Multi-Layered Gas & Flame Monitoring Protects As Well As Prevents Accidents at Petrochemical Plants

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According to the Centre for Effective Government, there have been over 400 petrochemical accidents in the U.S. during the last two years since President Obama issued an executive order in August 2013 to help improve petrochemical safety policies. These 400 accidents include a disturbing number of serious explosions and fires at petrochemical plants and other industrial plants that use petrochemicals, where the best safety practices and equipment should be in place.

Combustible gas and fire safety is a challenging problem at petrochemical process and industrial facilities of all kinds throughout the world, but worse in many developing countries. The recent catastrophic incident at Tianjin, China, while its cause is officially unknown, is likely another example of lax petrochemical safety practices. There is hope, however, because the latest generation of gas and flame safety detection systems is smarter than ever and can provide a layered human sensory approach that is more comprehensive to protect people and facilities.

The Plant Protection Problem

Detecting combustible gas leaks and flames at petrochemical plants can be a real challenge under the best of conditions. There are large indoor and outdoor areas to protect with a congested array of complex equipment, connecting pipes and tanks. Gas leaks also vary in their behavior based on their density and other factors such as the ambient temperature and nearby air flow, including the wind in outdoor areas. The problem is that no matter how many fixed gas and flame detectors are installed a leak or flame can still go undetected if it doesn't come into contact with a gas sensor or can't be seen by a flame sensor. (Fig 1)

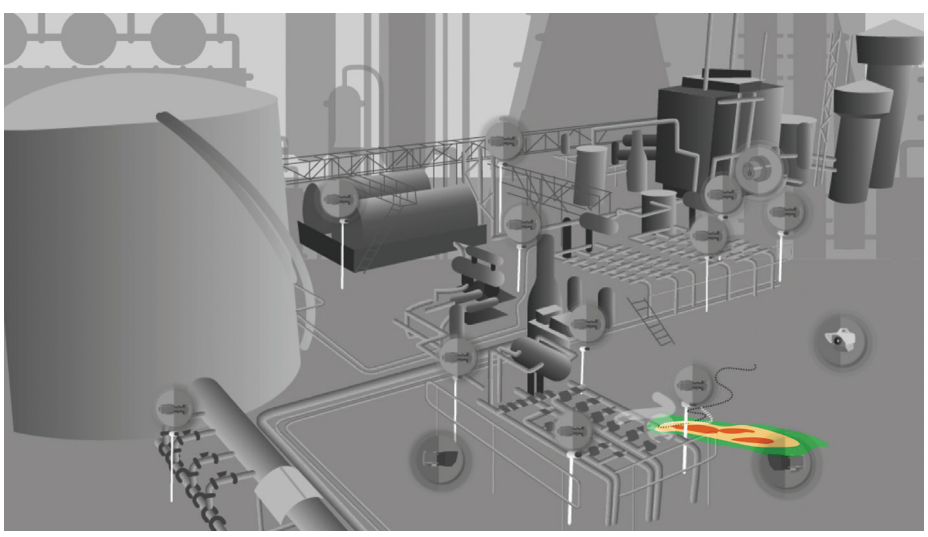

Figure 1: Outdoor Petrochemical Plant Equipment Illustration

Storage tanks and the pipelines that connect them are an excellent example of the challenge that petrochemical process and plant engineers face every day. They are located outdoors and subject to windy conditions, which can blow leaking combustible gas away from traditional gas detectors, such as catalytic bead sensors. These traditional sensors essentially "smell" the gas through a petrochemical reaction and initiate an alarm signal to the plant control system warning of the problem.

The major sensing technologies employed in the detection of combustible gas leaks and flames at petrochemical plants are: catalytic bead, point infrared (IR), open path IR, ultrasonic and optical. They are all well-known technologies with more than a decade of proven performance in the field. All of them have their unique advantages depending on the application environment. All of them are individually susceptible to false alarms under certain conditions. No single method of gas and flame detection is foolproof.

Gas leaks and flames come from a variety of sources within the petrochemical and industrial plant environment, including leaking tanks, pipes, valves, pumps, etc. Avoiding false alarms is also important because they result in unnecessary process or plant shutdowns, slowing production and requiring time-consuming reviews, paperwork, and reporting. False alarms can over time provide employees with a false sense of security because they become complacent if alarms go off for no apparent reason and then just choose to ignore them. The trouble is that you can't really determine by yourself the difference between a false alarm and a serious accident about to happen.

