THE ROLE OF COMBUSTIBLE AND TOXIC GAS DETECTORS IN INDUSTRIAL PLANT SAFETY

Hydrogen, a combustible gas, is colorless, odorless, tasteless and non-toxic, but hydrogen is ranked highest on the National Fire Protection Agency (NFPA's) flammability scale because it is flammable if even small amounts are mixed with air. Low concentrations of toxic gases such as ammonia can trigger coughing and nose and throat irritation, while high concentrations cause immediate burning of the eyes, nose, throat and respiratory tract, and can result in blindness, lung damage or death. Chlorine, though not flammable alone, can react explosively or form explosive compounds with other chemicals such as turpentine and ammonia.

These and myriad other combustible and toxic gases are found in industrial processing and manufacturing settings — whether they are used in the actual processing or are byproducts of processes. That’s why industrial plants need a gas detection network to mitigate risk in all areas where combustible or toxic gases could create a workplace hazard for life safety.

Gas Detection and Notification Techniques for Risk Mitigation

Life safety gas detection systems require not only the ability to detect leaking combustible or toxic gases — but also to mitigate risk through action.

According to IEC 60079-29 Series standards and IEC 62990 Series standards under development, a life safety gas system does more than detect the presence of combustible and toxic gases. It must be able to provide alarm notification if data from the gas detectors hits a certain threshold. It must also have the ability to take corrective actions such as increasing ventilation, closing a valve or door, or de-energizing equipment to mitigate risk.

In life safety systems, gas detectors tend to have feature-rich displays as well as smart capabilities that improve digital information transfers. The gas detectors are connected to a safety system controller (SSC) and various other devices that can take a number of different actions in order to help bring a dangerous situation back to a safe state.

The SSC for risk mitigation systems receives and interprets input from multiple gas detectors and decides whether or not some action needs to be taken. In order to prevent nuisance alarms, the SSC may discount information from a single detector if it is not confirmed by data from other detectors in the same area. The SSC must be IEC 60079-29 Series and/or IEC 62990 Series compliant as applicable to ensure that signaling, control, notification, and activations can be depended upon for life safety during adverse conditions.

Portable and transportable gas detectors will further mitigate personnel risk by ensuring full detection coverage in all areas of the workplace.

Risks of Combustible and Toxic Gases

Combustible gases are those that can cause a fire or explosion if the gas is exposed to an ignition source such as a spark, a hot surface, an open flame or even friction caused by gas escaping through a pipe fissure. Combustible gases include hydrocarbons and hydrogen.

A toxic gas can cause harm to humans, ranging from minor irritation to death. Toxic gases include, but are not limited to, hydrogen sulfide, carbon monoxide, nitrogen dioxide, ammonia and chlorine. Even at low concentrations measured in parts per million, certain toxic gases can cause death by poisoning caused by exposure to carbon dioxide or by asphyxiation. Many gases are both combustible and toxic.

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The gas detection system can perform a sequence of mitigation actions to reduce the risk level below the tolerable risk threshold. The strength of the mitigation actions taken increases with the severity of the ignition risk. Subject to conditions, the mitigation actions may or may not sufficiently reduce risk, so this process continues in a loop, continually monitoring and mitigating risk.
disadvantages of each technology and compare these to the proper rating for a hazardous classified location if intended for personnel should consider the capabilities, advantages and installation in such areas.

Properly rated for a hazardous classified location if intended for a plant, a hazardous-area gas detection system must be tested. Performance testing of gas detection equipment should be used for safety monitoring purposes.

Most gas detector manufacturers offer the following types of fixed-detection devices:

1. Gas detectors for risk mitigation and life safety are not used for validation of area classification (e.g., less than 10 hours favorable atmosphere exposure per year).
2. Limits for short and long-term exposure to toxic gas have not been set by any such as Occupational Safety and Health Administration in the U.S. and General Standards for Hazardous Area Equipment (IEC). 2.) A gas-related equipment explosion will likely also prove a threat to people.
3. Gas sensors for risk mitigation and life safety are not used outside of gas sensing devices that could pose a threat to personnel, equipment, or facility.

Point-type gas detectors have the advantage of being simple and portable. They are easy to install and can be used in environments where the gas concentration is not always predictable. However, point detectors have limitations in that they are susceptible to contamination and poisoning, require less maintenance than catalytic sensors, and are unaffected by changes in oxygen level or high gas concentrations. Unlike catalytic bead sensors, point detectors are failsafe, meaning that the instrument checks itself and reports any internal condition preventing detection.

