Early Warning Solution of Ammonia Leaks in a Melamine Plant

Introduction

Gas leaks of toxic or flammable gases are a huge and yet often underestimated hazard potential in the ammonia and urea industry. More than 30%[1] of dangerous gas leaks are not detected by gas sensors. Once in the air, a hazardous gas cloud is hard to control, especially because the situation, exact location, the distribution and propagation direction are difficult to access with common methods.

36% of major gas releases & 69% of significant gas releases are undetected by gas detectors[1].

Fig 1: Classification of gas releases (according to HSE) according to the total amount of gas that is released. For situation assessment this information is far more relevant than gas concentration.

Why Gas sensors fail

As of today almost all gas warning systems that are deployed in the field are based on measuring the concentration of the gas. A gas sensor that should warn upon a gas release does exactly this, the information provided by the sensor derives from the gas concentration the sensor is exposed to. This connection between gas concentration and information is the reason for failure.

The image on the right displays the measurement of a small gas release experiment. The time series display illustrates how quickly the gas is changing it's propagation direction.

While the measurement from the distance captures the gas at all times, a local gas sensor would return erroneous information. With the unpredictable distribution the correct placement of a gas sensor is impossible. Furthermore a conclusion on the situation from a single concentration information can never be achieved.

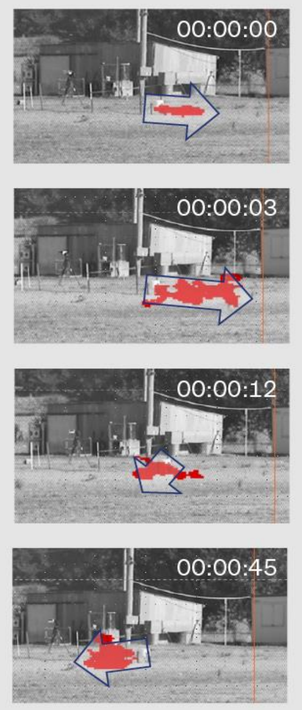

Fig 2: Measurement example of a release experiment of methane that shows how quickly the propagation direction of the gas cloud is changing. Correct positioning of a gas sensor is not possible.

The image below illustrates how a gas upon release propagates in the direction of the wind and gets diluted perpendicular to the propagation direction. The concentration measurement of a gas sensor provides no indication on the total amount of gas that is released or the hazardousness of the situation.

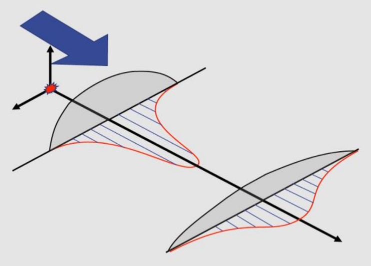

Fig 3: In the field the gas gets distributed perpendicular to the propagation direction. The gas concentration varies by orders of magnitude if the sensor is slightly off center.

The melamine plant

Fig 4: The melamine plant (name and location confidential) is part of a larger chemical park and very close to densely populated areas. The main purpose of the early warning solution is to detect a release in real time and track the moving gas cloud.

Scope of an Early Warning Solution

We introduce a new remote monitoring technique that offers both the early leak detection and the situation assessment for the incident. In the application of monitoring the melamine plant the early warning of ammonia emissions and the situation assessment is the primary goal. Large spontaneous emission that can occur on various points of the process shall be detected and the control room is to be warned of the incident in real time.

The gas cloud shall be assessed entirely and information of the location, the size of the cloud as well as information of the concentration distribution within the cloud shall be displayed and routed to the DCS. Once the gas cloud is located, the propagation of the moving gas cloud has to be tracked in order to define hazard zones for risk mitigation. Information on the position and the distribution of the gas cloud is essential information for a rapid response by first responders.

This situation assessment that is based on real measurement data of the gas cloud in it's entirety, rather than distribution simulation, contributes to a coordinated response for fire fighters and potential evacuation decisions.

In addition the installation is capable of detecting various other toxic or flammable gases from the melamine plant and neighbouring sites. Without much effort the solution can always be scaled up this way covering larger areas and a wider range of chemical compounds.

