LASER FOCUS INSPECTION

Christophe Durr, GAZOMAT, France, describes how laser technology can benefit gas leak detection measurement, as well as inspection and maintenance programmes.

Gas distribution and transmission network operators face the difficult challenge of guaranteeing a continuous supply at a competitive price, while reducing hazards all along the chain down to the final consumers. More recently, their role in climate change has been pointed out, as methane gas emissions count for a quarter of the global warming experienced today.

The solution exists. Network surveying is already part of the global maintenance policy of gas utilities. However, the issue is to reinforce gas emission prevention and remediation, using the right tools.

The goal of a pipeline network inspection programme is to identify gas leaks quickly and reliably, so as to eliminate those representing an immediate threat to safety and build the pipeline maintenance schedule. Using the right detection instruments is clearly a key factor in the process. Gas measurement technologies were initially based on flame ionisation (FID), electrochemical sensors or semiconductors. Over the past 15 to 20 years, the introduction of optical technology has gradually changed the game, with the development of high performance laser-based instruments. The new technology is extremely effective in detecting and quantifying polluting gases such as carbon dioxide or methane, thanks to the principle of infrared absorption spectrometry.

Selectivity as a basis

The technology is based on a gas molecule property of absorbing radiation. Optical technology uses a laser diode (acting as a light source) tuned to the specific absorption wavelength of a particular molecule, i.e. methane gas. Thus, when the laser beam emitted by the laser diode encounters the methane molecules present in the atmosphere sample inside the measurement cell, the laser light is absorbed because it matches the absorption spectrum of the methane molecule, which is specific to methane.

Another key factor to selectivity is the narrowness of the emission spectrum of the light beam. The narrower the beam, the lower the potential is for interactions with the absorption wavelengths of other chemicals. Coupled with the precisely tuned wavelength, this ensures that only methane is detected and false measurements are eliminated.

High sensitivity and more features

The interaction between the laser beam and the gas sample in the measurement area or chamber greatly impacts the capacity to detect the smallest methane gas concentrations. The extremely long optical path travelled by the laser beam – as is the case with the multipass cell of the tunable diode laser absorption spectroscopy (TDLAS) technology – enhances the system's sensitivity to the level of parts per billion measurement capacity.

The absorption technology is designed to ensure precise gas recognition and precise measurements. New laser-based instruments also feature:

- Quick response times (typically 1 sec.).
- A wide dynamic measurement range (from 0.1 ppm to 100% of volume).

- Precise and stable measurements (insensitivity to humidity and temperature).
- Lower ownership costs, because they are easier to calibrate and maintain with greater operational simplicity.
- Intrinsic safety – with no hot point, the laser technology is suited for use in potentially explosive atmospheres (outdoors and indoors).

Laser applications in gas leak detection

The latest advances in laser technology have translated into the growing compactness of laser-based instruments, as well as higher measurement performances, with detection capacities in the range of 0.5 ppm. This significantly extends the range of applications in the oil and gas sector, with versatile solutions:

- Stationary real-time continuous monitoring systems of greenhouse gases (methane, CO_2) to reduce gas emissions, diminish work safety hazards and prevent global warming.
- In-vehicle gas leak detection system to detect gas leaks while driving a vehicle along the buried gas pipeline network for their inspection. This type of application requires fast response times and low detection limits, since the vehicle can be moving at fairly high speeds (approximately 40 km/hr to match normal traffic speed) and is limited in proximity to leak sources based on roadway as well as pipeline configuration.
- Remote methane leak detection systems (handheld, built in drones, or easy-to-deploy systems) make difficult-to-access areas accessible for inspection.
- Handheld detectors operated by field technicians to monitor discreet location points along pipelines or in gas installations.

Figure 1. The GAZPOD monitoring station measures on a continuous basis up to four gases simultaneously. Monitoring data is transferred via wireless cellular connection to an enterprise management system for storage and processing.

Figure 2. The GAZOSCAN is a handheld remote methane leak detector. It connects wirelessly to a mobile phone and transfers readings to the GAZOSURVEY application.

