General Monitors
by MSA

Ultrasonic Gas Detectors With Artificial Neural Network Intelligence Improve Process Safety While Reducing False Alarms

Process and plant engineers tasked with improving the safety of hazardous oil/gas industry production, refining and distribution operations are today employing a variety of gas leak sensing technologies to protect people, equipment, and facilities. The consequences of failing to detect gas leaks can be disastrous, but at the same time there is a need to discriminate between actual dangerous gas leaks and nuisance false alarms. The primary technologies utilized today for combustible gas leak detection within the oil & gas and petrochemical industries are: catalytic bead, point IR, open path IR and ultrasonic. They are all well-known technologies with more than a decade of proven performance in the field. All of them have their unique advantages depending on the application environment. All of them are also susceptible to false alarms under the right conditions.

False alarms from combustible gas detectors have a variety of causes within the oil/gas production or refinery plant environment. Avoiding false alarms is important because they result in unnecessary process or plant shutdowns, slowing production and requiring time-consuming reviews, paperwork or reporting.

Truly dangerous pressurized gas leaks can be a challenge to detect reliably by anyone using any of the conventional catalytic bead, point IR and open path IR gas sensing technologies. Although some gas leak releases make a jet-like noise, operators may not be nearby to hear the escaping gas. Strong winds may dilute the gas and the momentum of the gas itself may disperse the material away from installed gas sensors *(Fig 1)*.

Given the challenges that conventional contact-based gas sensors (catalytic bead and infrared types) face in detecting high pressure gas releases in outdoor environments, it is not surprising that the newer ultrasonic gas leak detectors (UGLDs) are becoming common as part of a comprehensive protection scheme that may include the use of all of the technologies *(Fig 2)*. UGLDs offer a number of advantages including immunity to gas dispersion from wind, which is a serious potential limitation with point and infrared sensing detectors.

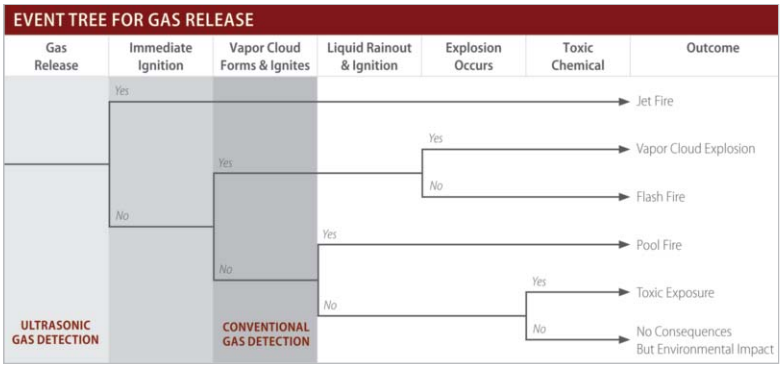

Fig 1

Fig 2

The Variable Background Noise Problem

UGLDs are used today on offshore p roduction p latforms, a round wellheads, compressors, and turbines, and on land where they are used to protect metering stations and gas storage tanks among several other process areas. Being non-contact measurement devices they protect against both combustible and toxic gas releases, and their detection range can be verified by using inert gases with similar molecular weight and heat ratio as those of the gases of interest.

In ultrasonic gas detection, a sound wave is simply a pressure pulse in the air that is detected by the human ear the same way that it is detected by a microphone. The human ear can only perceive acoustic sound waves in the frequency range between 20 and 20,000 Hz (20 kHz) and that is why this frequency range is called the audible frequency range. Acoustic sound frequencies above 20 kHz are called ultrasound.

When pressurized gas is released through a leak, the hissing noise produced is called broadband acoustic noise, ranging from the audible frequency range into the ultrasonic frequency range. Earlier generations of UGLDs only "listened" for the gas leak noise in the ultrasonic frequency range from about 25 kHz and up.

UGLDs measure the sound pressure produced by the escaping gas. As the sound pressure exceeds a preset level normally produced by background noise, the detector indicates an alarm condition. Such threshold-crossing devices essentially record deviations from baseline conditions early enough to detect dangerous leaks of pressurized gases and to initiate appropriate warnings.

Despite the advantages of threshold monitoring, the performance of today's conventional ultrasonic gas leak detector depends on an assumption of a fixed background ultrasound level at a particular installation. Likewise, the alarm delay setting on such devices is based on a presumption of intermittent ultrasonic sources (false positives) that are fixed in duration.

In any industrial environment such background conditions may vary in terms of both magnitude and time. Furthermore, as operators seek to avoid frequent changes to configured devices, preset sound pressure thresholds and alarm delays significantly limit the instruments' detection range and speed of response.

The Artificial Neural Network Solution

To overcome these limitations, we have developed a breakthrough intelligent UGLD based on artificial neural network (ANN) intelligence. This new UGLD design distinguishes the broadband ultrasound produced by pressurized gas releases from other artificial and natural sources. Such design can be implemented with or without a threshold-crossing scheme, enhancing the scalability of gas leak detection.