It's a challenge for anyone to detect dangerous gas leaks and flames reliably using any single one of the conventional technologies. IR detectors, for example, can't detect hydrogen gas because hydrogen doesn't absorb IR energy. In another example, while a pressurised pipe gas leak can create an ultrasonic noise so can other pieces of equipment that can trigger ultrasonic detectors. Optical flame detectors can be fooled by reflections or heat rising off tanks and other shiny surfaces on hot days.

The Human Sensory Model

Given the many challenges that all the best sensing technologies face, it's not surprising that a new strategy in gas and flame protection is emerging for petrochemical and other industrial plants. What if you combined all of the gas and flame detection technologies together and then layered them where they fit best in terms of their reliability in each unique plant layout?

When you think about today's gas and flame detection sensing technologies, they mimic the senses of the people who invented them. Catalytic bead detectors "sniff" gases for example, infrared and optical type sensors "see" gases and flames, and ultrasonic sensors hear "gases". What if some of these detectors behaved more like people, reacting based on their intelligence and retained past memories?

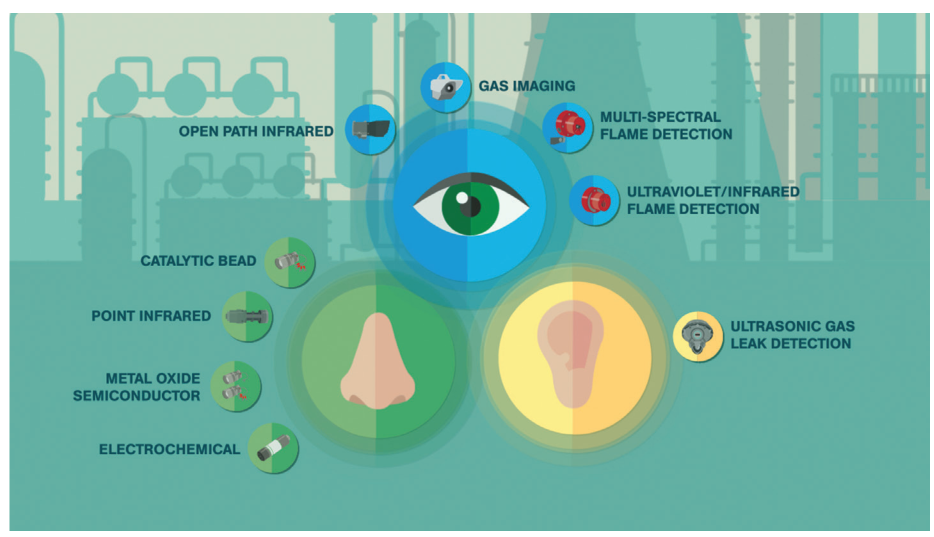

Figure 2: Human Sensory Model Chain of Dense Illustration

Layering sensor technologies throughout the plant where they fit best in terms of their reliability achieves a human sensory chain of plant defense against hazardous gases and flames (Fig 2). To understand better this new model of human sensory gas and flame detection, let's briefly look at each type of sensing technology, discuss how they work and then look at how artificial intelligence is being applied today to advanced gas and flame detection.

Catalytic Bead (CB). The operating principle of catalytic gas detectors employs catalytic combustion to measure combustible gases in air at fine concentrations. As combustible gas oxidises in the presence of a catalyst, it produces heat and the sensor converts the temperature rise to a change in electrical resistance, which is linearly proportional to gas concentration. A standard Wheatstone bridge circuit transforms the raw temperature change into a sensor signal.

Point Infrared (PIR). Infrared gas detectors use two wavelengths, one at the gas absorbing "active" wavelength and the other at a "reference" wavelength not absorbed by the gas; neither wavelength is absorbed by other common atmospheric components such as water vapor, nitrogen, oxygen, or carbon dioxide. In point IR detectors, the concentration of hydrocarbon gas is measured via the infrared absorption of an optical beam known as the active beam. A second optical beam, known as the reference, follows the same optical path as the active but contains radiation at a wavelength not absorbed by the gas.

Open Path Infrared (OPIR). The OPIR detection path of the IR beam is expanded from less than 10 centimeters, typical of point IR detectors, to greater than 100 meters. These devices can use a retro-reflector or separate IR transmitters and receivers housed in different enclosures. There are OPIR detectors available that monitor in both the LEL-m and ppm-m ranges to detect both small and large leaks. They cover large open areas, along a line of several potential leak sources such as a row of valves or pumps and also for perimeter monitoring of leaks.

