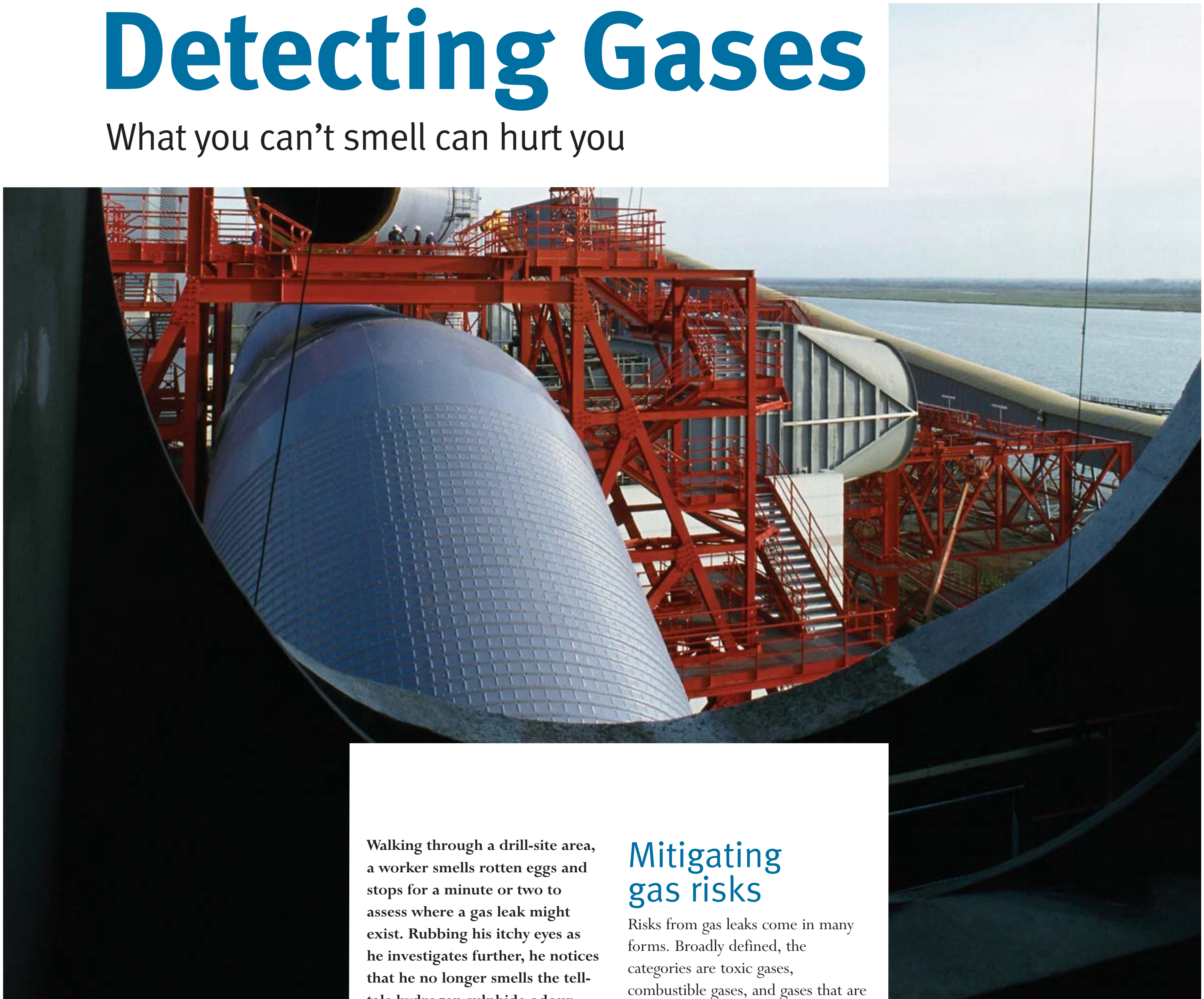
Detecting Gases

What you can't smell can hurt you



Walking through a drill-site area, a worker smells rotten eggs and stops for a minute or two to assess where a gas leak might exist. Rubbing his itchy eyes as he investigates further, he notices that he no longer smells the tell-tale hydrogen sulphide odour. He does not realize that the gas has deadened his olfactory senses and unless he leaves the area within seconds, he could lose consciousness and possibly his life. A well-researched and planned gas-detection strategy can help reduce the likelihood of situations such as this.

This article covers the types of gas risks and the fixed-gas detection technologies and methods available to mitigate those risks. It also covers the safety benefits of standards and approvals.

Mitigating gas risks

Risks from gas leaks come in many forms. Broadly defined, the categories are toxic gases, combustible gases, and gases that are both toxic and combustible. The risks of toxic gas leaks include death by asphyxiation or poisoning of the body. Combustible gas leaks pose risks such as fire or explosion after exposure to an ignition source, which could be merely the friction associated with gas escaping from a pipe fissure. An example of a gas that is both toxic and combustible is the deadly hydrogen sulphide gas.

