Detecting Danger

Kevin Dean, MSA, UK, discusses the monitoring of ammonia leaks with laser-based gas detection technology.

Process engineers in the fertilizer industry are keenly aware of the toxic and combustible properties of ammonia (NH_3). While the tragic 2013 ammonium nitrate explosion at a fertilizer storage plant in West, Texas, US, that took 15 lives was ruled an arson incident, the force of the explosion was the equivalent of 7.5 – 10 t of TNT according to multiple sources. The improper handling or monitoring of NH_3 can be a deadly mistake.

Ammonia is a colourless gas that has a pungent smell and is naturally found in nature in trace quantities. This gas is lighter than air, which means it can form clouds that travel beyond a fertilizer plant's perimeter in the wind during an accidental release. If there is water vapour in the gas mixture, then the cloud often remains lower to the ground and can be a serious issue inside a plant for employees.

Ammonia is used in fertilizer production and a number of other industries (Figure 1). It is also used in pharmaceuticals and as a refrigerant in food processing operations, and it is a commonly available household cleaning agent. Industrial grade ammonia is typically supplied either as anhydrous ammonia in tanks (in a pressurised or refrigerated state), or in liquid form (mixed with water). The anhydrous form is used in fertilizer production.

Fertilizer for agricultural purposes is typically manufactured through the Haber-Oswald process using anhydrous ammonia (gas state) and concentrated nitric acid to produce ammonium nitrate (AN). After mixing, a complex chemical reaction occurs and the resulting solution undergoes a drying process to remove excess water. Prills (small beads) are created from the AN melt from a spray tower. For granules, the process also requires spraying and then tumbling in a drum.

According to health and safety authorities around the world, toxic exposure symptoms of ammonia, depending on the form and level, can include: irritation of the eyes, nose and throat; dyspnea (breathing difficulty), wheezing and chest pain; pulmonary edema; pink frothy sputum; skin burns and blistering; and frostbite. Various government-mandated regulatory ammonia exposure limits are in place at fertilizer and other industrial plants to protect workers. Leak monitoring of this gas is a required safety procedure anywhere it is in use.

Detecting ammonia

In addition to being a toxic gas, ammonia is combustible. While not highly flammable, ammonia in containers is explosive under high heat. The lower explosive limit of ammonia is in the range of 15%, and the upper explosive limit is 28%. The most common types of fixed and portable NH_3 gas detector sensors are electrochemical, infrared, metal-oxide semiconductor (MOS) and charge-injection (CI).

Figure 1. Fertilizer plant exterior.

Figure 2. Senscient ELDS™ laser-based open path gas detector (OPGD).

Depending on the plant layout, ammonia can be difficult to detect. Many fertilizer plants are crowded with equipment where ammonia can be present, which makes perimeter monitoring essential to protect the entire plant and surrounding community. For these reasons, plant safety teams typically rely on a mix of portable detectors worn by employees and fixed gas detection systems where 24/7 monitoring is essential.

Typical fertilizer plant process and distribution site areas that require NH_3 gas detectors include the following:

- Spray towers.
- Plant perimeter monitoring.
- Pumps and compressors.
- Pipelines and valves.
- Storage tanks.
- Rail or truck loading/unloading.
- Port shipping terminals.

While all of the various types of ammonia gas detection sensors have their strengths and weaknesses, they also do a relatively good job depending on the plant application environment and the specific installed location (fixed gas detectors), routine maintenance and staff training. Depending on the sensor technology, problems can range from saturated cells to calibration drift to dirty lenses, which all require periodic attention.

A plant best safety practice for ammonia is a multi-sensor layered approach, including the various types of portable and fixed detectors utilised where they make the most sense depending on the application needs and areas of potential employee exposure. This provides a highly secure web of coverage with some redundancy to guard people, equipment and facilities from accidental gas releases.

Some of the hazardous gas detector problems, including ammonia, most frequently cited by all types of plant operators include a relatively short gas sensor life, the potential for sensor poisoning or fouling (contamination) and the need for frequent sensor testing, cleaning, maintenance and replacement. For this reason, the safety industry works continuously to improve existing gas sensor technologies and to develop new ones that address these problems.

The solution

To help fertilizer plants better address ammonia gas detection concerns, MSA offers a new open path gas monitoring technology that can be used in multiple fertilizer plant process locations, including perimeter monitoring. This new approach to NH_3 gas monitoring provides a maximum level of protection with the highest service uptime availability and virtually no maintenance.

Senscient ELDS™ gas detectors (Figure 2) create a highly reliable full detection perimeter around any fertilizer plant for the detection of NH_3 and are suitable for use inside the plant as well in process areas. The technology behind ELDS open path gas detectors (OPGD) relies on enhanced laser diode spectroscopy (ELDS) to detect specific toxic and flammable

