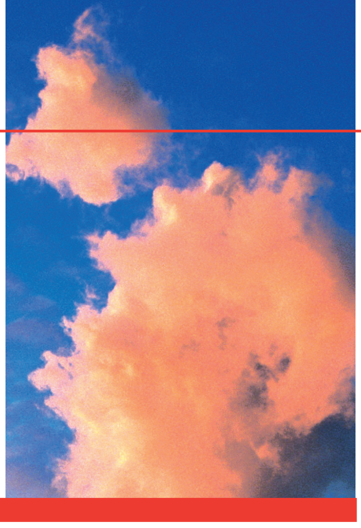
Can the Processing Industries Feel Safe with Traditional Gas Leak Detection?



"INCREASING SAFETY WITH ULTRASONIC GAS LEAK DETECTION"

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Introduction

Fixed ultrasonic gas leak detection systems have been widely used for installations in the processing industries - and in particular the oil/gas industry - for almost a decade now. But only recently it has become a natural part of the decisions that almost any project group takes regarding the fixed gas detection system. This indicates that there is an increasing focus on gas leak detection all over the world. At the same time it indicates that traditional gas leak detection systems (open path and point gas detection) have some imminent shortcomings. To support this statement, a recent HSE report illustrates that only 65% of all hydrocarbon gas leaks in the UK sector were actually detected by the traditional fixed detection systems.

Due to the changing weather conditions found on most outdoor installations, the wind may simply blow the gas cloud away or the gas cloud may dilute before it can build up a concentration and come into physical contact with the traditional detectors. This leaves the industry with a vital challenge. How do you measure/calculate where to locate the detectors for optimal detection and how do you verify that they will actually detect the gas leak – without being influenced by extreme weather conditions?

Besides from discussions on how to optimise the existing technologies, this calls for an alternative to the traditional detection methods.

This article gives an overall view on the technical aspects of the traditional gas detection technologies. Furthermore, it gives detailed insights into how and why to use ultrasonic gas leak detection in order to dramatically increase the total system performance of the plant gas detection system.

Ultrasonic Gas Detection Technology is now installed and recognised world-wide by leading companies within the processing industries as an alternative to traditional gas detection in outdoor gas installations. Innova Gassonic has delivered more than 2000 ultrasonic gas leak detectors world-wide.

Due to extensive market research, Innova Gassonic has recently released the next generation of ultrasonic gas leak detectors, the GASSONIC OBSERVER.

1. Traditional fixed Gas Detection Systems.

The traditional gas detection systems available today are based on two main concepts. We call them the sniffing technologies:

- **Point Detectors** where the gas has to be in physical contact with the detector.
- **Open Path Detectors,** where the gas has to be within a predefined path of infrared light to be detected.

Both detection concepts are based on LEL (Lower Explosive Level) measurements.

The **Point Detector** has been widely used for many years, and the name of the detector refers to the fact that this type of gas detector detects the gas only in a point around the detector itself.

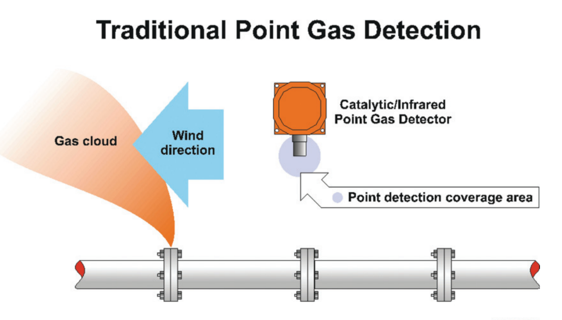

Figure 1: Traditional Point Gas Detection

Actually, the gas has to enter INTO the detector head, before the LEL level will be measured by the Point Detector.

Inside the detector head the gas concentrations can either be measured by a catalytic pelistor, or by means of infrared absorption, but still, the concentration measurements are only performed in a point.

