ULTRASONIC GAS LEAK DETECTION

A critical component of a layered flammable gas detection strategy.

Honeywell

INTRODUCTION

Gas leak detection is key to protecting workers and assets in many industrial applications, from oil and gas to petrochemicals, and power generation. This white paper examines the critical role that ultrasonic gas leak detection plays within a layered safety model and how the deployment of a mix of different types of flammable gas detectors enables operators to optimize coverage and effectiveness. Ultrasonic gas leak detection is an essential component of this integrated approach to monitoring both toxic and flammable gases. It provides the additional layer of safety that is needed to detect gas leaks early enough to help prevent catastrophic consequences.

THE DANGERS OF FLAMMABLE GASES

Industrial processes increasingly involve the manufacture and use of highly dangerous substances, particularly flammable and/or toxic gases. According to the EU-OSHA's latest ESENER survey, chemical or biological substances, including hazardous gases, constitute a 'risk factor' in nearly 4 out of 10 workplaces[1]. Inevitably, occasional escapes of gas occur, which create a potential hazard to industrial infrastructure, employees, and people living nearby. A recent study published in Energy and Climate estimated a staggering 630,000 leaks a year in gas distribution mains in the U.S.A.[2]. Worldwide incidents involving asphyxiation, explosions and loss of life are a constant reminder of this problem. Flammable gases bring the risk of fire and explosion. These are a threat to life, property and the environment. Between 2019 and 2020, the OSHA recorded 29 major workplace accidents caused by toxic or flammable gases, which involved severe injuries or fatalities[3].

The igniting substance is usually, but not always, a hydrocarbon compound. In this white paper we take into consideration the threat posed by common hydrocarbon flammable gases used for power generation, processes within chemical and petrochemical facilities as well as mid and downstream gas production and distribution. These hydrocarbons are sourced from the oil and gas supply chain, both onshore and offshore. The supply chain consists of exploration, production, processing, distribution, and storage (via pipeline or transportation vessels).

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2. Zachary D. Weller et al., A National Estimate of Methane Leakage from Pipeline Mains in Natural Gas Local Distribution Systems, Energy and Climate, June 10, 2020: https://pubs.acs.org/doi/10.1021/acs.est.0c00437
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THE LAYERED SAFETY APPROACH

In most industries, one of the essential components of any safety program is the use of early-warning systems such as gas detection. These devices help to allow adequate time to take remedial or protective measures thus reducing risks to personnel and infrastructure. Gas detectors can also be part of a total integrated monitoring and safety system for an industrial plant.

This is usually described as a layered safety approach.

As per the Honeywell Process Solutions white paper “An Integrated Approach to Safety: Defense in Depth,” an integrated approach to plant safety helps improve business performance and ensure peace of mind. This methodology includes independent yet interrelated layers of protection to monitor, detect and mitigate potential threats. The concept of layers of protection is widely recognized by the process industry, and the term is clearly defined in industry safety standards such as IEC 61508 and IEC 61511. Some layers of protection are preventative (e.g., emergency shutdown), while others mitigate the impact of an incident (e.g., fire and gas protective systems or plant emergency response systems). Other layers of protection can mitigate against incidents in the first place (e.g., plant and physical asset protection, constraint and boundary management, operator training, and asset management); while others can provide detection and alerting, and associated guidance (e.g., operator alarms, early event detection and integrated operator procedures).

Layers can either be automated, such as emergency shutdown (ESD) equipment, or require human intervention, such as operator responses to process alarms.

Some layers offer quantifiable risk-reduction benefits but require identification of potential risks at the onset. And others are less tangible and offer less obvious benefits.

