autronica solution for containerised electrolysers



Autronica solution for hydrogen filling station



Autronica solution for steam methane reforming facility



Solution for steam methane reforming facility using Det-Tronics EQP

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