Case study: a major gas operator's laser conversion

What if, at one point, the drawbacks of the measuring instruments used for network surveying and gas leak detection outweigh their strengths? This was the experience of a major gas operator some 25 years ago. In charge of the longest gas distribution network in Europe, its stock of detection instruments was predominantly made up of explosimeters, catharometers, and FID detectors. The highly sensitive FID technology, which detects at 1 ppm level, was used in the operator's network survey vehicles and in a number of portable detectors. However, because it uses hydrogen, a highly flammable gas, the technology represented a safety issue. The gas operator was looking for new solutions.

At the same time, the first optical sensor-based detection systems were beginning to be introduced on the market. One example is the open path system mounted on a vehicle. The system uses an infrared light spread at the front of the vehicle plus an optical filter. It detects gas at ppm level and requires no sampling equipment. The main drawback is that as it is exposed to shocks and dirt, the optical sensor needs regular maintenance and measurement accuracy may be impacted.

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 system chosen by the gas operator for network surveying has been developed.

As a first step, the gas operator started replacing its FID network survey vehicles with laser vehicles. The Iaser portable detector soon followed. Since 2006, the amount of laser-based equipment has been constantly growing. Today, there are over 400 portable units and over 35 laser vehicles in operation for the regular inspection of more than 200 000 km of the gas operator's distribution network.

Network surveying – a regulated process

Every year, more than 70 000 km of the operator's gas network are surveyed to detect and localise leaks. In compliance with European legislation, the network is surveyed according to its classification:

- Three inspections per year for higher risk sections.
- One inspection per year for the copper pipeline sections.
- One inspection within the first year of operation for newly laid pipelines.
- One inspection every four years for the low pressure network.

For the network sections accessible to vehicles, inspection is carried out by the network survey vehicles that are being road-driven along the buried pipelines at an average speed of 40 km/hr, instead of the previous 20 km/hr. Equipped with sampling suctions at the front bumper, positioned at ground level, the gas operator's survey vehicle can 'sniff' the smallest methane gas concentration, down to the ppm, even at a distance (sometimes up to 8 - 10 m depending on the wind direction, for example).

An instant audio and visual alert is given in the presence of methane gas, and the data is recorded in real-time in the onboard survey PC. Any indication of a gas leak needs to be confirmed immediately, on foot, by the network survey vehicle operator, using the laser portable detector. If the gas concentration exceeds 10 000 ppm (1% gas or 20% LEL), the operator will immediately call the emergency intervention cell.

With the laser system's selectivity to methane, eight to nine leak alerts out of ten correspond to actual gas leaks, as opposed to two out of ten with the former FID equipment. This is a significant improvement, considering that each vehicle surveys an average of 20 - 25 km/d (including gas connection boxes).

For the network sections not accessible to the vehicles, such as pedestrian areas and elevated installations along bridges, inspection is performed on foot by field technicians using the laser portable detector, with a daily average distance per operator of 3 - 6 km, depending on network specificities.

A global pipeline data management framework

Laser technology keeps moving forward, improving detection performances. Current research is actively working to reduce the signal noise (laser noise or electronic noise) that affects measurements. Balanced photodetectors could help achieve a sensitivity of 100 ppb (0.1 ppm). Gas dilution in the air and the vehicle's speed would no longer be an issue for detecting the smallest gas concentrations and spotting gas leaks precisely.

On the contrary, amplifying the signal by frequency modulation can improve sensitivity for remote distance detection. Also, detection distances beyond 100 m are possible, as demonstrated by the latest remote methane leak detectors on the market.

Detection performance is certainly essential to obtaining reliable measurements. However, looking at the big picture, it is actually one of the many steps that will lead the oil and gas industry to a fully integrated pipeline integrity management plan. Technologies such as GPS or GIS complement live measurements. The latest communication and software solutions enable equipment interconnectivity, providing a continuous flow of data that needs to be managed efficiently. Making the most out of it within a big data approach is the next big challenge facing oil and gas operators.