FIGURE 1 – INTEGRATED LAYERS OF PROTECTION

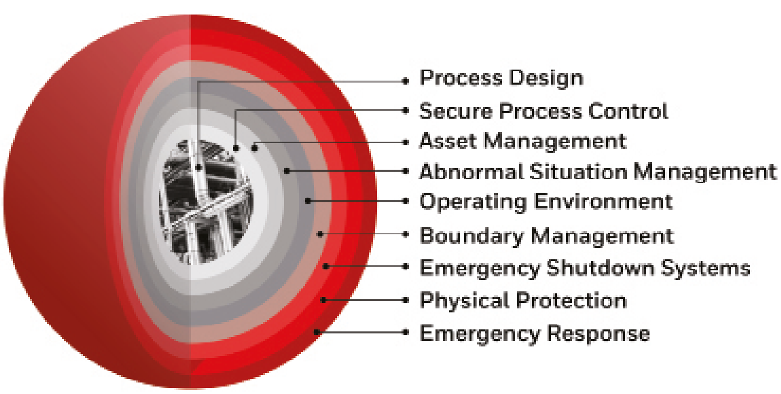


Diagram courtesy of Honeywell Process Solution white paper "An Integrated Approach to Safety: Defense in Depth"

As shown in Figure 1, the individual elements of the safety system mirror the layers of an onion, each encompassing the previous layer(s) and adding to the safety case. Each acts independently so that individual failure does not affect more than one layer.

At the core of a layered architecture is a well-structured and implemented process design that is the embodiment of the business, safety and production levels necessary for effective operations. The procedure must be controlled by a secure process control network that extends across the entire plant and business networks. Managing the plant's assets ensures that the operation design continues to function as intended, while protecting the plant from pending incidents with an early indication of failing assets.

As one moves through the layers of protection further away from the core of process design, mitigating risk due to human error is the key to ensuring safety. Implementing tools and procedures (such as boundary and alarm management and early event detection) for the purpose of managing abnormal situations reduces incidents and prevents escalation.

Appropriate operating windows need to be defined and managed, and properly designed emergency shutdown systems must be in place as preventative measures in the event that an incident escalates beyond the inner layers of the sphere of protection.

Across the various layers of protection, a plant or facility must operate in a secure and safe atmosphere, including safeguarding of the perimeter, facility, people and assets. With the adequate work practices and technology in place, if an abnormal situation does occur disrupting safety operations, an emergency response plan can be executed, controlled and monitored to minimize the impact of the incident.

To maximize plant efficiency and to maintain adequate safety levels, a systematic approach to safety is required. This procedure can minimize risks to safety and security, and it requires that independent and interrelated layers of protection are in place across an organization. For the fire and gas detection system, these can be seen as two separate layers. If the gas detection layer fails to detect a gas leak and a gas ignites, flame detection comes into play.

GAS AND FLAME DETECTION TECHNOLOGIES

SEARCHPOINT
Optima Plus Infrared
Point Gas Detector

SEARCHLINE EXCEL
Plus / Edge Infrared
Open Path Gas Detector

FS24X Plus
Triple Infrared
Flame Detector

SEARCHZONE
Sonik Ultrasonic
Gas Leak Detector

> **There are different types of gas and flame detection technologies to choose from. The selection process will ultimately depend on the industrial application, hazardous gases involved, and risks to workers, which should always be identified through assessment of the risks.**

There are two main types of gas detection: fixed and portable. Typically, fixed gas detection is the process industry's first line of defence, alerting workers to gas leaks. Portable detectors offer a personal layer of protection, particularly in 'blind spots' that may be out of a fixed detector's reach such as a confined space. Process industry applications will often require a combination of the two technologies. Trusted suppliers like Honeywell are ideally consulted on how to integrate fixed and portable detection effectively so to maximize worker safety.

For the purpose of this white paper, we will examine three main types of fixed gas detection that are recommended for detecting flammable gases.

- Point infrared (IR)
- Open path infrared (IR)
- Ultrasonic

Like gas detectors, optical flame detectors also come in different shapes and sizes. Some of the main technologies include ultraviolet (UV), infrared (IR), and visible sensors. The selection process will be determined by the application type and the fire and explosion risks involved. Application-based tools such as the *Honeywell Analytics Flame Detection Wizard* can help users identify the most appropriate detection based on their requirements.

In this white paper, we will examine multi-spectrum triple IR flame detectors, which are particularly suited for the process industry.

A TECHNOLOGY MIX APPROACH

Let's now take a closer look at the three main gas leak detection technologies: point IR, open path IR and ultrasonic. The table below describes some of the main features, strengths and weaknesses of each of them.

