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GAS LEAK DETECTION

Laser Methane Assessment

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Needless to say, safety is of the utmost importance within the gas transport industry. However, maintaining an effective emission monitoring and leak detection program in economical tough times is a challenge for operators. The approaches – or the utilized technologies - for the non-continuous leak detection have surprisingly changed little over the years. The tougher business environment in the gas industry and constantly stricter requirements from regulatory bodies give fresh impetus to alternative concepts such as the laser methane assessment.

Going back, there are three basic reasons why leak detection plays such an important part in the integrity management of a pipeline. There is the safety aspect which is beyond dispute. An incident quickly costs millions and severely harms the reputation of the company. With the 'go-green-movement' and all the different greenhouse gas emissions programs from several national and international environmental protection organizations, the general public has a close eye on the gas industry and its eco-credentials.

By the same token, the financial losses through leaks are substantial. Even through a medium sized leak, an amount of gas escapes that would have brought considerable income over time. By saying this, it becomes obvious that time – or rather the frequency – plays an important role in the leak detection program and its financial impact. "Find the leaks and find them fast" was recently the statement by an integrity manager after a presentation about leak detection programs. This statement defines the theme in a nutshell.

TRADITIONAL INSTRUMENTS VS. LASER METHANE ASSESSMENT

As diverse as the international gas industry is, the approaches to leak detection are diverse. Traditionally, a crew equipped with some kind of gas detection device such as a flame ionization detector (FID), a combustible gas indicator (CGI) or a gas sniffing dog walks or drives over the pipeline corridor and looks for gas indications. Excluding the dog, all technologies measure the gas concentration fairly accurate and the size of the leak can be pinpointed.

"An effective emission monitoring and leak detection program in economical tough times is a challenge for operators."

> Boris. A. Horn

Bell 206 JetRanger

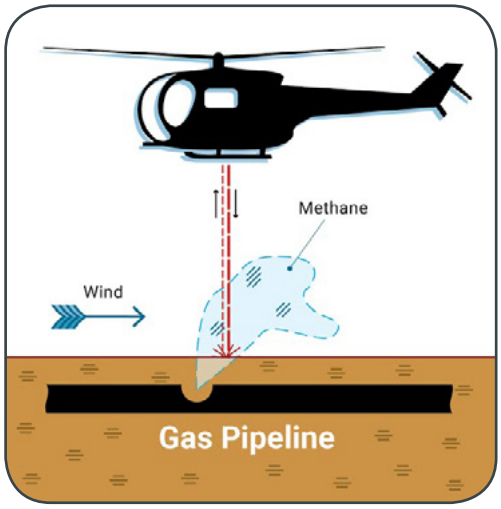
The multi-purpose helicopter can be quipped with Pergam's laser system within only one hour.

Used mainly for transmission lines, operators often trust a visual inspection from an aircraft. An observer on board looks out for starved vegetation over the pipeline; an indication for a leak. The vegetation situation as well as construction activities (especially earth movement) within the right-of-way are another required check during the patrols. Interestingly enough, even operators of pipelines with an installed continuous leak monitoring system often still complete an aerial or ground based leak detection.

There are basically two characteristics that distinguish a laser from a FID or CGI instrument: the laser can detect emissions remotely with up to 10 pulses per second. Within the application, this means that the crew doesn't have to be positioned over the pipeline and the potential gas cloud. Later, I will address the point why detection over a distance as well as speed can be very handy besides the increased safety for the crew. Furthermore, the laser can even measure through some materials like glass – an excellent characteristic of the technology to assess an emergency situation.

The sensitivity of a laser based detector is excellent, even the smallest emissions can be detected. If it comes to the accuracy of the measurement result, the FID or CGI wins the race. Nevertheless, the accuracy of a laser is more than sufficient for pipeline leak detection programs and finding the leak is commonly the priority and high accuracy quantification is optional. Comparing the deliverable from a pure visual patrol with a technology supported patrol; the value is based in the complete documentation and the early detection of minute leak indications.

Nowadays, leak detection lasers, including the related optics and electronics, are available in all sizes and designs. From handheld devices, over vehicle / aircraft mounted systems up to fixed installed platforms for single- or multipoint monitoring are commercially available and field-tested. A fairly new application of laser methane assessment systems for mainly LNG terminals are fixed installed monitoring solutions. Using highly effective retroreflectors, there are measurements along a line with a distance up to 2.5 miles (4 km) possible.



Laser Methane Assessment

The figure 1 above illustrates the basic principle of aerial laser methane assessment. The laser light is partially absorbed if methane is present somewhere along the path.

The base of laser methane assessment is a tunable diode laser that emits in the spectral range of 1.65 nm. At 1.65 nm, methane has very high absorption characteristics that makes this concept so effective. The laser is targeted through mirrors or prisms to the pipeline. The beam is reflected on the surface (either on the pipeline itself or in underground networks on the surface over the pipeline). The backscattered light is collected in the optical unit of the system and through spectroscopic signal demodulation and a complex algorithm, the gas concentration can be calculated if methane is present somewhere along the laser path [1]. This method can be used for many different gases, as long as the gas has a high absorption in a certain spectral range. Unfortunately, major changes in the laser, filter and algorithm are necessary to adapt a system to another gas.

