When it comes to gas, it is always a serious business. Gas operators’ maintenance programs are specifically designed to limit safety hazards through close monitoring of their pipelines and installations. But in addition to the concern for assets and human safety, global warming must now also be taken into account, along with the need of operational cost reductions. Methane, the main component of natural gas, is an odourless, invisible, yet combustible gas. Like CO2, it is a greenhouse gas, but its effect on climate change is far greater than CO2. Methane is responsible for a quarter of the global warming we experience today. In response, the natural gas industry has to proactively deal with methane emissions mitigation all along the gas chain from production down to the end consumers. This is why pipeline operators and gas utilities worldwide are currently reviewing their integrity management system with tougher Leak Detection and Repair (LDAR) programs.

### GAS DETECTION : THE LASER APPROACH

**Measurement is the key in gas detection**

When it comes to methane leak detection, the performance of the instruments used for the safety/maintenance checks carried out on natural gas installations needs to be constantly upgraded to meet the latest operational and regulatory requirements. In gas measurement, instruments have evolved considerably within the past 15 to 20 years, from the catalytic bead and electrochemical point sensors as well as flame ionisation (i), with the introduction of laser spectroscopy technology.

**Why use laser technology in gas measurement?**

Laser-based gas sensor technology is an extremely effective tool for detecting and quantifying polluting gases such as carbon dioxide or methane owing to some key advantages.

(i) Flame ionisation consists in passing a gas sample through a hydrogen flame. The presence of gas produces a current between two electrodes. The current intensity is measured and translates to a gas concentration level.

**Higher sensitivity…**

One of the major advantages of laser-based technology is that it is highly sensitive compared with other sensor technologies. In the field of gas measurement, laser-based absorption techniques are the most widespread and the leading commercial technologies fall into two categories:

- Tunable Diode Laser Absorption Spectroscopy (TDLAS), including single-pass, dual-pass and multi-pass cells (see box)
- Cavity Enhanced Absorption Spectroscopy (CEAS) under which Cavity Ring-Down Spectroscopy (CRDS) and Integrated Cavity Output Spectroscopy (ICOS) fall. (see box)

…And other key features make the difference

Newer gas analyser instruments use a laser diode mounted on a thermo-electric cooler in order to tune a laser wavelength to the specific absorption wavelength of a particular molecule. They exploit their high frequency resolution, which results in enhanced sensitivity (in the order of parts per billion, ppb) and selectivity, as they are tuned to a specific compound of gas. In short, the laser remains locked on the specific absorption wavelength of the target gas. The extremely narrow width of the laser beam, coupled with the tuned wavelength of the laser diode, is a key factor to selectivity. The absorption technology ensures precise gas recognition, eliminating the potential for false alarms, which represents a real issue with other gas detection technologies.

Generally speaking, the new instruments feature high speed of response (typically one second), wide dynamic measurement range, extremely precise measurements and low cost of ownership because they are easier to calibrate and maintain with greater operational simplicity.

**No gas detection without the LASER**

Because of the growing compactness of latest laser-based gas sensors and their capacity of detecting very low concentrations of hazardous gas, even when its source is at a distance, the laser technology has found numerous ways to serve the oil and gas world:

- Stationary real-time continuous monitoring systems of GHG (methane, CO2) to reduce gas emissions, diminish work safety hazards and prevent global warming.
- In-vehicle gas leak detection system to detect gas leaks while driving.
driving a vehicle along the buried gas pipeline network for their inspection. This type of application requires fast response time and low detection limits since the vehicle can be moving at fairly high speeds (around 40 km/hr to match normal traffic speed) and is limited in proximity to leak sources based on roadway as well as pipeline curvature.

- Remote methane leak detection systems (hand-held, built in drones, or easy-to-deploy systems) rendering accessible difficult-to-access and inspect areas. Hand-held and, in particular, drone-based systems impose serious limitations in terms of size, weight and power.

- Hand-held detectors operated by field technicians to monitor at discreet locations points along pipelines or in-gas installations.

Focus on a gas operator’s experience

Almost 25 years ago, a major European gas operator in charge of the longest distribution network in Europe, felt a real need to renew their stock of detection instruments. At the time, the instruments used for their network surveying and gas leak detection program utilized predominantly the technologies of explosimetry, catharometry and flame ionisation. Since the ionisation detector (FID) detects methane gas at ppm level, it was used in all of their network survey vehicles as well as a number of their portable detectors. Though very sensitive and relatively stable in measurements, the technology presented, however, some major disadvantages:

- Response to all gaseous compounds indiscriminately.
- Response time too long
- The use of high pressure hydrogen gas bottles with a flame posed serious operational safety concerns (hot point) and rendered the technology unsuitable for detection indoors.

The gas operator’s initiative was typical of an overall trend noticeable among a growing number of gas operators worldwide. At the same time, manufacturers of detection instruments were beginning to commercialise optical sensor-based detection systems.

One example is the open path system mounted on a vehicle. The system uses an infrared light spread at the front of the vehicle. When combined with an optical filter, this enables gas detection at the ppm level and eliminates the need for sampling equipment. However, the detection device is dangerously exposed to shocks and the optical sensor is exposed to dirt and mud. Measurements may not always be accurate and regular maintenance is required.