The PointWatch Eclipse Model P125C is the Point infrared gas detector. It is the most rugged stainless steel, point infrared gas detector. It is approved to be factory calibrated to detect methane, propane, ethylene and butane. The Eclipse goes beyond just gas detection by acting as a control with its onboard relays and tri-colored LED indicator.

Gas Detection

The risk mitigation objectives are ranked in priority order, based on severity of risk, the type or types of gas detection required for detecting the risk underlying each objective are also listed.

From a risk mitigation perspective, there is a hierarchy of risk that should be considered when designing a plant’s hazardous-area gas detection system. The “Risk Mitigation” chart above ranks the risk mitigation objectives in priority order, and describes the type(s) of gas detection required for each objective.

Product & Performance Standards and Certifications

Because life safety gas detection equipment is used in high-risk areas, each component has to be product certified for hazardous locations as well as performance certified for the specific attributes and functions required.

Before embarking on the design of a life safety gas detection system, plant engineers should also review applicable safety standards, which can provide the backbone of a plan to help ensure continuous safe operation of plant processes. Standards address which devices and systems should be included in a life safety plan. There are also standards that deal with detector performance, installation, calibration and maintenance, all of which are critical to effective gas detection. (See the sidebar, “Gas Detection Guidance Documents.”)

Hazardous-location standards are meant to ensure that a device can survive and perform adequately in a hazardous-classified environment. These standards vary depending on the region of the world. The IEC standards are followed as a basis by most countries, but in some cases national deviations apply.

New proposed changes to IEC standards are intended to harmonize standards worldwide for greater safety and reliability. Increased uniformity would also benefit the many global companies operating in multiple countries, which would otherwise be subject to dozens of different codes and standards.

Some standards set out the performance levels to which each life safety device should be tested. Performance testing and certification verifies that a device will operate as specified by the manufacturer under worst case standardized conditions.

Accredited third-party testing is done by experts in reliability and compliance engineering in accordance with a certification process. A number of independent organizations are accredited to issue product certifications for performance testing of gas detectors.

In addition to gas detector performance in a life safety gas system, the performance of the control architecture should be third-party certified from detection to action to validate the entire safety function relied upon. The SSC itself should also be properly rated for a hazardous classified location if intended for installation in such areas.

Choosing a Detector

There are a number of different gas detection technologies currently available. In order to choose from among them, plant personnel should consider the capabilities, advantages and disadvantages of each technology and compare these to the characteristics and requirements of the application.

It is important to recognize that toxic gas detectors are categorized by two types of equipment: Type HM (Health Monitoring) for occupational exposure equipment and Type SM (Safety Monitoring) for general gas detection equipment. For Type HM equipment, the performance requirements are focused on uncertainty of measurement of gas concentrations in the region of Occupational Exposure Limit Values (OELs). For Type SM equipment, the performance requirements are focused on alarm signaling for such purposes as safety warning and leak detection.

As for combustible gas detectors, there are two basic types of equipment: 1) performance certified equipment with focus on alarm signaling for such purposes as safety warning, and 2) process monitoring equipment with focus on control means of a process. Only performance certified combustible gas detection equipment should be used for safety monitoring purposes.

The technologies discussed below are incorporated into what are known as fixed-detection devices, which are permanently placed in a location where gas leaks might occur. Fixed-detection devices are part of systems that protect people in a given area from harm caused by toxic and combustible gases.

Most gas detector manufacturers offer the following types of fixed-detection devices:

Point-type

Point-type gas detectors monitor a specific area or point in a facility. These detectors are used to indicate the presence of combustible or toxic gas. The gas must come into contact with the detector for sensing to occur. Point detectors require calibration for the gas type to be detected and must be regularly calibrated by experts in the field.

IR

Infrared (IR) gas detection is based on the principle that hydrocarbon combustible gases absorb specific wavelengths of IR light. Detectors using this technology include an IR light source and a sensor to measure light intensity at IR wavelengths. If gas is present in the optical path, the IR light intensity is reduced. This change provides the data needed to calculate gas concentration.

Like catalytic bead detectors, IR detectors must be in the gas cloud for detection to occur. Unlike their catalytic bead counterparts, IR sensors can only detect hydrocarbon gases, making IR detectors not suited for settings where there is danger from hydrogen.

Nevertheless, use of IR gas detectors is growing rapidly because they compare favorably to catalytic bead detectors in other ways. For example, IR detectors are immune to contamination poisoning, require less maintenance than catalytic sensors, and are unaffected by changes in oxygen level or high gas concentrations. And unlike catalytic sensors, some IR detectors are failsafe, meaning that the instrument checks itself and reports any internal condition preventing detection.