If talking about aerial applications, low altitude and low speed are safety concerns. It is easy to imagine that the sensitivity is dependent on conditions like wind, distance and background. Modern aerial laser methane assessment systems can be flown at 500 ft. (150 meters) over the pipeline up to 90 mph (145 km/h) and deliver excellent results, even in windy environments up to 25 kt. This flight configuration gives the pilot enough time to start an autorotation landing in case of a turbine failure. The highest sensitivity is obtained at 250 ft. (75 meters) with maximum 15 kt. winds. Other aerial technologies have the benefit of visualizing the leak and can also detect different gases. Quantification is almost impossible and very specific weather conditions need to be present during the inspection to have enough radiation for the technology to work. These limitations restrict the commercial operation of these technologies in the field.

"This method can be used for many different gases, as long as the gas has a high absorption in a certain spectral range"

> Boris. A. Horn

Almost all systems today that are based on the laser methane assessment concept have a built-in reference cell. This reference cell is primarily used to get a stable signal of the reference channel but secondary also for an automatic system test and calibration check. Users of traditional instruments know the elaborate procedure of the daily check to ensure that the equipment works. In some countries, the check is even mandatory in regards to regulations. Besides this daily check, a yearly recalibration is required for most of the instruments. The built-in reference cell lasts up to six years and waives the yearly recalibration. Furthermore, it runs the system check automatically at each start-up. The process is usually done in three steps. In step one, the concentration of the reference cell is confirmed. Step two self-checks the instrument and step three is the calibration-check. Only if all three steps have successfully passed can the system be operated. These capabilities help to keep the costs of ownership low through saving time for the system check and especially the waived yearly calibration. Depending where the next service center is located, a calibration can typically take several weeks and can cost up to 12 % of the equipment price.

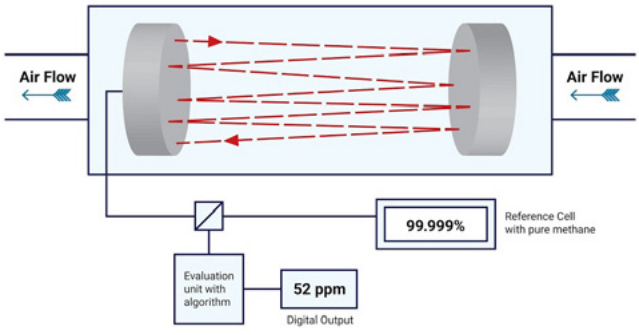
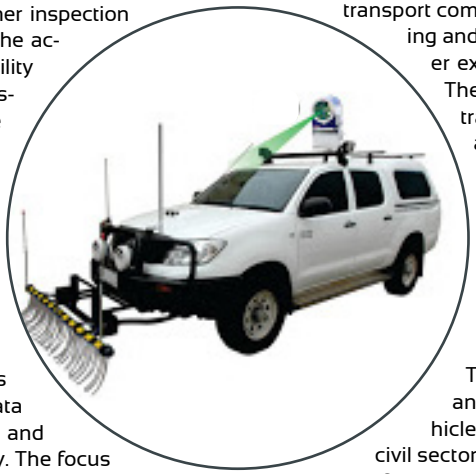


Figure 2: Multi Pass Cell

MULTI PASS CELL FOR VEHICLE BASED PATROLS

The gas concentration on the surface in city applications through low pressure pipelines is often extremely small. A special design of the laser methane assessment platform utilizes a multi pass cell in order to achieve sensitivities better than 0.1 ppm. The employed multi pass cell in the SELMA MPB systems reflects the laser 108 times (see graphic). A pump constantly sucks in air samples through nozzles close to the road surface and blows the sample through an optical channel. The alignment of the laser requires the highest precision in the optical channel, the use of only materials that are temperature stable and an installation with highly effective shock absorbers. The manufacturing effort with this extraordinary precision results in relatively high system costs. However, the high sensitivity and the stable readings can be utilized to gain inspection speed. Together with high capacity pumps, an inspection speed up to 30 mph (50 km/h) can be archived. The higher inspection speed might not sound crucial but considering the accidents that are caused through slow driving utility inspection vehicles, the speed remarkably increases the safety for the surveying team. Besides the economic advantages of having the job done faster, the higher investment is consequently justifiable.



VOICE FROM THE MARKET

Within the scope of its innovation process, Pergam has conducted a user study with 46 gas transport companies from 18 different countries regarding leak detection. The objective was to learn the work flow from planning through data archiving, the value in the leak detection chain and specific issues with today's available technology. The focus group were transmission pipeline companies without an internal continuous leak monitoring system. The result of the study shows that the three main concerns are data management, operator qualification / operator supervision as well as having proof of inspection that meets the requirements of the regulatory bodies, sometimes even the company internal compliance standards.