One of the most effective ways to mitigate the risks associated with gas leaks is to follow good engineering and design practices during the design, planning and execution of processes and facility construction. Also important is to implement well-designed coverage into a gas-detection strategy.

An effective gas-detection strategy often includes both portable and fixed detection devices. Portable gas detectors are small and can be carried on a pocket or on a belt for personal protection. As the individual walks from area to area, the portable detector monitors the air for specific toxic or combustible gases. An alarm indicates that the individual might be walking through or standing in a potentially unsafe location. Fixed gas detection systems, on the other hand, are installed at fixed locations to provide long-term service life and detection for that area. The detector monitors a specific location all day. Addressed in this article are technologies and approaches that concern only fixed gas detection.

Fixed-detection techniques

Fixed gas detectors survey an area by using a variety of techniques. Gas-detector manufacturers offer the following types of fixed-gas-detection options: point, open-path, acoustic, and analytic or sampling detection systems.

Point gas detectors: Either combustible or toxic gas sensors can be fitted into point-type gas detectors. These detectors monitor a specific point or area and are strategically located for effective gas

Point gas detectors monitor a specific point or area

Open-path gas detector pair must be properly aligned

detection. In large critical areas, point detectors often are installed in a grid. Whether a gas is lighter or heavier than air determines where the detectors are mounted: high or low. These detectors require calibration for the gas type to be detected and, though some are self-monitoring, many must be routinely inspected to ensure they are capable of sensing gas.

Open-path or line-of-sight (LOS) gas detectors: Open-path gas detectors consist of a pair of modules that monitor the presence of combustible hydrocarbon gases within the infrared light beam projected between them. The gas/vapour hazard must pass through the light beam; therefore, the modules must be strategically located and properly aligned. Open-path detectors must be calibrated for the gas type to be detected and often are self-monitoring for a blocked light beam or electronic trouble.

Acoustic detectors: Ultrasonic gas-leak detectors sense the high-frequency sound emitted by high-pressure gas leaks. The detector can detect sounds of leaking gas independent of ambient conditions, such as wind direction. The gas leak must be released under pressurize. Ultrasonic gas leak detectors do better when they complement traditional gas detection methods because the ultrasonics do not detect specific gas types or values of Lower Explosive Limit (LEL) or toxic parts per million (ppm) concentration.

Analytic/sampling gas detection systems: Some analytical instruments extract an air sample, analyze the sample, and exhaust or return the sample to a safe location. These systems are mounted generally on a sub-plate within an enclosure with compression fittings for sample tubing connections.

Best fits for combustible gases

For combustible gases, the most common detection choices are catalytic and infrared point gas detectors.

Catalytic sensors detect a wide range of combustible gases both hydrocarbon and non-hydrocarbon, such as hydrogen and acetylene. Catalytic sensors offer good repeatability and accuracy with fast response time and low initial cost. But at high combustible gas concentrations, there might be insufficient oxygen to sustain the catalyzing process, resulting in a false reading that understates the actual gas concentration. Catalytic sensors require routine calibration (typically every three months or less). Catalytic sensors are susceptible to poisoning from exposure to substances such as silicones, halogens, tetraethyl lead, acid, PVC vapours, and other corrosive materials. Sensors can fail without annunciation, hence the requirement for routine calibration or bump testing.

Infrared (IR) detectors are immune to poisoning from contaminants and require less maintenance than catalytic sensors. They are unaffected by prolonged exposure to gas, high gas concentrations, and changes ▸

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in oxygen level. Unlike catalytic sensors, some IR detectors provide automatic and periodic full-function self tests, meaning that the instrument checks itself and reports any internal condition preventing detection capability. IR sensors detect only hydrocarbon-based gases and vapours. IR sensors do not detect the presence of substances such as hydrogen (H2), carbon disulphide (CS_2), or acetylene. Apply IR sensors in combustible gas applications where hydrocarbons are present.

Best fits for toxic gases

Currently, two main fixed-detector families are available to detect toxic gases: electrochemical cells and Metal Oxide Semiconductor (MOS) sensors.

Relatively stable and repeatable, electrochemical sensors can be used to detect a wide range of toxic gases in a variety of applications. The sensors do, however, have limitations that include restrictions in very hot and very cold environments. The limits arise because the sensors use an electrolyte that can evaporate in hot arid conditions. In addition, electrochemical sensors are generally not failsafe, meaning they must be visually inspected and routinely calibrated to ensure proper operation.

MOS sensors can live a long life while operating in a wide operating temperature range with good performance in low humidity environments. Historically, MOS sensor stability was not ideal in regions prone to major changes in ambient relative humidity. Recently, however, nanotechnology (NT) has advanced MOS sensors. NTMOS sensors look and operate much like standard MOS sensors, but NTMOS sensors significantly improve MOS performance in both arid and humid environments.

In addition, the NTMOS sensors can provide very fast speed of response to hydrogen sulphide (H_2S) gas. T50 can be as quick as 5 seconds. The speed benefits arise, in part, because each nanotube's total surface area is many times the surface area of its footprint. In addition, the NTMOS sensors do not go to sleep, as do some conventional MOS sensors. Many devices can also be compensated for humidity, and therefore operate over a large temperature and humidity range.