For convenience, the detector can operate with the threshold-crossing scheme or one of several enhanced modes that rely on ANN to classify ultrasound signals. Furthermore, testing results show that the UGLD with the ANN algorithm achieves a longer detection range (radius ~ 28 m) and a shorter response time in the presence of ultrasonic background noise.

An artificial neural network operates in a manner very similar to how the human brain handles the constant flow of information. When we meet a person, the brain receives a massive amount of visual information through the eyes, and over time this substantial amount of information is used to recognize this person years later or even to identify further family members. When the brain has received visual information about other family members, it is easier for it to distinguish between family and non-family members.

In other words, the more we train our brain to recognize familiarity the better we will be able to recognize or deny a person's face. The brain does not look for an exact match, it looks for familiarity, and so does the ANN. Like the brain, however, the neural network needs to be trained first. A UGLD does not have to recognize different people. It needs to recognize the sound signature from a gas leak effectively while at the same time rejecting sound signatures from acoustic background noise that are not related to gas leaks.

Acoustic noise from a real gas leak source normally ranges from 10 kHz and up to the 60 to 70 kHz range. Acoustic noise from a false alarm source, such as a gas compressor for example, can easily generate high level frequencies in the range of 100Hz to 20 kHz.

Earlier generations of UGLDs were designed with electronic filters to screen out and ignore noise below 20 kHz, which eliminated false alarms resulting from most normal plant background noise such as gas compressors, but also limited detection of smaller real gas leaks. With most real gas leaks generating a sound typically with a frequency of 10 to 60 Khz, detecting a higher frequency range of 75 kHz or greater doesn't add any meaningful capability.

Next Generation OBSERVER-i UGLD

The OBSERVER-i UGLD is the world's first device in its class equipped with ANN and real-time broadband acoustic sound processing technology. This technology is based on extensive studies and more than a decade of real recording of gas leak sounds and industrial background noise from a wide array of industry sources. The ANN algorithm has been factory "trained" with these recordings to automatically distinguish between unwanted acoustic background noise and dangerous gas leaks *(Fig 3)*.

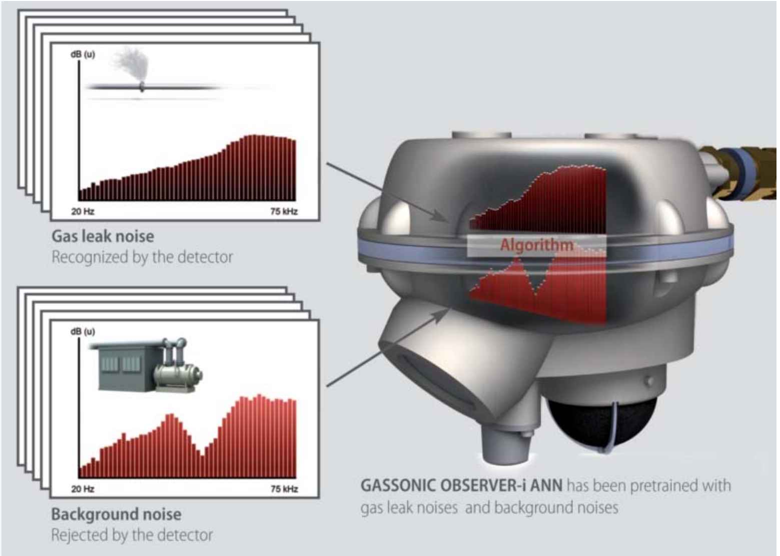

Fig 3

With ANN technology, the OBSERVER-i UGLD makes it possible to fully analyze the sound spectrum as low as 12 kHz by eliminating the use of common high pass filters. This advanced approach provides a broader leak detection range, which also increases sensitivity to smaller gas leaks without interference from unwanted background noise.

ANN technology allows the OBSERVER-i UGLD to be installed without time consuming "training" sequences, and it provides industry-leading detection distance with unprecedented suppression of false alarms. In addition, ANN technology ensures that the OBSERVER-i UGLD has the same gas leak detection coverage in high and low noise areas. The device requires no alarm set points or trigger levels to be configured, nor do these alarm parameters need to be adjusted if background ultrasound were to increase or decrease over time.

The OBSERVER-i UGLD also features the Senssonic™ self-test function. This well-proven self-test checks the device's electrical integrity and microphone every 15 minutes and ensures the UGLD is operational at all times. The microphone and the microphone windscreen are constantly monitored to ensure that the detector always has optimal sensitivity and detection coverage.

Conclusions

Adding ANN intelligence capability to UGLDs provides process and plant engineers with a new tool that can help them detect more real gas leaks and avoid nuisance false alarms. The OBSERVER-i UGLD with its capability to reliably detect leaks below 20 kHz provides another layer of safety to the industry, protecting people, equipment and facilities from hazardous gas leaks.

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