GAS LEAK

Point gas detectors monitor a specific area or point in a facility. Because the gas leak must come into contact with a point-type detector, performance of point detectors can be limited by environmental and application factors, as shown.
Gas Detection

In addition to combustible gases, point-type gas detectors are also designed to pick up leaks of toxic gases. The detectors measure gas concentration at the point where the detector is located and give readings in ppm. Contact with the gas is required for detection to occur.

Point toxic gas detectors are placed where there is a potential for a toxic gas leak. Placement considerations include airflow in the area, as factors like the density and anticipated source of the toxic gas.

For toxic gases, the most common fixed-detector technologies are electrochemical (EC) cells and metal oxide semiconductor (MOS) sensors.

EC sensors consist of electrodes connected via a load resistor. The electrodes are encased in a permeable membrane that diffuses detected gas across the electrodes. Once this occurs, the assembly is submerged in an electrolyte solution.

Available in a variety of different sizes and packages, EC sensors are used to detect a wide range of toxic gases in many applications. Generally considered the main choice for toxic gas detection, these sensors offer a number of advantages, including stability, repeatability, consistency, high sensitivity and low-power requirements. On the downside, use of EC sensors is restricted in very hot and very cold environments. In addition, EC sensors are generally not failsafe, so in most cases they must be routinely inspected and calibrated to ensure proper operation.

As for MOS sensors, there are many variations of this technology, which is most frequently used if the target gas is hydrogen sulfide. MOS sensor advantages include long life, wide operating temperature range, and excellent performance in low-humidity environments.

Open path/line of sight

Open-path, or line-of-sight (LOS), gas detectors continuously monitor combustible hydrocarbon gas levels between two points. This detection technology uses a beam of light that travels between two modules. When a gas cloud passes through the beam, the gas concentration is measured. To ensure that the target gas passes through the beam, the modules must be strategically located and properly aligned. The modules themselves, however, need not be in the gas cloud for detection to occur.

LOS detectors should be designed to withstand harsh industrial conditions, including chemical exposure and heavy vibration. Other specific product features to look for include large-area coverage, fail-safe operation, infrequent calibration requirements and low maintenance.

Disadvantages of the technology can include a high initial cost and the module alignment challenges that can prevent the detectors from working properly. Ideally, the design of the chosen detector will provide the largest possible field of view, which increases the modules’ alignment tolerance, making installation faster and easier. In addition, LOS detectors do not provide a direct gas concentration measurement, measured in % lower flammable limit or LFL. Rather, the detector provides a gas concentration measurement integrated over the entire beam length, measured in % LFL. Therefore, the detector cannot discern between a small, dense gas cloud and a large, dispersed gas cloud.

Intended to supplement rather than replace point detection systems, LOS detectors often work with point detectors to provide optimal protection of chemical facilities. In situations like this, the point detectors should be installed at or near known high-risk gas leakage points or accumulation areas to provide specific information about the level of gas present in these locations. LOS detectors should be installed at plant or process-area boundaries, where they can monitor the plant perimeter and track gas cloud movement in and out of the facility. Movement of gas clouds throughout the facility can be followed by monitoring the output signals of all the gas detectors on a workstation graphic display screen.

Acoustic

Capable of recognizing unique acoustic “fingerprints,” ultrasonic gas leak detectors sense the high-frequency sound emitted by pressurized leaking gas. In some applications, acoustic gas detection is faster than other fixed gas detection technologies because acoustic detectors do not have to wait for gas to contact them in order to “hear” a leak. Acoustic detectors are generally unaffected by rain, fog, wind or extreme temperatures, making them suitable for harsh outdoor environments.

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Matching Detection Capabilities with Requirements

Plant owners and operators need to understand whether the area they are planning needs gas detection for risk mitigation and life safety — which, as stated earlier, requires performance certified equipment — or for process monitoring equipment to control a process. While both functions are important in a processing plant, there are significant differences between the purposes and equipment depending on the needs for gas detection.

Process monitoring detectors are integrated with a gas supply line for the sole function of continuously measuring the concentrations of gases in the supply line for process adjustments.

Life safety risk mitigation requires a uniquely qualified type of gas detector, which is used in a facility’s hazardous-area safety system. These detectors are responsible for detecting leaks of combustible and/or toxic gases for alarm signaling purposes. The gas detection equipment uses the alarm signaling for purposes such as alarm notification, releasing action, increasing ventilation, shut-down action and/or other safety functions.

Specifying and installing the right combustible and toxic gas detectors — with appropriate product approvals and performance certifications — ensures that your gas detection system will mitigate risk as intended.

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