The **Open Path Detector** refers to the fact that this type of gas detector detects the gas in a narrow path of infrared light. These detectors consist of a separate transmitter and a receiver unit and they make use of the fact that Hydrocarbon gas absorbs infrared light.

The transmitter emits a concentrated beam of infrared light. This is beamed all the way to the receiver unit that can be placed in distances up to 60 meters away. The receiver unit consists of an infrared receiver that will detect if Hydrocarbon absorption has taken place in the infrared path between the transmitter and the receiver and the absorption is then directly related to the LEL level.

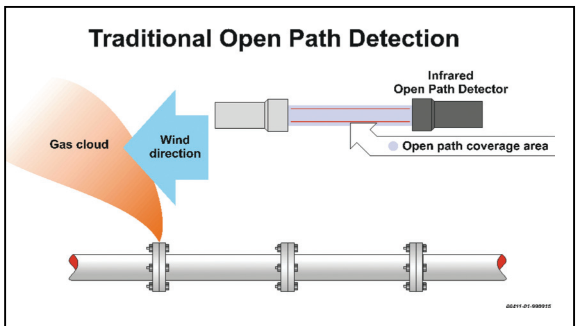

Figure 2: Traditional Open Path Gas Detection

1.1 Can the traditional gas detection systems detect leaking gas?

In outdoor locations the answer is **maybe!!!!**

A potential gas cloud will ONLY be detected by the traditional detectors IF the gas is in physical contact with the detector (point detector) or within a predefined beam of infrared light (open path detector).

The main problem is that nobody can predict this due to the following unknown factors:

- Leaking gas is diluted extremely fast after it has escaped from the leak.
- Changing wind directions often carry the gas cloud away.

The traditional gas detection systems work well – IF THE GASEVER REACHES THE GAS DETECTOR.

This means a gas detector perhaps measures 10% LEL but just a few meters away from the detector the gas concentration may be100% LEL. This is due to the dilution that takes place before the leaking gas reaches the gas detector. If, at the same time, there is just a little wind carrying the gas cloud away from the gas detector, this detector will NEVER detect the gas leak.

In other words, it can be **a false feeling of safety** to believe that a low LEL level, measured by traditional sniffing gas detection technology, means that there is no explosion risk!!

In outdoor installations, the gas cloud from a gas leak often either dilutes or drifts away in the wind before it reaches the gas detection point.

As mentioned in the introduction, in a recent report about hydrocarbon releases in the North Sea, Health and Safety Executive (HSE) in UK concludes that only 65% of all hydrocarbon gas leaks are actually detected by traditional gas detection systems.

1.2 How is a traditional gas detection system commissioned and approved?

After a traditional gas detection system has been installed, the normal procedure is that it is calibrated with a calibration gas that is similar to the gas that the system is supposed to detect, that could be Methane. The calibration gas is injected directly into the detector, and if all the detectors in the detection system are proven to give correct readings compared to the concentration of the calibration gas, the total gas detection system is approved.

1.3 Why is the traditional commission practise questionable?

The injection of gas directly into the detector will only determine if the detector itself is functioning properly, it will not determine if the gas detection system will pick up a potential gas leak a few meters away from the detector.

None of the traditional gas detection systems available today can ensure a 100% reliable detection of gas within a predefined area around each gas detector in the gas detection system.

If a predefined coverage area for each gas detector in the complete detection system cannot be predicted, how can the total gas detection system's ability to detect gas leaks then be ensured?

The only way to find out if a gas detection system is able to detect leaking gas, is to perform so-called "live gas tests" where real hydrocarbon gas is released in various places on the platform, and then see if the gas is actually picked up by the detection system. And of course, for optimal testing this would have to be done under a variety of environmental conditions.

1.4 Case story about real live gas release tests

To illustrate a real situation, a test on a North Sea offshore gas platform was performed:

Gas was released through a simulated leak (3 mm hole with a gas pressure of 55 BAR), as illustrated in fig. 3.