GAS DETECTION TECHNOLOGY: POINT INFRARED

Deployment and key features	• Must be deployed within a few meters of potential leak sources such as valves, flanges, and pumps (upon risk assessment). • Detects gas clouds that are large enough to cause structural damage in case of an explosion. • Several instruments in an area (zone) are connected into the decentralized control system (DCS).
Advantages	• Less sensitive to calibration errors than catalytic sensors. • Can be used in inert atmospheres. • Covers all flammable hydrocarbons. • Measures actual gas concentration at a point in space and time. Multiple point gas detectors provide an accurate map of the event. • Works in adverse weather conditions, including fog, rain and mist.
Disadvantages	• Can be ineffective if positioned incorrectly. Detectors should be placed higher if a gas is known to be lighter than air and vice versa. • The detection point activates only when it is reached by a gas. A serious leak may not be detected if it is dispersed or dissipated by wind. • Requires annual inspection and cleaning. • High sensitivities can trigger nuisance alarms at low gas concentrations. • Cannot detect non-hydocarbon gases (e.g. hydrogen (H_2)).

GAS DETECTION TECHNOLOGY: OPEN PATH INFRARED

Deployment and key features	• Covers a path of up to 330 m, increasing chances of detecting a gas leak (when combined with point detection). • Less sensitive than point detectors to wind speed and direction. • Greater area coverage helps reduce the number of point detectors needed.
Advantages	• Positioning is not as critical as for point detectors. • Can detect low gas concentrations and measure threat levels according to size and concentration. • Covers all flammable hydrocarbons. • Doesn't need to be near the leak source (even with some air movement). • If detection path is obstructed, the detector reports the issue. • Works in adverse weather conditions, including as fog, rain and mist.
Disadvantages	• Has higher initial purchase cost than point IR detection. • Is unsuitable for use in smaller areas. • Longer-range devices and still air can cause instruments to trigger nuisance alarms at relatively low gas concentration levels. • It can take time for the gas to reach the detector as it has to physically pass between the transmitter/receiver pair. • Reduces disadvantages of point detectors in windy conditions, but doesn't eliminate them. • Location of the gas leak cannot be exactly determined along the path length. • Cannot detect non-hydocarbon gases (e.g. hydrogen (H_2)).