Placement of technologies

To determine gas detector placement, teams from the loss-prevention and project-management groups should survey the facility. Site drawings are analyzed to determine the probable sources of leaks, e.g., valves and flanges. They should consider the number and location of hydrocarbon and toxic sensors. Typically, sensors will be placed next to potential release points.

Toxic and hydrocarbon gas detectors should be placed in the air intakes to safe areas, including accommodation and process-control areas. Consideration should be given to relative weight of the gas with respect to air. For example, H_2S gas is heavier than air and it will sink to low-lying areas.

The environmental setting of the application is the single most significant property that influences vapour dispersion characteristics and gas-detection capability. Wind direction, temperature and its fluctuation, and humidity with its changeability all affect the accuracy and response of detector.

In addition, LOS detectors might be installed around the boundaries of each area to supplement the point detectors. Also important is the coordination between the use of personal portable detectors, ▸

hand-held portables, and fixed gas detectors.

Detector characteristics

Important detector characteristics include availability, self-diagnostics, speed of response, accuracy and repeatability, and maintenance.

Availability: Ideally, due to the danger to personnel and the risk to capital equipment, detectors must operate correctly and without faults.

Self-diagnostics: If a detector does experience a fault or break down, ideally it should annunciate the abnormal condition so that the person responsible for monitoring is made aware of the fault condition.

Speed of response: The more quickly the leak can be detected, the more likely that the risk for potential injury and property loss can be mitigated.

Accuracy and repeatability: People's lives depend on the detectors' ability to annunciate gas leaks.

Maintenance: Gas detectors are electro-mechanical devices. By their nature they require routine maintenance: functional tests, calibration, and periodic replacement of the sensor, filter, and electronics.

Benefits of standards

One can describe a standard as a consensus document to define minimum criteria for determination of good engineering practice. By verifying operations and functionality, industry standards such as EN 60529 and IEC61508 can work together with gas detectors to protect people and property.

Each set of standards typically sets good practice for one arena of the larger safety picture. Taken as a group, the standards complement each other to consider the safety of a more complete picture.

For example, hazardous location standards provide that a given device can endure and operate in a defined environment. Ingress protection provides that a sensing element is protected from its environment and will continue to operate. Performance testing verifies that the operating device performs in accordance with its design. And, the SIL rating indicates that devices, orchestrated together, should function in the presence of certain defined hazards.

Currently, several groups require certain standards to be met, depending on the location of the hazardous area. For example, in the US, the Occupational Safety and Health Administration (OSHA) requires that industries follow certain standards. Several European directives also now require other standards to be met. Check local codes for requirements.

Beyond safety requirements dictated by external organisations, many companies now have internal standards compliance groups. Some of these groups are required by company insurers. Regardless of the organisation requiring them, standards help companies take safety precautions deemed best practice by the industry and give better assurance that the facility will operate safely.

Standards also can provide policies for correct procedures to maintain safety equipment and, in some cases, show methods to improve the procedures.

Third-party certifications to standards

Some gas-detector manufacturers rely solely on their own internal test to self-certify to standards. Others add to their own testing by calling upon unbiased third-party testing agencies or insurance companies. These third-party testers can provide additional assurances and document development procedures, testing processes, and results.

The third-party testing is completed by experts in the certification process and in reliability engineering. Although the safety-device manufacturers know their devices and are experts in their field, third-party testing provides a third-eye into the design. In addition, the testing agencies maintain a high level of expertise in the most current standards and best testing procedures.

In the case of SIL testing, the third-party agencies document the design of the process and they test both the hardware and the software, which provides a more complete overview of the product operation.

A product that has undergone third-party SIL certification has had reliability calculations performed and reliability statistics determined and verified by a third party with expertise in SIL certification and reliability engineering. The results are available for the Safety Instrumented System (SIS) designer to derive the Safety Instrumented Functions (SIF) SIL number. This can significantly cut lead times in the implementation of a SIS.

Each certified product carries with it a certification report from the certifying body. This report contains important information ranging from restrictions of use, to diagnostics coverage within the certified device, to reliability statistics. Additionally, ongoing periodic testing requirements of the device are clearly outlined and include:

- *Restrictions of use*
- *Diagnostics coverage within the certified device*
- *Reliability statistics*
- *Ongoing device testing requirements*

Final considerations

Gas detection is as complex as the process being protected and careful analysis of the hazards is necessary to clearly identify the nature of the risk and then, the risk reduction techniques that will reduce the exposure of the plant operators and owners to a measured and manageable level. Gas detectors make a vital contribution to the hazard management process and when effectively applied, can save lives and property in the event of a potentially catastrophic leak. ■

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CoGDEM is the UK-based trade association which has the world's leading gas detection companies amongst its membership. Established in 1974, CoGDEM's key role is to represent the industry in matters of standards and regulations. Det-Tronics is an active member of CoGDEM's Industrial Sub Group.

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