DETECTING HAZARDOUS AMMONIA LEAKS IN REFINERIES AND PRODUCTION PLANTS

Leaking ammonia (NH_3) gas, no matter the industrial process, application, or type of plant, is a potential danger to employees, plant equipment, and surrounding communities. Fortunately, today's newest ammonia fixed gas sensor technologies, including infrared (IR), electrochemical, laser, and ultrasonic, provide highly effective point and area monitoring solutions to help prevent accidents.

Fig 1. Ammonia Gas Production

The production of ammonia around the globe relies primarily on natural gas (less polluting) as a feedstock or coal (Fig. 1). In addition, the petrochemical industry and other heavy industries rely on ammonia for nitrous oxide (NOx) control in stacks or flues to prevent air pollution. The demand for ammonia production is expected to continue growing in the near term as a fertilizer, refrigerant and potentially a hydrogen-carrier gas to reduce reliance on carbon-based energy[1].

As a potential carrier gas for carbon-free hydrogen (H_2) fueled energy, ammonia production could rise dramatically as the world embraces it as part of the solution to de-carbonize the economy and reduce global warming[2]. Due to the challenges of producing, handling, and storing H_2, the comparatively stabile nature of NH_3, which can be converted to H_2 near or at the source of use to power emission-free fuel cells or turbines, is expected to gain traction.

About Ammonia

Ammonia is a colorless gas that is naturally found in nature in trace quantities. This gas is lighter than air, which means it can form clouds that travel beyond a refinery or industrial plant's perimeter in the wind during an accidental release. If there is water vapor in the gas mixture, then a cloud can form and often remains lower to the ground, which poses a great risk to employees.

In addition to being a toxic gas, ammonia is potentially combustible. While not highly flammable, ammonia in containers is explosive under high heat. The lower explosive limit of NH_3 is in the range of 15 percent, and the upper explosive limit is 28 percent. Refineries, NH_3 production plants, and storage facilities are today protected with a mix of NH_3 sensing technologies matched to specific hazards to provide point, perimeter, and personal protection.

Ammonia Exposure

No matter the production process or end-use application, ammonia gas is toxic and dangerous in lower concentrations and lethal in higher ranges. NH_3 is well known for its pungent odor, and most people can smell it right away unless they've had prolonged exposure. The trouble is with longer periods of exposure, or repeated exposure, a person's sense of smell becomes immune to NH_3 and leaves one vulnerable to the toxic effects of this gas.

For ammonia, the U.S. Occupational Safety and Health Administration (OSHA) specifies an 8-hour exposure limit of 25 ppm and a short-term (15-minute) exposure limit of 35 ppm in the workplace. Recommendations and regulations vary globally and are updated periodically as more information becomes available, so limit values should be confirmed with respective national agencies and/or organizations before proper usage.

Detecting Ammonia Leaks

Ammonia can be difficult to detect, depending on the plant layout and environment. Oil and gas refineries, NH_3 production plants, and storage facilities are often crowded with equipment where the gas could be present, resulting from leaking valves or elbows and other production equipment, such as pumps. For these reasons, plant safety teams typically rely on a mix of portable detectors worn by employees and fixed gas detection systems.

When evaluating ammonia sensors for use in occupational exposure assessment, there can be several competing types from which to choose. For process and plant engineers responsible for fixed gas detection systems, a best practice for plant safety is to follow a multi-sensor layered approach with strategic NH_3 detector positioning that provides a highly secure web of coverage to guard against accidental gas releases.

Electrochemical Cell Sensors

Target gas-specific electrochemical (EC) sensors are available for many of the most common toxic gases, including ammonia. This sensing technology functions on principles similar to those found in batteries. Ammonia gas enters the sensor inlet and then generates a chemical reaction with a catalyst that is in contact with an electrode. When the target gas encounters an electrolyte solution on the working electrode, a reaction occurs (Fig.2). This reaction causes a release of electrons, whereby the flow of the electrons is measured as current within the sensor. The current is proportional to the gas concentration and is measured in parts per million (ppm) of the gas.

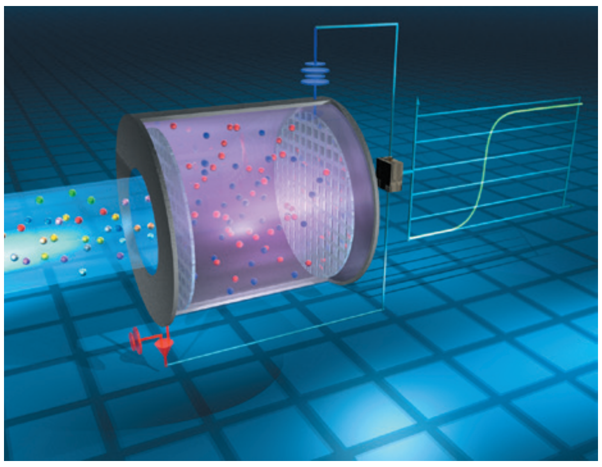

Fig 2. Electrochemical Cell Sensing (Graphic)

Most traditional ammonia electrochemical sensors have a 1-2 year life, but actual lifetimes can be on the order of months or weeks when ammonia concentrations are high or where extremes in temperature or humidity are encountered. It can be difficult to predict when an ammonia sensor will begin to lose sensitivity, so frequent calibration may be needed to ensure an accurate reading.

They also often degrade at a faster rate when exposed to heavily polluted conditions. Another limitation of traditional EC sensors is cross-sensitivity to interfering gases, or non-targeted gases, which will also be detected by the sensor resulting in skewed measurements of the desired gas.

