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USING ULTRASONIC GAS LEAK DETECTION

IN HARSH APPLICATIONS

By Dr. Eliot Sizeland

***Dr. Eliot Sizeland** is Business Development Leader, Flame & Gas Europe at Emerson Process Management. Dr. Sizeland graduated from the University of Wales, Swansea, Faculty of Engineering with a Bachelor's degree and received his PhD working with semiconductor gas sensors at the University of Southampton. Dr. Sizeland is also a Chartered Engineer and member of the UK Institute of Measurement and Control.*

Gas leaks present a potentially critical risk for every oil and gas installation – refineries, offshore platforms, onshore terminals, underground gas storage areas, natural gas well pads, and many others. Each type of leak – hydrocarbon, hydrogen, hydrogen sulfide, and more – poses its own safety concerns for staff, facilities, and equipment.

Traditional gas detection technologies, including infrared, catalytic bead, and electrochemical-based sensors, are well suited for enclosed process areas where gas leaks can collect to a detectable level. However, in well ventilated areas, gas leaks quickly disperse and dilute to safe levels even short distances from the leak point, so these leaks are much harder to detect as there is no gas accumulation. If containment is lost close to the edge of a platform the gas leaks may be blown out to sea only to be pulled back towards the platform by air currents. If this leak were to enter into an unprotected ventilation system linked to a safe area a significant risk exists. In fact, an industry study found that more than 38 percent of major gas leaks in the North Sea actually go undetected [1].

ULTRASONIC GAS DETECTION

Within a process environment, ultrasonic gas leak detection uses acoustic sensors to identify fluctuations in noise that is imperceptible to human hearing. The sensor and electronics are able to detect these ultrasound frequencies (25 to 100KHz), while excluding audible frequencies (0 to 25KHz). Unlike traditional gas detectors that measure the accumulated gas, ultrasonic gas detectors "hear" the leak, triggering an early warning system. Rather than replacing traditional point and line-of-sight gas detection solutions in challenging applications, ultrasonic gas detectors provide an additional layer of coverage on top of current conventional systems for greater safety.

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The noise generated by a gas leak is produced as gas moves from a high-pressure to a low-pressure atmosphere, and is comprised of both audible and ultrasonic frequencies. Previous generations of ultrasonic gas leak detectors often used broadband technology that also monitored audible frequencies, but today's advanced technologies exclude audible frequencies and instead focus only on detecting ultrasonic waves.

An ultrasonic gas leak detector (UGLD) doesn't require the accumulation of potentially explosive or otherwise dangerous gases to trigger an alarm; this is an important benefit over traditional sensors. Another benefit is that UGLD's are faster at detecting leaks than traditional techniques because there is no transit time of the gas from the leak point to the detector. Depending on the settings that have been programmed in, an alarm can be signaled within the milliseconds it takes for the ultrasonic noise to reach the detector from the location of the leak.

Ultrasonic leak detectors are ideal for use in applications that are unattended, remote, offshore, or in other environments where traditional technologies are insufficient, such as fin fan coolers. The detectors offer improved coverage in zones that are most likely to have gas leaks, such as wellheads, heat exchangers, filters, flange joints, instruments, compressors, and fin fan coolers.

LEAK VARIETIES

Ultrasonic gas detectors do not discriminate between different leak types, so any type of leak can be monitored. In offshore installations, the most common types of leaks are hydrocarbons, especially methane. These can often result in jet or spray fires and structural damage or worse. Hydrogen gas is found extensively in many chemical processes and has a strong tendency to leak due to its low molecular weight. These leaks also disperse very quickly. Currently, the catalytic bead sensor is the detection technology used most often to detect hydrogen leaks. Although this technology is well-established, it has some significant disadvantages, including high maintenance requirements and a non-fail-safe failure mode.

In sour gas environments, the risk of exposure to hydrogen sulfide (H_2S) can be extremely high. In some parts of the world, the concentration levels are so high that they will immediately render personnel unconscious which may lead to death. UGLDs offer a real alternative for some applications, and the safety advantage is clear, as the speed of response is absolutely critical to help preserve lives.

OVERCOMING THE NOISE CHALLENGE

The most important issue when employing ultrasonic gas leak detectors is that the sound of the leak must be louder than the ambient noise produced by the plant processes and equipment. Most facilities have a wide range of both audible and ultrasonic noise being emitted from the process equipment. A plant with especially high levels of noise can have a constant decibel level upwards of 95dB. Examples of such plant equipment include turbines, compressors, and other types of machinery.

It is important to note that most facilities are not generating high levels of ultrasonic frequencies on a regular basis, and the low-level ultrasonic frequencies that are constantly present can be measured and ignored as background noise within the ultrasonic leak detector settings. Facilities also frequently have equipment, such as pressure relief valves, which emit temporary blasts of high-level ultrasound. Plant personnel are sometimes concerned that these events might trigger false alarms on the ultrasonic leak detector, but this challenge can be easily overcome using time delays built into the instrument itself or in the control system.

Plant background mapping studies, and assumptions based on experience and data from these studies, provide helpful information to determine the best places to mount units, so they are positioned strategically at locations that would be closest to the most likely potential leak points. The coverage the detectors provide is then confirmed by matching it against the plant process and

using an inert gas that has release parameters that mimic that of a true process gas leak. This cannot be done with traditional technologies.

