Infrared: a different way of seeing

In the oil and gas industry, leaks are a serious concern: emissions of volatile organic compounds can affect air quality, on-site safety and overall production figures. To combat leaks RasGas is using infrared technology to make a powerful, positive impact

Conservation of wildlife is important to RasGas

A major petrochemical plant is a vast labyrinth of interconnecting pipes, valves and vessels, each playing its part in a complex industrial process. But every valve and every connection between components, no matter how precisely engineered, is also a potential source of what are known as 'fugitive emissions', or leaks, of volatile organic compounds (VOCs). On its own, a single minor leak might not seem so important, but when you consider that a facility such as the RasGas site at Ras Laffan Industrial City will have tens of thousands, even hundreds of thousands, of such potential leak sources, and that the plant operates 24 hours a day, seven days a week, the size of the risk is clear.

RasGas takes leak prevention extremely seriously. Any leak of process fluids or gases will obviously affect production volumes, and more importantly, VOCs also present an environmental threat and an immediate on-site safety hazard. In 2007 a new leak detection and repair (LDAR) programme was launched; its principal innovation was the use of infrared cameras for the initial detection of leaks. RasGas was the first company in Qatar to adopt this technology, and since then it has achieved 'control effectiveness' figures consistent with target figures published by the US Environmental Protection Agency (USEPA). The swift investment in new technology is paying off.

Silent and invisible

VOCs are organic compounds that participate in photochemical reactions. They include butane, hexane, octane, propane, toluene and xylenes, all of which are familiar compounds at many industrial facilities. One result of the photochemical reactions is the formation of ground-level ozone when nitrogen oxides (NOx) and VOCs interact in the presence of heat and sunlight. Ground-level ozone is a major component of smog, causing or aggravating respiratory problems.

It's easy to see why leaks must be traced, it's not so straightforward to see the leaks themselves: they are invisible to the naked eye, and almost always silent. So engineers have to know where to look. Leaks can be caused through normal wear and tear, improper or incomplete assembly of components, inadequate material specification, manufacturing defects, damage during installation or use, corrosion and fouling. Components also tend to have greater average emissions when subjected to frequent thermal cycling, vibrations or cryogenic services.

Results in the field have shown that gate valves are the type of component most prone to leaking – they are routinely opened and closed, so the packing in the valve can deteriorate or be disturbed. In this case, the leak can often be repaired simply by tightening the packing bolts.

The new LDAR programme

RasGas has always made leak detection a high priority, but impetus was added to the company's efforts in 2005, when Ras Laffan Industrial City's new environmental regulations specified fugitive monitoring and reporting requirements for processing equipment that includes valves, pump and compressor seals, pressure relief valves, open-ended lines and sampling connection systems.

It was natural for RasGas to look for technological innovations as it developed its new LDAR programme, and in 2006 at ExxonMobil's Baytown Olefin Plant, in Texas, RasGas engineers first saw infrared cameras at work. Introducing them at Ras Laffan was an obvious next step. The RasGas LDAR progamme was launched in 2007 and is being implemented in phases, starting with Trains 1, 2, and 3, and the AKG-1 plant, and progressing to the newer installations: Trains 4, 5, 6 and 7, and AKG-2.

The programme has six elements, described below: component identification, component tagging, monitoring, data collection, repairs and database management.

Component identification The percentage of VOCs, by weight, of each process stream is calculated and those streams with more than 10 per cent VOCs are identified on plant process flow diagrams and piping and instrumentation diagrams.

Component tagging Using colour-coded diagrams, the LDAR team locates the components and attaches to each one a metal tag with a unique identification number. Tag information is captured in an electronic data logger, for uploading into a comprehensive database.

Monitoring Technicians employ two instruments for detecting fugitive emissions: an infrared image camera and a portable organic/inorganic compound detector. The infrared camera is used first, producing real-time thermal images in which gas leaks resemble 'black smoke'. All potential leaks are then subjected to the USEPA's Method 21 monitoring, which involves placing a gas-sampling probe (the portable organic/inorganic compound detector) near the surface of the equipment to measure the VOC concentration. Any hydrocarbon concentration equal to or exceeding 10,000 parts per million by volume (ppmv) is considered a leak. The infrared camera enables the LDAR team to assess significantly more components in a given time. It also allows them, in calm weather, to pinpoint a leak more easily, to detect very small leaks and to identify leaks up to 10 metres away – during windy conditions the portable detector is used first, with the infrared camera providing confirmation monitoring of any leaking components.

Data collection An electronic data logger is used to collect the monitoring data, which consists simply of the tag number and the VOC concentration for each component. After each monitoring session, the technician

RasGas was the first company in Qatar to adopt infrared technology for leak detection, and has since achieved 'control effectiveness' consistent with USEPA targets

uploads the information collected into the monitoring database.

Repairs A component with a leak concentration of 100,000 ppmv or greater is considered high risk by RasGas and a repair attempt is made as soon as possible. A component with a concentration between 10,000 ppmv and 100,000 ppmv is repaired and remonitored within 15 days. If a follow-up VOC reading is below 10,000 ppmv, a leak repair is considered successful. In most cases, the environmental technicians accompany the maintenance staff to the leak location, so the maintenance team can see the leak using the infrared camera, conduct the repair and have immediate confirmation of its success.

Database management The LDAR database records all monitoring efforts, repair attempts, repair delay details and information on the equipment repaired. The system also schedules inspections, generates custom reports and provides access to historical data such as leak history, repair records and calibration information for the portable detector.

Estimating emissions, assessing effectiveness

There are several ways to estimate equipment leak emissions, including the 'average emission factor', 'screening ranges', 'EPA correlation' and 'unit-specific correlation' approaches. RasGas has adopted the screening ranges method, as it allows some adjustments for individual unit conditions and operation.

Once the data has been collected and the fugitive emissions estimated, the final step in assessing the performance of the LDAR programme is to calculate its 'control effectiveness'. The factors that feed into this calculation are: (1) how a 'leak' is defined, (2) the initial leak frequency before the LDAR programme was implemented, and (3) the final leak frequency after LDAR implementation. The definition of a leak is the screening value at which a leak is indicated for a given piece of equipment; the leak frequency is the proportion of equipment items with screening values equal to or greater than the leak definition.

To date at RasGas, valves (in gas and light liquid service) have been the only leaking components. To establish the control effectiveness of the LDAR programme, the initial and final leak rates were determined for the leaking valves.

RasGas' annual control effectiveness figures are higher than the USEPA's quarterly figures for gas and light liquids, and higher than its monthly values for light liquid valves. As RasGas' monitoring frequencies increase, it is reasonable to expect a correspondingly higher control effectiveness.

Overall, RasGas has launched a very successful LDAR programme and is making significant progress. Not only are its control effectiveness figures consistent with USEPA references, but emissions and product loss have been reduced, and on-site safety has improved. As interpretation of historic data enables technicians to focus more attention on components that are more susceptible to leaks, the programme will register further successes.

This feature is drawn from the experience in using LDAR for monitoring fugitive emissions of volatile organic compounds with special reference to RasGas' experience, a paper given in Doha in January 2010 at the 2nd Annual Gas Processing Symposium. Its authors are Chris Horne, Roger Medalla and Julius Bacani, all members of the RasGas SHE Group.

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