MSA's patented XCell® technology utilizes the same principles found in traditional electrochemical sensors but employs a number of significant physical design advancements for better performance and longevity. Instead of a typical water-based electrolyte, XCell sensors employ a unique class of ionic electrolyte liquids that features an evaporation-resistant profile capable of withstanding extreme environments with large humidity and temperature fluctuations (-40 to +60°C).

Another differentiator is the choice of catalyst in the electrode material. Unlike traditional electrochemical sensors, the XCell catalyst is not consumed by the gas reaction. Contact with ammonia has virtually no effect on the lifespan of the sensor.

They also can withstand background gas concentrations without reducing the sensor's life.

In addition, the mechanical design of the sensor is optimized for operational efficiency. Every arrangement and placement of the sensor components have been strategically positioned to develop the most efficacious interaction between the electrolyte, electrode catalyst, and target gas regardless of environmental conditions to overcome.

These design advancements are instrumental in heightening sensor performance and lifetime, which can help keep plants safe from ammonia gas leaks, while lowering the cost of maintenance for the user. The result is a relatively lower instrument lifecycle cost.

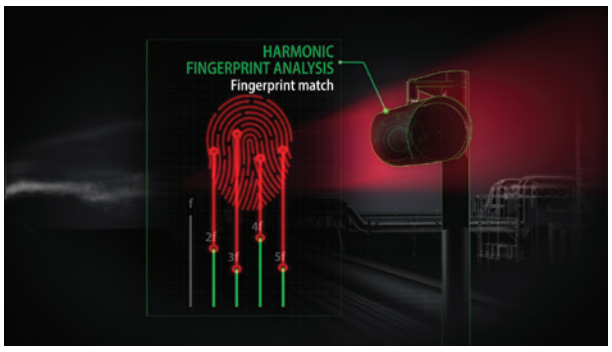

Fig 3. Enhanced Laser Diode Spectroscopy (ELDS) Sensing

Laser Based Open Path Detectors

Laser-based open path gas detectors (Fig. 3) use the effect of absorption of specific optical light by ammonia. This sensor technology utilizes enhanced laser diode spectroscopy (ELDS), which is available with the Senscient ELDS™ Gas Detector from MSA. Unlike other point gas detectors that measure the gas concentration at a particular (fixed) location, ELDS gas detectors measure the concentration (ppm.m) over the full distance between the transmitter unit and receiver unit.

ELDS open path detectors analyze the signal using a technique called Fourier transform, which breaks the signal into several component parts that can be analyzed against a predetermined pattern that is similar to a harmonic fingerprint. That means there are no false alarms from interference gases and the detectors are less prone to water vapor interference, and are more reliable with heightened performance in rain, snow, or fog.

Ultrasonic Gas Leak Detection (UGLD)

UGLD technology detects leaks from pressurized gas systems by sensing the airborne ultrasound produced by the escaping gas (Fig 4). This means that the ultrasonic gas leak detectors sense gas leaks at the speed of sound in a detection radius up to 28 meters (92 ft) depending on the gas, leak size, and leak rate.

Unlike conventional point or open path detectors, ultrasonic detectors do not have to wait for gas to accumulate into a potentially dangerous gas cloud and come into physical contact with the detectors. They instantaneously raise an alarm if a leak is detected. The ultrasonic acoustic gas leak detector picks up the leak without being affected by conditions such as changing wind directions, gas dilution, and the direction of the gas leak—conditions relevant for most outdoor gas installations.

Conclusions

Compared to just 20-30 years ago, ammonia point sensor technology has substantially improved, with the new design and introduction of ionic liquids in the chemistry of electrochemical sensors. Moreover, they can be supported by other ammonia perimeter or area detection technologies such as Enhanced Laser Diode Spectroscopy open path gas detectors and Ultrasonic gas leak detectors.

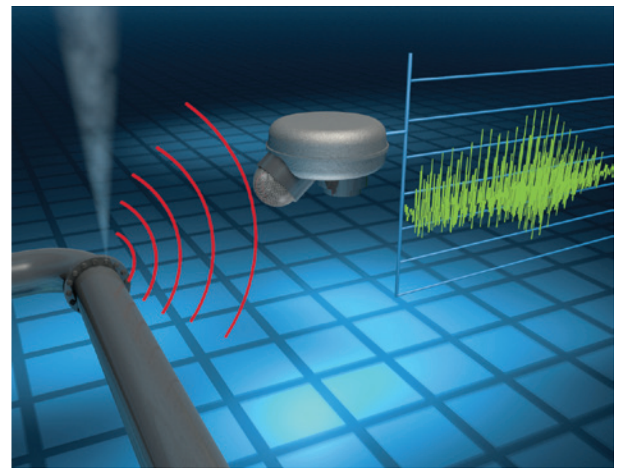

Fig 4. Ultrasonic Gas Leak Detection

When assessing a plant's safety requirements, users should consider a layered strategy to design the most comprehensive gas detection system for the facility. There is no single perfect solution, so understanding the monitoring environment and the specific benefits and limitations of the sensors selected is paramount to ensuring optimal plant safety from ammonia gas releases.

Footnotes

1. U.S. Energy Information Agency, Natural Gas Weekly Update, April 1, 2021: https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2021/04_01/

2. Chemical & Engineering News: March 8, 2021:

https://cen.acs.org/business/petrochemicals/ammonia-fuel-future/99/i8

Author Contact Details

Sarah Rajasekera, Segment Marketing Manager FGFD, MSA Safety • 1000 Cranberry Woods Drive, Cranberry Township, PA 16066, USA

• Tel: +1-724-776-8600 • Email: sarah.rajasekera@msasafety.com • **Web: msasafety.com/detection**