Another example is the multipath measurement cell, which multiplies the interaction between a gas sample and a laser beam. This corresponds to the TDLAS technology from which the optical detection systems chosen by the gas operator for network surveying have been developed.

In a first step, the gas operator started replacing its FID Network Survey vehicles with INSPECTRA VSRs. And, as soon as the hand-held portable version was approved, the INSPECTRA Laser portable detector was introduced. Since 2006, the number of INSPECTRA technology equipment has been constantly growing. Today, there are over 400 portable units and over 35 INSPECTRA VSRs in operation for the regular inspection of the more than 200,000 km of the gas operator’s distribution network.

Every day, the gas operator invests 1 million Euros into the safety of the natural gas network, of which 25% goes to the surveying and monitoring of the natural gas network, of which 25% goes to the surveying and management of leak detection data.

**Network Surveying – how it works**

Every year, more than 70,000 km of the operator’s gas network are being surveyed to detect and locate leaks. And in compliance with European legislation, the network is surveyed according to its classification:

- 3 inspections per year for higher risk sections
- 1 inspection per year for the copper pipeline sections
- 1 inspection within the first operation year for newly laid pipelines
- 1 inspection every 4 years for the low pressure network

**Tangible benefits along the pipeline**

The decision of this European gas distribution operator to equip their leak survey equipment with high-performance optical detection instruments falls within the environment protection commitment policy of the company. And looking back, laser detection clearly supports the strategic challenges to be met by the gas operator, bringing:

- Increased safety:
  - Shift from FID with removal of hydrogen and “hot point” (furnace and flame). The laser instrument is intrinsically safe and its use can be extended indoors.
  - No interference from other hydrocarbons, chemicals or water – no false measurements. The laser system delivers a measurement in the presence of methane only.
  - Accurate, reliable measurements well below the PPM – almost no gas leak goes undetected.
  - Stable, reliable measurements – Detection system insensitive to temperature variances, vibrations and humidity.
  - Response time reduced from 3 seconds to 1 second enables pinpointing gas leak points, limits gas dilution and increases detection capacity.
  - Lower maintenance and operating costs
  - Reduced gas consumption – no hydrogen
  - Elimination of re-occurring false alarms, saving time-

**Safety**

The GA20SICAN is a handheld remote methane leak detector with exceptionally long detection distance (up to 40 meters) that supports all professionals in emergency response situations, as well as gas utilities in their gas network leak survey. With built-in Bluetooth® technology, the GA20SICAN can connect wirelessly to a mobile phone and transfer readings to the GA20SIS/REN application which is compatible with a comprehensive enterprise solution for the management and storage of leak detection data.
Laser technology, as part of the new BIG DATA approach

Research in laser detection continues actively today, looking into new solutions to improve detection performance. The main, current issue with laser technology is signal noise (laser noise or electronic noise) that hampers the measurement. Integrating detectors such as Balanced Photodetector (BD) or Frequency Modulation (FM) spectroscopy are serious options currently explored. BD, for example, could help reducing the signal noise and improving the measurement to achieve a sensitivity down to 100 ppb (0.1 ppm). A feature most relevant for the survey and improving the measurement to achieve a sensitivity down to 100 ppb (0.1 ppm).

Reduced training time for operators
Increased productivity with a survey speed multiplied by 2 (20 to 40 km/hr) and a larger daily inspection range.
Reduced start-up time from 15 to 5 min for the VSRs and from 15 to 0 min for the portables, making it possible for field operators to combine vehicular leak detection and on-foot leak confirmation in one inspection circuit.
Reduced acquisition and maintenance costs owing to the removal of a number of components (oxygen furnaces, hydrogen gas bottles) and to the simplification of the sampling circuit.
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The breakthrough of Laser technology

The LASER acronym stands for Light Amplification by Stimulated Emission of Radiation. Lasers are devices that amplify light and produce or emit coherent light beams (light waves emitted are all in step with one another), ranging from ultraviolet to infrared. Laser light can be extremely intense, highly directional and is usually of one wavelength.

Basic principle is the following: A laser oscillator usually comprises an optical cavity in which the light can circulate between two mirrors and a gain medium (such as a laser crystal or laser diode) which serves to amplify the light and compensate the losses it experiences in each round trip inside the cavity.

The laser materials such as dyes, gases, crystalline solids, glasses and polymers are used as gain medium and deciding which one to use depends on the final application. Some lasers are designed to emit light in a continuous mode while others can produce optical pulses with very short durations from femtoseconds (10-15s) to nanoseconds (10-9s).

Current laser technology is focused on making the most out of it. The toolkit at their disposal also calls for a broader framework to enable operators moving in that direction will soon come to realize that the BIG DATA supplied by a larger set of interconnected fixed and mobile detectors. So the future is already with us here today. Gas operators moving in that direction will soon come to realize that the toolkit at their disposal also calls for a broader framework to enable operators moving in that direction will soon come to realize that the BIG DATA supplied by a larger set of interconnected fixed and mobile detectors.

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Reduced acquisition and maintenance costs owing to the removal of a number of components (oxygen furnaces, hydrogen gas bottles) and to the simplification of the sampling circuit.
Reduction of the network survey vehicles fleet and of the number of inspection crews, despite the fact that the distribution network continues to expand.

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