Ultrasonic (UGLD). In comparison to conventional gas detectors that measure % LEL, advanced ultrasonic gas leak detectors with neural network technology (NNT) include pattern recognition capability that responds to the ultrasonic noise created by a pressurised gas leak. This ultrasonic noise provides a measurement of the leak rate and establishes warning and alarm thresholds. Gas does not need to reach the sensing element as the detector "hears" the gas leak. They are best suited for outdoor installations and indoor spaces with high ventilation rates.

Ultraviolet/Infrared (UV/IR). By integrating a UV optical sensor with an infrared (IR) sensor, a dual band flame detector is created that is sensitive to the UV and IR radiation emitted by a flame. The resulting UV/IR flame detector offers increased immunity over a UV-only detector, operates at moderate speeds of response, and is suited for both indoor and outdoor use.

Multispectral Infrared (MSIR). Advanced multispectral infrared (MSIR) flame detectors combine multiple IR sensing arrays with neural network intelligence. They provide pattern recognition capabilities that are based on training to differentiate between real threats and normal events thus reducing false alarms. MSIR technology allows area coverage up to six times greater than that of more conventional IR flame detectors.

Artificial Neural Networks (ANN)

Figure 3: Human Brain Illustration

Safety monitoring system manufacturers have applied the concept of artificial neural networks (ANN) to develop their own neural network technology (NNT) to improve conventional gas and flame detectors. NNT is based on the human brain (Fig 3), and this technology is now being applied to gas and flame detection. Detectors equipped with NNT intelligence provide a more reliable solution because they can eliminate many false alarm sources while improving overall detection.

The concept of artificial neural networks, which are mathematical models, comes from biological neural networks. In artificial neural networks, an interconnected group of artificial neurons process information and actually change structure during a learning phase. That allows the network to model complex relationships in the data delivered by sensors in a quick search for patterns (Fig 4).

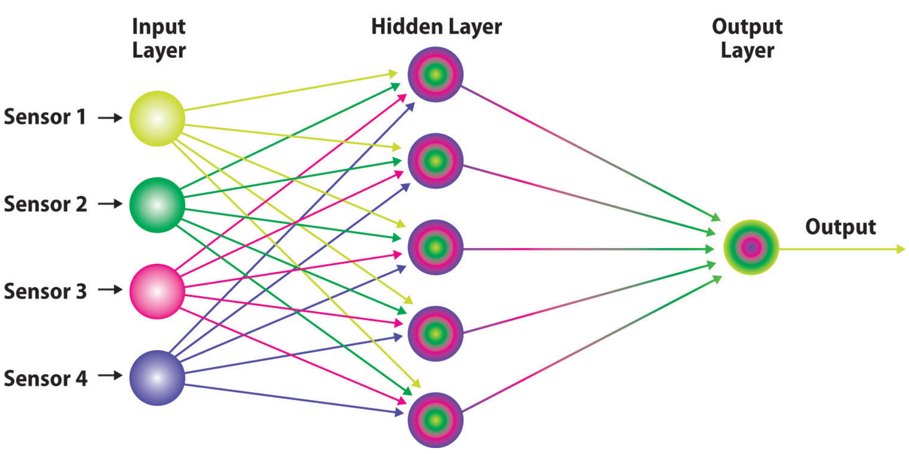

Figure 4: Sensory Network Illustration

Going back to the 1940s, computer researchers were inspired by the human brain when they developed the first conceptual model of an artificial neural network to solve certain kinds of problems that are easy for humans, but difficult for computers – otherwise known as pattern recognition. There are today a variety of applications of neural networks, some of which are at work in gas and flame detectors. They include:

- Pattern recognition
- Signal processing that can filter out irrelevant data
- Controls that manage decisions
- Soft sensors that analyse a collection of many measurements
- Anomaly detection – the ability to generate output when something occurs that doesn't fit patterns thus issuing alerts when something is amiss

NNT, which is based on ANN, is in essence an artificial intelligence. A key advantage of this technology is its ability to learn. It learns through a type of apperceptive process; meaning the comprehension or assimilation of something such as a new idea can then be related in terms of previous experiences or perceptions. NNT operates similarly and is much like a human mind in the way that it enables a person to recognise a face from the distant past. For example, the brain facilitates recognition by matching a face with an image stored as a memory.

Next generation gas and flame detectors, just like the human brain, each have thousands of pieces of data stored in their memories from hundreds of gas leak, non-gas leak, flame and non-flame events that have been observed in the past. These detectors have been trained through NNT intelligence to recognise an actual gas leak or flame based upon that data, and they make decisions about whether they are detecting an actual gas leak or flame, even if they have not seen that exact pattern in the past.