On the offshore platform, there were several traditional point detectors and open path detectors installed in order to detect hydrocarbon gas leaks. The test team carried hand held gas detectors to investigate in what range such a gas leak could be detected.

To their astonishment, the gas cloud was diluted into 0% LEL only 4-5 metres from the leak. But the most alarming was that none of the traditional fixed gas detectors on the platform ever detected the gas from the test leak.

The ultrasonic gas leak detector the Gassonic MM0100 detected the same gas leak instantly up to 19 metres away.

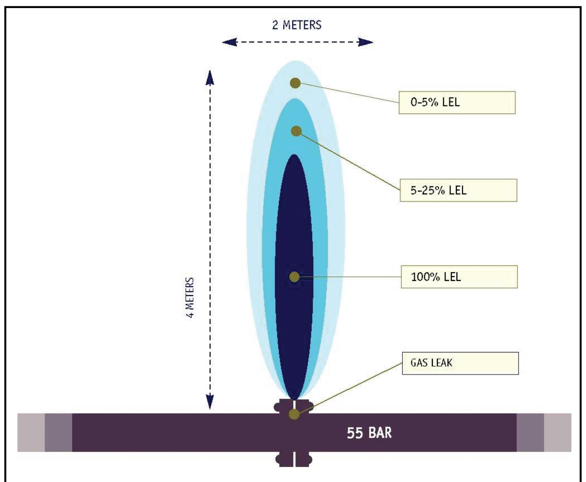

Figure 3: The dilution of an outdoor gas leak

2. Ultrasound – a new philosophy of detecting leaking gas

As explained earlier, the traditional gas detection systems are based on "sniffing" technology where the gas has to be in physical contact with the detector in order to be detected.

For the last eight years Innova Gassonic has developed and marketed a new type of gas leak detector for fixed outdoor installations; a system, which does not rely on the traditional "sniffing" methods. **Instead it is based on airborne ultrasound, emitted from the gas leak.**

An ultrasonic gas leak detector does not provide a concentration level in LEL as traditional gas detectors instead it gives an instant alarm if a leak is detected.

When the ultrasonic gas leak detector triggers, the alarm indication will be raised at the speed of sound since the alarm will be active as soon as the detector "hears" the leak noise. The ultrasonic gas leak detector does not have to wait until the gas concentration accumulates into a potentially dangerous gas cloud. It reacts instantly.