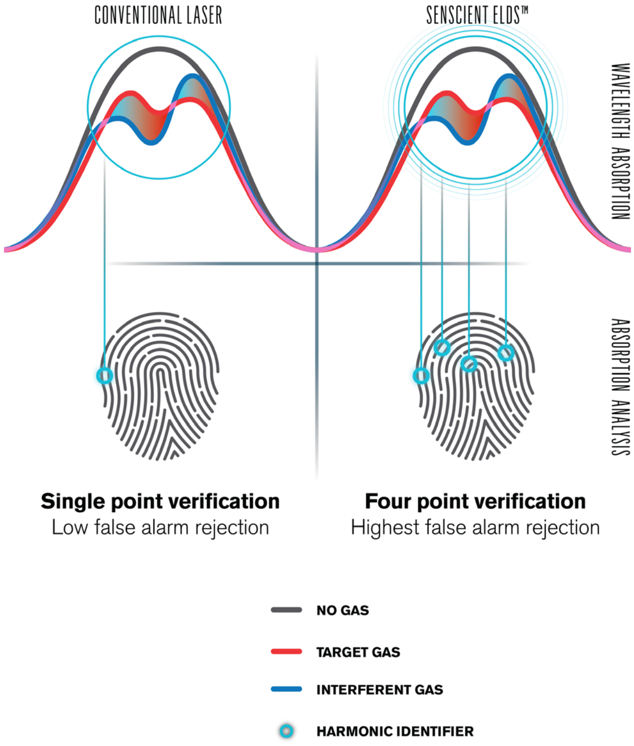

Figure 3. Harmonic Fingerprint ensures precise measurement.

gases. In the event of a gas leak, the sensor's laser technology recognises and analyses a gas's specific harmonic fingerprint, which in this case is NH_3, and issues an alarm when the gas is present.

During normal operation, some of the detector's laser light is reflected continuously through a sample of the target gas contained by a hermetically-sealed reference cell. This design ensures the laser remains locked on the selected gas wavelength for the specific target gas (such as NH_3). False alarms caused by interference gases, which are experienced with other detection technologies, are no longer a problem. The detector's patented harmonic fingerprint technology (Figure 3) helps ensure precise gas NH_3 recognition, eliminating the potential for false alarms, even during adverse environmental conditions.

False alarms are a serious problem with many gas detection technologies. They can result in excessive plant downtime, which often requires complex investigations and regulatory reporting. From a safety perspective, frequent false alarms lead to a lack of confidence by employees in the gas detection technology and a culture of apathy that can cause employees to fail to act promptly during an actual emergency event.

Class 1 eye safe lasers designed into ELDS detectors are used to penetrate thick fog, heavy rain and snow beyond the capability of traditional open path infrared (OPIR) detectors. With its daily automated SimuGas™ functional safety self-check, there is no need for the typical OPIR sensor gas checks and recalibrations requiring field technician time to address. Unlike electrochemical cells, ELDS sensors are target gas specific and have no consumable sensing elements.

Fertilizer plant production teams will appreciate that the ELDS NH_3 gas detectors are relatively easy to install, commission and operate. They also feature Bluetooth® wireless technology with advanced smart diagnostics. Using a mobile device and product specific software, the ELDS can be interrogated from a safe distance. This is especially useful in hard to access high areas where scaffolding and safety harnesses might be necessary to prevent employee falls.

Process engineers at fertilizer plants will find this gas detector's performance to be excellent for perimeter monitoring and other interior plant process applications. With a fast response time (<3 sec.), ELDS technology provides a relatively fast alert to the presence of NH_3 gas compared to other toxic gas detector technologies. The ELDS gas detector features separate transmitter and receiver assemblies, which are certified for use in potentially explosive atmospheres and can detect NH_3 over distances of 5 – 120 m.

The ELDS gas detectors are constructed of high grade corrosion resistant 316 stainless steel, which helps ensure long life in rugged industrial plants. Unlike traditional point detectors and other field instruments, NH_3 corrosion is of less concern as this transmitter/receiver arrangement allows them to be located away from the high NH_3 concentrations found close to any potential leak source.

ELDS detectors are ideally suited for open and enclosed environments. This includes the cold freezing winter temperatures in northern latitudes or the high temperatures required for service in much of Asia, the Middle East or Africa. Heated optics provide service over a wide temperature range from -67°F to 140°F (-55°C to +60°C). ELDS detectors are also hazardous area approved to CSA, UL Class 1, ATEX, IECEx, EAC and INMETRO standards.

With their daily auto-self testing diagnostic feature called SimuGas, ELDS detectors offer significant installed and operational cost savings over conventional fixed point toxic gas detectors. Manual intervention and ongoing costs for routine real gas testing are eliminated with SimuGas. Often, the cost of inspecting and maintaining some gas detector technologies can over time exceed the cost of the actual instrument.

While the cost of an open path detector may be higher than traditional point gas detectors, the total installed cost can be similar or less expensive than installing multiple fixed point devices to achieve an equivalent coverage area. For example, to achieve a 50 – 60 m path length, a plant may require six separate point gas detectors to provide the same monitoring effectiveness as one open path ELDS detector.

ELDS detectors are also virtually maintenance-free. They have no consumable parts, therefore resulting in zero ongoing costs for replacement of sensing elements and associated service labour costs. These devices are factory calibrated for life, requiring no re-calibration effort, with the result that the ELDS detectors offer significantly reduced lifecycle costs compared to traditional point gas detectors.

Conclusion

Ammonia is both a toxic and combustible gas hazard within fertilizer plants. When developing an NH_3 safety plan, be sure to consider relying on the gas sensing technology that will be most effective in the various process areas inside the plant and surrounding communities. Gas detection technologies are not necessarily interchangeable because of the variability in the plant environment (inside and outside). Also, be sure to consider maintenance and reliability (failure to alarm and false alarms) requirements. Over the long-term, the cost of maintenance can exceed the initial cost of the detector. WF