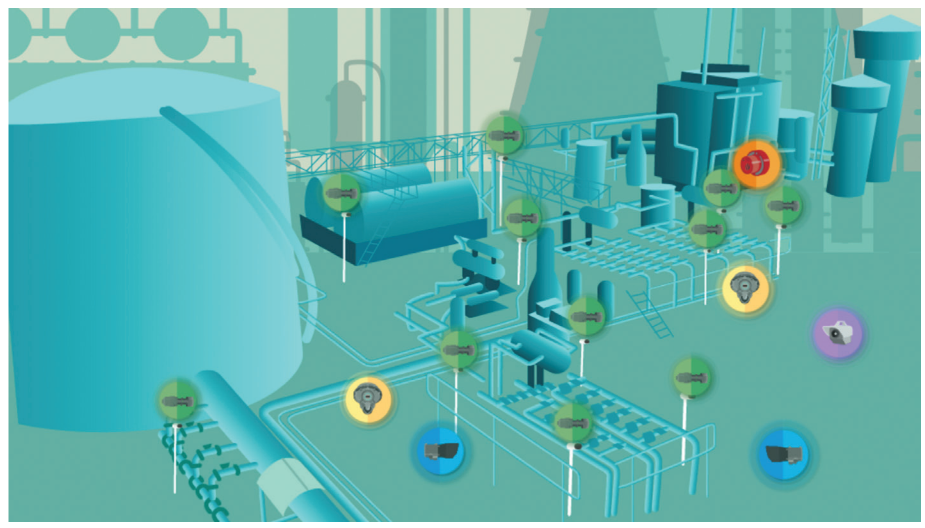

Figure 5: Human Sensory Model With Various Detector Technologies Illustration

Conclusions

Applying the concept of a human sensory model builds a chain of defense (Fig 5) to protect petrochemical and other industrial plants allows process and plant engineers to add layers of protection that increase overall system reliability. The adoption of next generation gas and flame detectors with neural network technology (NNT) adds pattern recognition capability, which mimics the human brain's ability to memorise, recall and recognise hazardous conditions based on past experience.

Gas and flame manufacturers have built decades of their safety monitoring experience into these highly intelligent devices and are thereby increasing system reliability further. When assessing the safety requirements at your plant, please don't hesitate to contact us. If you have a particular problem, we have most likely seen it and solved it before for someone else—probably several times over.

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Ardem Antabian holds dual BS degrees in chemical engineering and chemistry. Joining the company in 1999, he has held various positions, including global assignments living both in Dubai, UAE, and Berlin, Germany. He also helped develop and launch the company's advanced point and open path IR gas detectors, and multi-spectral IR flame detector.

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Ground Investigation Specialists Choose PID Instruments to Measure VOC

Leading independent site investigation, geotechnical engineering and environmental consultancy, Southern Testing, has opted to use handheld Tiger VOC detectors from **Ion Science** (UK) to measure volatile organic compounds in the field.

Recommended by Ion Science's exclusive UK distributor, Shawcity Ltd, as a replacement for equipment that was no longer supported by its manufacturer, the revolutionary Tiger PID (photoionisation detection) instruments enable Southern Testing to make an assessment of risk associated with ground-borne vapour, and also to screen soil samples, which then allows them to make the best use of their laboratory analysis budgets.

According to Dr Lawrence Mockett, Director at the Sussex-based consultancy, the ground vapour is measured in monitoring wells, while soil samples are screened by headspace, with the equipment used four or five times each week at various sites around the UK.

He says: "The Tiger's reliability, ruggedness and in-built humidity resistance are all key benefits to us. We frequently encounter high humidity conditions so it enables us to obtain reliable data where other kit has previously failed."

Designed for rapid, accurate detection, with the fastest response time on the market of just two seconds and the widest measurement range of one part per billion (ppb) to 20,000 parts per million (ppm) the robust Tiger requires no complex set-up procedure and is ready to use straight out of the box.

The instrument features worldwide Intrinsic Safety (IS) certification, making it suitable for use in potentially explosive, hazardous environments. It also meets ATEX, IECEx, UL and CSA standards.

Every effort has been made to ensure that the Tiger is the most cost-effective PID available on the UK market. It has been designed for use with long life rechargeable Li-ion batteries that give up to 24 hours usage and offer fast battery charging. Plus, inexpensive disposable parts such as filters and lamps are easy to change, minimising downtime.

Simple connectivity to a PC via the USB also ensures data may be downloaded quickly.

For More Info, email: 36395pr@reply-direct.com