3. Ultrasonic Gas Leak Detector coverage and gas dispersion

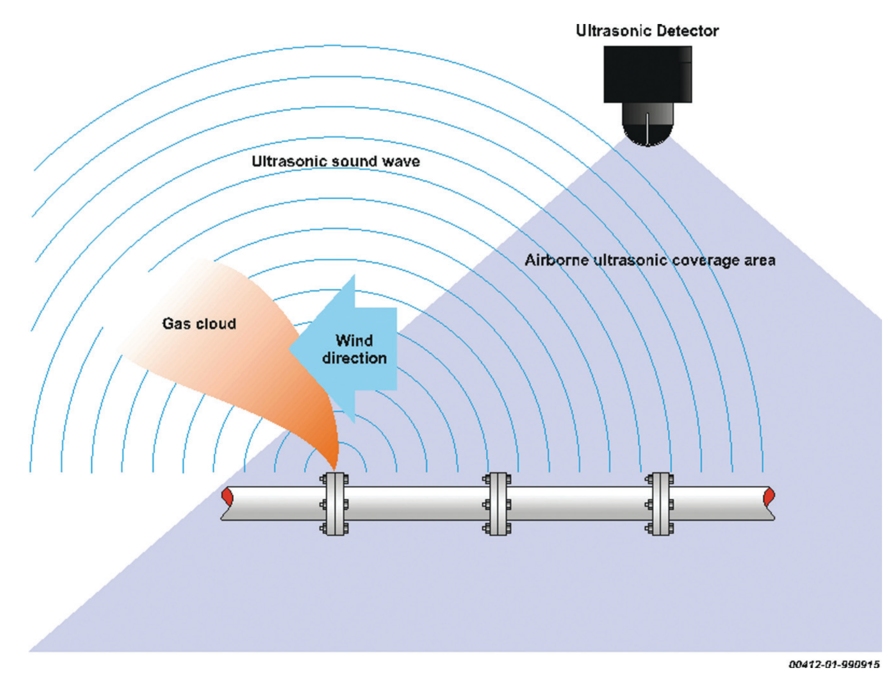

Figure 4: Ultrasonic Gas Leak Detection

To build up a potentially dangerous gas cloud, a certain amount of gas has to be released through the leak, this phenomenon is called the leak rate, and is based on mass flow calculations.
The leak rate unit of measurement is Kg/Sec and it tells how many kilograms of gas are released through the leak per second.

Compared to traditional area limited LEL level measurement, the leak rate can give a picture of potential catastrophic situations and hazardous gas built-up in the entire detection area.

The question is now how big a leak rate can be tolerated, before the gas detection system should alarm? This is defined due to the so-called performance standard of the system. The performance standard defines the maximum release rate of gas, before the gas detection must respond.

Leak rates can be divided into three categories:

Small leak	<0,1 Kg/Sec
Medium leak	0,1 Kg/Sec to 2,0 Kg/Sec
Large leak	>2,0 Kg/Sec

These categories have been defined based on the potential explosion risk that the leak would cause.

3.1 Example of ultrasonic detection coverage based on the leak rate

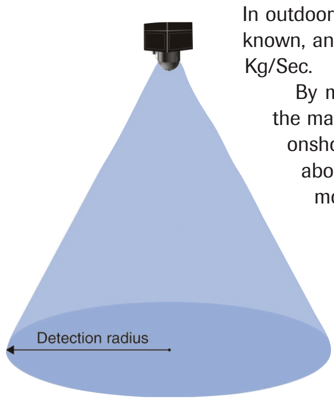

Figure 5: Gassonic MM0100 detection radius 8-12 metres

In outdoor plant installations, the gas type and the gas pressure are known, and the maximum release rate to be tolerated would be 0,1 Kg/Sec.

By means of leak rate calculations, it is possible to calculate the mass flow through the leak. The performance standard of an onshore/offshore platform requires that all methane leaks above 0,1 kg/s are detected. Gas pressure in the system to be monitored is 90 BAR.

By means of mass flow calculations a methane release rate of 0,1 kg/s at 90 BAR will require a leak size at 3 mm. The ultrasonic sound emitted from a leak with 3 mm diameter at a pressure of 90 BAR will generate enough acoustical sound energy to be detected 8 to 12 metres away from the leak by the ultrasonic gas detectors!

In this way it is actually possible to calculate a leak detection coverage, and this coverage will not be influenced by neither wind nor gas dilution.

In addition, due to the fact that this technology does not need the gas to accumulate, the detection of the gas leak will be instant, at the speed of sound!

4. Theory behind Acoustic and Ultrasound.

When gas moves from a high-pressure area through a hole to a low-pressure area, it expands very rapidly and produces a turbulent flow, resulting in an audible "hissing" sound.

The "hissing" sound is a broadband acoustic sound wave, which ranges from the audible frequency range (20 Hz to 20 kHz) into the ultrasonic frequency range (16 kHz to 10 MHz).

The level of ultrasound produced by a gas leak is determined by three main factors:

- The pressure drops across the leak.
- The physical size of the leak.
- Gas specific properties such as: molecule weight and the specific heat ratio of the gas.

As described earlier, it is the turbulent flow in the hole that produces the ultrasound. This turbulent flow can only occur if the pressure on one side of the leak is at least twice the pressure on the other side of the leak.