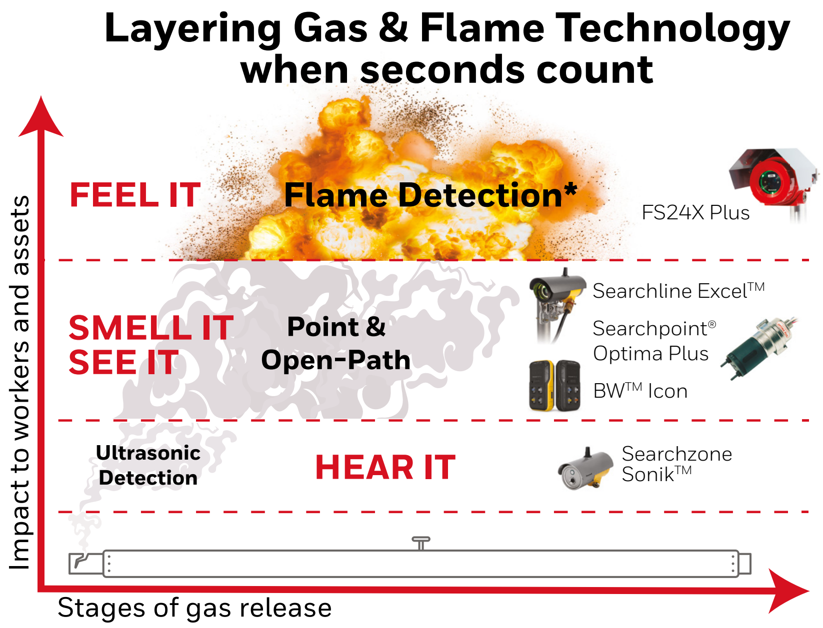
GAS DETECTION TECHNOLOGY: ULTRASONIC

Deployment and key features	• It is easy to deploy over an area featuring valves, flanges, and pumps. • Typically has a 20 m area protection range on axis (+/- 90-degree field), increasing chances of detecting a gas leak when combined with point and open path detectors. • Gas does not have to physically reach the detector to trigger a response, only the sound. • Eliminates the dilution and wind direction effect.
Advantages	• Detects pressurized gas releases (flammable or toxic gas) within a 20 m range. • Is not affected by wind speed or direction. • Can detect very small leaks at low leak rates meaning it does not depend on a gas cloud to accumulate. • Ensures high-speed response, activating as soon as it detects the sound of a leak. • Isn't affected by rain, mist or fog. • Requires no calibration.
Disadvantages	• Has higher initial purchase cost than point infrared gas detectors. • Cannot activate unless gas is pressurized and emits ultrasounds, meaning it may not detect large holes with small pressures. • Other ultrasonic noise sources can reduce its effectiveness and/or trigger nuisance alarms. • Is not as effective for multiphase gas streams containing droplets or liquids, which can dampen the ultrasound signal. • Does not provide an indication of the gas concentration, providing notification of the leak only.

By combining the above three technologies, it is possible to achieve the optimal coverage and detection of a gas leak, mitigate the hazard and thereby protect life, property and the environment.

Given their unique strengths and features, these technologies complement each other and lend themselves particularly well to a layered and integrated safety approach:

- Open path IR can be deployed as the primary (or secondary) layer of flammable gas leak detection for boundary protection in process areas.
- Point IR detection provides the primary (or secondary) layer and should be deployed at risk points (e.g. valves, pumps/compressors, flanges).
- Ultrasonic detection constitutes the tertiary layer of flammable gas leak detection and should be deployed at risk points, where high air flows may reduce the effectiveness of traditional gas detection, and near metering skids.



These important layers of flammable gas detection should always be deployed in conjunction with multi-spectrum triple IR flame detectors. This advanced technology is able to detect hydrocarbon and non-hydrocarbon fuel fires under most environmental conditions, which makes it ideal for the petrochemical and process industries. The use of sophisticated software algorithms and multiple microprocessors ensure a high detection performance combined with optimal false alarm rejection. Multi-spectrum triple IR detection can identify a 0.09 m^2 Heptane reference fire over 60 m away. This means fewer detectors are required.

Together, all the technologies described above provide a robust detection system with each delivering to its strengths. Improving the safety case is achieved by using technologies in combination, thus increasing coverage and hence the chance of detecting gas, resulting in improved event confirmation and analysis.

CONCLUSION

This white paper has examined the critical role that ultrasonic gas leak detection plays within a layered safety approach. Adopting and integrating multiple gas and flame detection technologies is key to protecting workers, property, and the environment from the dangers of flammable gas leaks. In order to detect a flammable gas leak, point infrared and open path infrared need the gas to reach the detection point or path. While this confirms the location of the leak area or path, air movement may take a gas cloud away from a detection point or path or dilute it to a lower, safe level. Ultrasonic gas leak detectors cover an area and do not need the gas cloud to reach the detector as they hear the pressurized gas leak. This means fast detection of a pressurized gas leak within the covered area. In conclusion, the recommendation is to deploy integrated technologies within the gas protection layer and then a flame detection layer above it as the final protection layer.

Honeywell's Searchzone Sonik™ ultrasonic gas leak detector delivers fast, reliable detection of pressurized gas leaks and does not need field calibration, thus reducing operational costs. Searchzone Sonik™ complements portable gas detectors, Searchpoint® Optima Plus, Searchline Excel Plus and Edge fixed gas detectors and FS24X Plus flame detectors, delivering a comprehensive solution to gas-layer safety systems in the most demanding environments.

REFERENCES

Honeywell Process Solutions white paper. "An Integrated Approach to Safety: Defense in Depth" https://www.honeywellprocess.com/library/ marketing/ whitepapers/Integrated_Safety_WhitePaper.pdf

Honeywell Industrial Safety Gas Book. A detailed gas detection reference book: https://www.honeywellanalytics.com/~/media/honeywell-analytics/ documents/ english/11296_gas-book_v5_0413_lr_en.pdf?la=en-gb. Translated versions are available.

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