Refinery protection with gas detection

Stephen B Harrison *Nexant Energy & Chemicals Advisory*

Based on several recent M&A transaction valuations it is fair to say that the price tag of a medium-sized, medium-complexity refinery in Europe is in the order of 2 billion Euros. Such a refinery will also be the workplace for hundreds of employees and many additional contract staff and suppliers. With such a valuable mix of people and assets, it is essential to consider the right gas detection systems for process and personal safety.

Multiple explosions and a blazing fire rocked the Philadelphia Energy Solutions refinery on the east coast of the US on the 21st of June 2019. The incident led to the announcement that the refinery would shut down after more than 150 years of operations on the site. At 335 thousand barrels per day of crude oil refining capacity it ranked as tenth largest refinery in the US and the largest on the eastern seaboard. This case demonstrates that the risks posed by flammable gases on refineries are more than theoretical: they present a real and present danger that must be monitored using an array of suitable gas detection techniques to protect people, assets and entire facilities.

Health, safety and environmental management

It is a miracle that the dramatic refinery blaze at Philadelphia resulted in no deaths. It is equally fortunate that violent explosions and raging fires at refineries in Vohburg in Germany in 2018 and Sannazzaro de'Burgondi in Italy in 2016 also resulted in no fatalities. But toxic and inert gases present hazards which are equally as dangerous, but much subtler that these sensational events.

Entry into confined spaces generally takes place on refineries during inspection, maintenance and turn-around events. Prior to entry into the space, it must be released as safe through a permit to work. Gas detection for residual toxic gases such as hydrogen sulphide or high levels of nitrogen which may have been used to purge the vessel using a portable gas detection system is a routine step in the precautions taken prior to confined space entry.

Toxic gas leaks can present a dire health hazard, as can the accumulation of an inert gas, such as nitrogen, to displace life-giving oxygen. A toxic gas cloud is likely to be invisible. Some toxic gases are detectable by their odour, but many are not. And, nitrogen accumulation resulting in oxygen deficiency is completely invisible and odourless – but extremely dangerous. Gas detection systems have a vital role to play in protecting people in such situations.

Hydrocarbon gas-leaks on the refinery present a flammability risk on the one hand and an environmental concern on the other. The monitoring of hydrocarbon gas-leaks on refineries is regulated by the US EPA according to Method 21 – 'determination of volatile organic compound leaks'. It prescribes suitable distances between the potential leak point and the gas detector and proposes suitable gas detection technologies such as photoionization, infrared absorption or catalytic oxidation. All these sensor types are common in various modern chemical-based fixed gas detection systems.

People, equipment and open spaces

For expansive areas, such as a tank farm or the route of a gas pipeline oven flat terrain an open path gas detection system might be ideal to cover the long distances involved. However, in a complex refinery process field where distillation columns, scrubbers, reaction vessels and piping are obstructing the line of sight the open path system is unlikely to have the ideal surroundings to operate to its full potential. For a location that has been assessed as a high-risk leak area during a HAZOP study, such as a gas compressor or volatile liquid pump, a fixed location gas detector may be more suitable.

Portable gas detection systems which are worn by operators as they move around between locations can be effective to warn personnel to avoid

	Fixed gas detection system	Hand-held portable gas detector	Open path gas detection system
Suitability for employee protection	1.8	3.0	1.3
Suitability for asset protection	3.0	1.0	2.7
Suitability for overall site protection	2.7	1.3	3.0
Affordability per device	1.8	2.8	1.2
Range of toxic components detectable	1.8	1.8	1.8
Range of environmental pollutants detectable	2.7	2.2	2.3
Range of flammable components detectable	3.0	3.0	2.0
Average score less than 1.5		Weak	
Average score between 1.5 and 2.5		Good	
Average score more than 2.5		Excellent	

areas where toxic, flammable or inert gases have accumulated. Fixed systems, on the other hand are designed to detect gas leaks as they happen or soon after. However, whether they are fixed or portable, gas detection systems based on chemical sensor technologies are limited to monitoring gases close to the location where they are situated. Open path gas detection systems, on the other hand, can detect flammable gases in the line of sight where they are installed and can cover a vast range.

Given the differences that exist, we might consider that each system has its purpose and a combination of strategies is the most effective solution. To investigate the consensus on the most suitable applications for the range of options, several leading equipment suppliers and systems integrators in the sector were invited to share their opinions. Their responses are presented in the table above.

A rainbow of solutions

Each system has its strengths and limitations. Fixed and portable chemical-based gas detection systems require frequent bump testing and periodic calibration – and that incurs some ongoing maintenance effort and cost. Portable systems are not easily integrated into site alarm systems and the device batteries require re-charging in a docking station, making them unsuitable for uninterrupted long-term use. Open path systems can have comparatively high one-time installation costs and are limited in the number of toxic gases that they can detect. Despite the comparatively high cost per system, due to their large range, a single pair of open path optical gas detectors may be able to do the job of many fixed chemical detectors and the maths can quickly add up to cost savings.

Equally, each system has some merits. For example, a portable gas detector is just right for short term entry into a confined space such as a reactor vessel that requires inspection. It is also ideal for use in areas that will be temporarily occupied such as gas exploration drilling rigs or construction sites. On the other hand, a fixed gas detector, for example sniffing for hydrogen sulphide close to a flanged joint on a desulphurisation Claus reactor would be ideal for integration into the site alarm network. And, an open path system is a great option for monitoring the perimeter of the process field to detect a hydrocarbon gas cloud that may be moving towards the administration building or control room.

As with many aspects of refinery health, safety and environmental management the optimal solution is not a black and white either / or situation. Rather, a colourful rainbow of technologies will lead to the best possible protection of people, assets and facilities. Instead of opting for a single system, most refinery and hydrocarbon processing sites will find it optimal to employ a combination of solutions. Portable devices for site-walks and the release of confined spaces to issue a permit to work for maintenance. Fixed systems for leak detection around high risk equipment and integration to the site alarm system. Open path systems for large zone coverage and to validate the alarm signals generated by other fixed gas detection systems.

Digital developments

Digital innovations have the potential to minimise the short-comings of some of the systems.

For example, increased diagnostics and intelligence can minimise the frequency of false-alarms caused by rogue readings on chemical sensors or physical obstructions such as birds or trucks passing through an open path gas detector beam.

Each of these gas detection systems lend themselves to the increased use of wireless communications technology allowing easer installation and more effective communications. Units can be set up to act as one large mesh network and some may be selected as communications gateways. Additionally, for portable gas detectors, peer notification of alarms combined with remote monitoring allows for shortened response time, plus accountability of users. They also enable voice communications or 'man-down' communication from the user to a base location.

LINKS

More articles from the following categories:
Emissions Reduction
Instrumentation, Automation and Process Control
Safety, Health, Environment and Quality (SHEQ)