SOUND GENERATION AND LEAK RATE MONITORING

Traditional gas detection systems are designed to detect gas buildups and directly measure gas concentration at the point of installation – usually expressed as a percentage of the LEL or ppm. UGLDs on the other hand, are essentially sound monitors that output a dB level in the ultrasonic range. This sound level is loosely related to leak rate. Leak rate is the rate at which gas escapes from a hole over an exact period of time. A high leak rate indicates the potential of a large gas cloud accumulation, which can result in an explosion or other dangers. Per the UK Health and Safety Executive (HSE), gas leaks at less than 0.1 Kg/s (2 minutes) are categorized as "Minor", 0.1-1.0 Kg/s (2 to 5 minutes) are "Significant" and over 1.0 Kg/s (greater than 5 minutes) are "Major" [2].

Generally speaking, if the pressure remains constant, the larger the fissure size, the greater the leak rate. This holds true up to a point, but as the size of the leak becomes greater, the ultrasound generated reduces. A simple example of this can be explained using a party balloon. If two identical balloons are inflated, they have the same volume (reservoir) and pressure in the reservoir. But pulling the neck tightly of one balloon produces a very high-pitched sound; these frequencies are tending to move towards ultrasound. If one takes the second balloon, though, and simply releases it from the neck, the balloon will fly around and produce much lower tones, nowhere near ultrasonic frequencies.

GOOD PRACTICE FOR DETECTION COVERAGE

When applying UGLDs assumptions can be made for a range of applications concerning suitability, e.g. air cooled heat exchangers, gas compression, and metering stations. For more challenging applications, project mapping is needed. Mapping is a simple process that helps determine the quantity of detectors needed for a given application. Readily available information such as gas composition, temperature, and pressure help determine the mass flow rate (Kg/s) and ultrasound level (dB) produced at that leak rate. The sound level is then compared with the measured or assumed background sound level and the detection coverage is determined.

When mapping an installation for implementing ultrasonic detectors, it's good practice to set up devices to target coverage for specific risks, while referencing the 0.1 Kg/s release rate. In this way, facilities optimize the detection range for the broadest array of potential leak rates rather than simply maximizing detection range overall.

Setting up detection coverage is based on the ultrasonic background noise level of the area and the size of the leak that the user wants to detect. Detection area increases in very low ultrasonic noise areas and decreases in noisy areas.

The following shows detection coverage in high, low, and very low noise environments:

- High noise areas (e.g., compressor area)
  Noise Levels: Audible 80-120dBA | Ultrasound <75dB
  Coverage | Settings: 7-10 m (22-32ft) | Alarm level 80dB
- Low noise areas (e.g., normal process area)
  Noise Levels: Audible 50-80dBA | Ultrasound <65dB
  Coverage | Settings: 10-15m (32-49ft) | Alarm level 70dB
- Very low noise areas (e.g., remote onshore wellhead)
  Noise Levels: Audible 40-50dBA | Ultrasound <55dB
  Coverage | Settings: 15-20m (49-66ft) | Alarm level 60dB

It's important to understand that the direction in which the detector is pointing can also affect coverage area since the greatest detection will occur in front and to the sides of the detector, depending on the kind of ultrasonic gas detector that is installed.

DETECTION IN THE REAL WORLD

One oil and gas company is using ultrasonic leak detectors for pressurized natural gas wellhead protection in facilities that are typically unattended. When the company considered mounting traditional gas leak detectors close to wellheads, they ran into two areas of concern. The first was that it was difficult for operators to access the area for maintenance and repair. In fact, in some cases, operators had to remove gas detectors to gain maintenance access. The second issue was the unlikely potential of a gas cloud accumulating near the leak location.

Natural gas is much lighter than air, so it quickly disperses when it's released under pressure. In this application, ultrasonic gas leak detection was ideal because it could be mounted close to the wellhead, but in a way that maintenance operations and accessibility were not affected, and at the same time, the system could detect the sound generated from a gas leak at the well.

The facility initially installed ultrasonic gas leak detectors on a trial basis; additional units were subsequently purchased and installed following the trial's success in its extension facilities.

IDEAL DETECTION PLANNING

No single method of leak detection is a perfect fit for all applications. A standard point monitoring device for LEL measurement of gas concentration is still the detector of choice in many confined areas. But, UGLDs are ideal in industrial applications like offshore and onshore oil and gas platforms, refineries, gas storage facilities, natural gas wellheads, and LNG plants and trains, where dangerous leaks can go undetected because of air flow, ventilation or other environmental conditions. The detectors provide an almost immediate response, improved coverage area in even the most challenging environments, and are extremely robust and reliable. In addition, depending on the sensor installed, they don't expire or require calibration or maintenance. These benefits, in addition to the early warning and coverage capabilities, clearly demonstrate that ultrasonic gas leak detectors are an important component in an effective gas detection system. ■

References

1. *Health and Safety Executive: http://www.hse.gov.uk/offshore/statistics/hsr2002/hsr2002.pdf*
2. *Health and Safety Executive: http://www.hse.gov.uk/offshore/statistics/hsr2002/section6.htm*

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