The level of ultrasound in the turbulent flow is related to the pressure behind the leak and the size of the hole. For example, if the hole is too large, the pressure drop across the hole will be too little, and no ultrasound will be produced.

4.1 The acoustic frequency spectrum of a leaking gas.

The sound waves produced by a leaking gas are very close to so-called white noise. White noise is acoustic sound waves with a continuous and uniform spectrum, but capable of containing many frequencies. These range from very low frequencies up to several hundred kHz. Practical tests have shown that most of the ultrasonic sound energy from a gas leak will be in the frequency range between 5 kHz to 50 kHz.

Tests were carried out to see if different gases emit different kinds of white noise. The results in the curves above show that the ultrasonic noise spectra for Methane and Nitrogen are almost similar.

The curves show an overall higher sound pressure level for Nitrogen. This is due to the higher Nitrogen pressure in this test. Both spectra show that the noise from a leak is very broad banded (5 kHz – 100 kHz), but they also show that most of the noise energy is in between 10 kHz – 40 kHz.

5. Background noise in the measured area.

Figure 6: Innova Gassonic service engineer measuring the background noise

Because an Ultrasonic Gas Leak Detector detects the gas by "listening" for sound waves, ultrasonic background noise from compressors, turbines, or large fans, could cause false alarms. However, tests have shown that the typical outdoor background noises do not exceed frequencies above 6-8 kHz, and as the filter of the ultrasonic gas leak detector does not cover these frequencies, they are not able to activate the alarm.

It is, however, still very important to perform an analysis of the ultrasonic background noise in the measured area, in order to determine the exact number of detectors needed, and to make sure that no sound waves will affect the detector. For this purpose, Innova Gassonic has developed a customised Ultrasonic Mapping Meter , which is battery powered and has a read-out of the airborne ultrasound.

The sensitivity of the Ultrasonic Mapping Meter can be adjusted in exactly the same way as the ultrasonic gas leak detector. A graduated scale on the readout shows if the ultrasonic level is above or below the alarm trigger level of the detector.

In this way it is possible to map the area and find the ultrasonic background noise level at the locations to be monitored.

When the ultrasonic background noise level is found, it is possible to decide the minimum trigger level for the individual detector. The safety margin between the ultrasonic background noise and the selected trigger level should be at least 6 dB, in order to ensure that any fluctuations in the background noise do not trigger the detector.

5.1 False alarms and how to avoid them.

It is essential that a gas leak detection system detects the gas leak quickly before it causes any damage. At the same time, it is equally important that the detector does not cause false alarms. In an industrial environment, spontaneous air-releases may generate ultrasound and trigger the alarm.

However, spontaneous air releases only last for a few seconds whereas the ultrasound emitted from a gas leak lasts for a longer time. Therefore, there is a built-in delay function in the ultrasonic gas leak detectors. Alternatively, the trigger level and the alarm delay can be integrated into the plant DCS system through the 4-20 mA signal of the new detector the Gassonic Observer.

6. Reduce costs and increase safety with Ultrasonic Leak Detection.

Cost savings are always a very relevant topic within all fields of plant instrumentation, including the plant fire/gas detection system. In some parts of the industry, it seems there is a trend towards more and more unmanned installations.

This means that the instrumentation on these unmanned installations must require as little maintenance as possible, and at the same time it needs to operate continuously in all weather conditions, without breakdown or the need for re-calibration.

Using traditional gas detection methods, a potential leak spot would need at least 3-4 traditional point gas detectors to ensure proper gas detection with different wind directions. Using Ultrasonic Gas Leak Detectors, the same spot may be monitored by only 1 or 2 gas leak detectors. This will not only reduce the overall system price, but also reduce the regular maintenance costs, since the Ultrasonic Gas Leak Detector does not need calibration.

7. Commissioning an ultrasonic gas leak detection system.

When commissioning a traditional gas detection system, calibration gas is injected into the sensor head, and if all the sensors indicate the correct concentration level, it is said to be commissioned and operational.