PROOF OF INSPECTION

When speaking about documentation, surprisingly many companies still use paper maps to plan, conduct and analyze the leak survey. The 'boots on the ground team' marks the areas that they have inspected and leaks are indicated with a marker or simply with sticky notes. This might sound very basic but there are a large number of utilities even in the developed countries that still follow this procedure. The operating platform of all laser methane assessment systems is fully digital which simplifies reporting capabilities. A GPS module or a connection to a mobile phone tracks the inspected route and matches the gas indications with the location. Furthermore, the data can be analyzed for quality assurance purposes of the patrol. The hired crews do not always follow the inspection procedure. A common problem is that leak surveyors use some kind of vehicle instead of walking to save time. In this case, the variance in speed shows the 'simplification measures'. Overlaying the shape files of the grid with the inspected route gives a clear overview about the inspection process. The logged data contain the track, time and date stamp, notes from the operators and basic instrument information together with the measured gas concentration. This information can be processed for compliance reports and saved in all formats. Optional available geo-referenced still frame or video cameras provide additional information for easy location of the found leak.

DATA MANAGEMENT

With the mass of data available in today's world, everyone seems to know the problem of data management. During the conducted survey in 2014 about the further use of the leak data, from which departments the data are used, who and how data can be reviewed and updated, it turned out that the bottleneck are often the highly paid internal GIS and IT experts. These departments are often required to enter the data in a management software or the field inspection software. A major gas transport company in Canada stated that the costs for preparing and post-processing the inspection data are a higher expenditure than conducting the field inspection. The inspection work itself is conducted by a contractor who gets the shape files and delivers back a report about the assets with a leak. This issue was addressed in the latest software and data can be imported and exported in a variety of industry standard data formats directly to and from the laser methane assessment platform.

THE LATEST AND GREATEST - UAV LEAK DETECTION

There are not many markets that are so dynamic and full of innovations as the unmanned aerial vehicle (UAV) industry. Within only a couple of years, the civil sector grew to a multi-million industry. The Unmanned Aircraft Systems report by the Congressional Research Service from September 2015 estimates 300,000 sold nonmilitary UAVs with projected revenues of $200-$400 million in 2015 [2]. A UAV methane sensor dedicated to the gas industry has been launched in the middle of 2015 and immediately received enormous interest from UAV manufacturer and UAV service providers but also from gas utilities. UAV providers consider the platform often as panacea for inspection tasks. The gas industry itself is more hesitant and sees it more as an additional tool.

Application studies showed that a UAV equipped with a camera and the laser methane sensor is excellent for inspections of spans e.g. pipes underneath bridges or the inspection of gas storage tanks; applications where traditionally scaffolding or a lifting platform were required. Another confirmed practicable application is the pipeline inspection in rural areas with pipelines through agriculture fields. A ground based inspection is possible but if grain is tramped down, the utility often has to compensate the damage. Inspectors in residential areas know the hassle if the last part of the line and the meter is behind a closed fence. Contacting the owner to agree a new appointment for the inspection is time consuming and expensive. The UAV based sensor enables them to continue the rest of the inspection without any mayor delay. The same applies to assets in back yards that have to be inspected. Applications beyond the pipeline industry are emission monitoring on landfills, the check of wellheads or measurements for first exploration indications.

The solution based on a variety of UAVs is commercially available and successfully tested. However, it is at this point in time only partially used in the industry. An obstacle in many markets is the unclear situation of the regulations. The national aviation authorities of most countries work on a framework for regulations but very little is adopted. The Federal Aviation Authority of the United States (FAA) requires, in addition to other requirements, visual contact with the UAV [3]. A typical distance for line of sight is 1.5 miles (2.4 km) – a distance that makes the inspection of even a small grid already difficult. Other countries have similar rules. Japan and Australia have probably one of the most developed UAV regulations. In these countries, UAVs are already established in other applications such as agricultural spraying. Another obstacle is the battery capacity today – not many platforms are able to stay longer than 40 minutes in the air before the batteries need to be swapped. Despite all the restrictions, a UAV equipped with a gas sensor and cameras is a very valuable additional tool for the right applications. For the classical long distance patrol, the main aerial platform will probably remain the helicopter and fixed wing planes for the next few years.

FUTURE

According to the Global Industry Analysts gas detection equipment report from September 2015, the global market for gas detection equipment is projected to reach US$ 3.2 billion by 2020, driven by the growing number of safety and environmental regulations worldwide [4]. For example, in October PHMSA (Pipeline and Hazardous Materials Safety Administration of the United States) proposed regulations for a more complete system for detecting leaks as well as inspections of affected pipeline following extreme weather events or natural disasters [5]. Currently, this proposal has only been reviewed but this and many other international rulemaking proposals will certainly lead to more stringent rules about pipeline leak detection around the world. New technologies such as the laser methane assessment and more automated data management systems with direct integration of the leak detection data into the work flow will be adapted from the industry and economize the leak surveying.

LMmini
A portable laser methane assessment instrument, initially.

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