There is only one problem. This commissioning of the detectors ONLY shows that the sensors are working correctly, but it does not say anything about whether the sensor will pick up a gas leak just a few meters away.

With an ultrasonic gas leak detection system it is possible to verify that the ultrasonic gas leak detectors will also pick up gas leaks AT A DISTANCE from the gas leaks.

Innova Gassonic provides the service of performing on-site commissioning of the ultrasonic gas leak detection system. A high pressure hose connected to a bottle of nitrogen enables the Innova Gassonic service engineer to simulate real gas leaks at a leak rate of e.a. 0,1 kg/sec in all the potential leak locations (flanges, fittings, wellheads, etc.). This makes it possible to verify that the ultrasonic gas detection system does in fact comply with the pre-defined safety standards.

8. The Innova Gassonic Ultrasonic Gas Leak Detectors.

Today Innova Gassonic produces and manufactures two types of ultrasonic gas leak detectors, the Gassonic MM0100, and the Gassonic Observer.

8.1 The Gassonic MM0100

In the Gassonic MM0100 (picture on the left) a special high quality stainless steel microphone picks up broadband noise and feeds the signals to a specially designed ultrasonic high-pass filter. A level detection circuit detects if the ultrasonic level exceeds the alarm level. The level detection circuit is user definable. If the alarm level is exceeded, the detection circuit will trigger an alarm delay timer, which will prevent false alarms. The timer runs for a predefined period. If the ultrasonic level is still above the alarm level after the alarm delay time-out, the alarm relay of the detector is activated.

The Gassonic MM0100 can be connected to the plant DCS system or to the existing fire and gas detection system by means of EX approved safety barriers. The Gassonic MM0100 is an intrinsically safe unit that needs to be electrically connected through approved safety barriers.

8.2 The Gassonic Observer

The Gassonic Observer (picture on the right) is the next generation of ultrasonic gas leak detection. The Gassonic Observer has a high quality stainless steel microphone installed, which is acoustically comparable with the Gassonic MM0100.

The Gassonic Observer was developed on the basis of input from the industry. Therefore it holds the following features:

- 4 –20 mA standard analogue interface.
- RS485 digital communication interface for addressable communication
- Integrated acoustic selftest function to ensure that no unrevealed failures will occur
- Integrated connection cable termination so that no additional junction box is necessary.
- Full stainless 316 steel design for installation in corrosive offshore environment
- Approved for installation in explosive environment (ATEX and UL/ULC CLASS1 DIV1)

Since the Gassonic Observer has the same acoustical characteristics as the existing Gassonic MM0100 this means that it can be installed according to the same performance criteria with regards to leak detection performance (detection of methane leaks at 0,1 Kg/sec) as the well known Gassonic MM0100.

9. Conclusion

Relying on traditional gas detection technologies can be highly problematic. Although these technologies may work fairly well, changing wind directions and fast dillution of the gas cloud make it extremely difficult to ensure that these technologies will in fact detect gas leaks. The LEL level does give an indication of the concentration of the leaking gas but only in the sensor head or within the beam of IR light. Just a few metres away the concentration could be 100% LEL.

The acoustic alternative makes it possible to pre-define the safety standards and use them when verifying the performance of the entire detection system. Besides, the ultrasonic gas leak detection technology minimises the influence of ever changing weather conditions found on most outdoor gas installations. An issue that is becoming increasingly relevant because the tendency seems to be that the industry strives to have more ventilated and open modules – so that potential leaks will dillute as quickly as possible!

Along with discussions on improvements of the traditional technologies, that ought to be taken into account also on future project group sessions regarding the fire and gas detection system.

As a British oil and gas supplier in the North Sea concludes in a report.

"It is my opinion that in the future, gas production platforms will be protected from gas releases by a few strategically positioned IR open path detectors and the main source of leak detection will be by ultrasound detection."