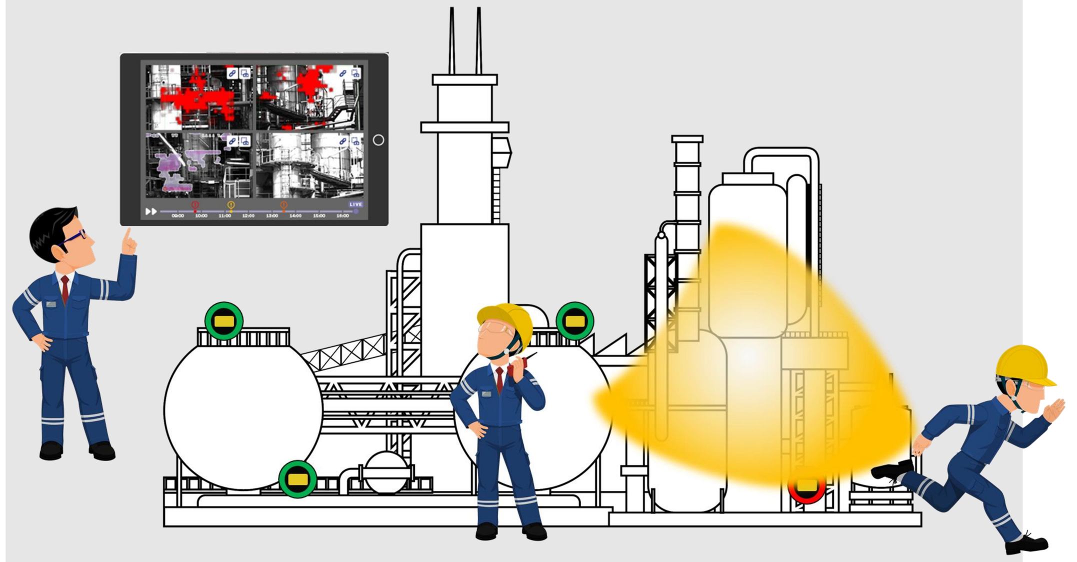

Fig 5: Traditional emergency response training uses the wind direction to find the next safe assembly point. The information of the location of the leak and the gas cloud can now add an additional layer of safety.

Situation assessment from the distance

The concept of remote monitoring is the situation assessment from large distances. The measurement of the gas from a distance of up to 4 km is the key benefit of this approach: It is the only way to detect a gas release without prior information about the location of the gas leak and the only measure to provide the necessary overview to assess the entire gas cloud rather than just measuring arbitrary concentration values at uncertain positions. The scanfeld™ early warning solution that is used for the monitoring of the melamine plant uses remote monitoring sensor units to detect a gas release in real time, assesses and visualizes the gas cloud distribution and tracks the moving gas cloud.

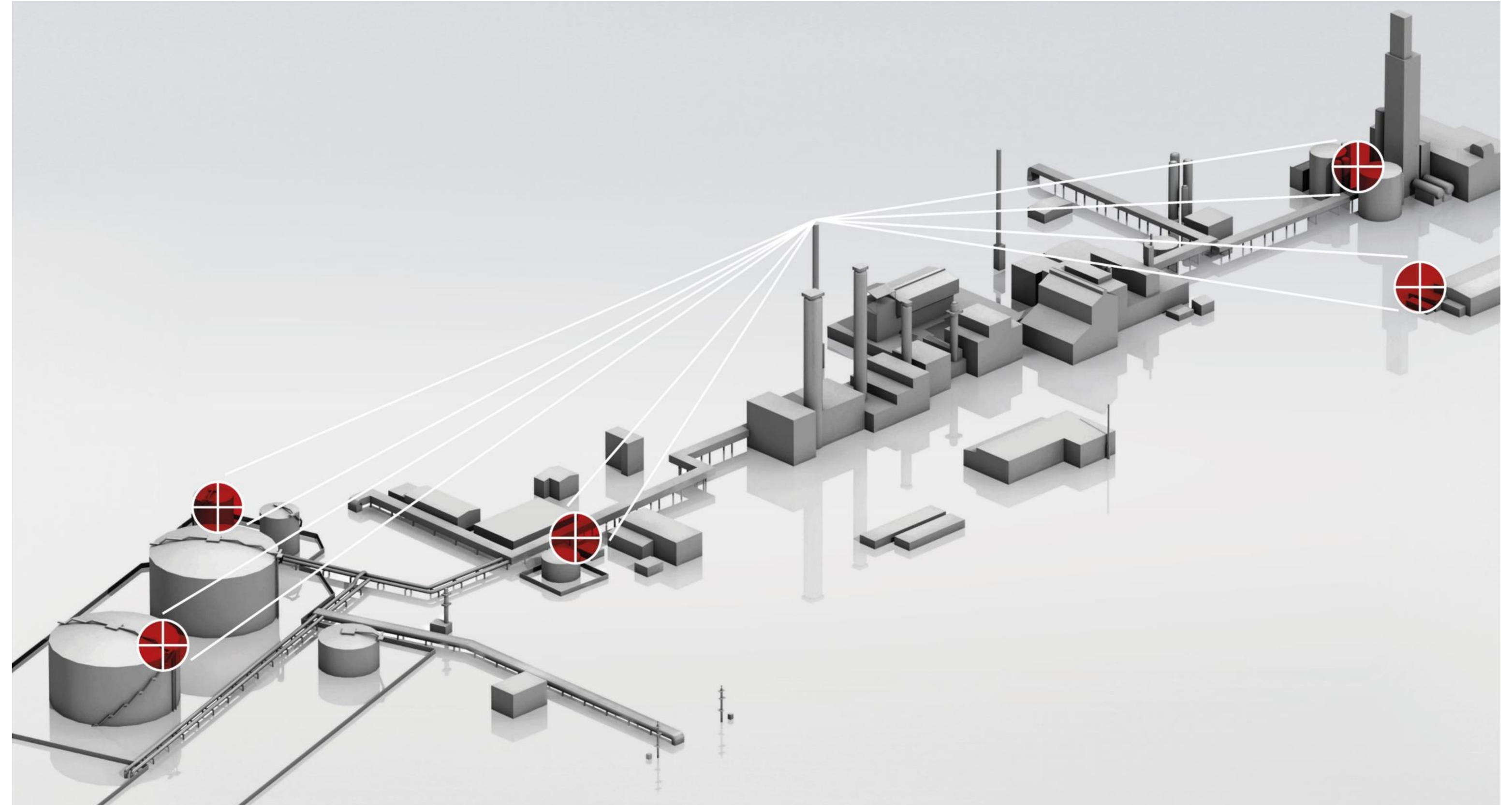

Fig 6: Remote monitoring with optical measurement technology allows surveillance of vast areas with a small number of sensor units.

scanfeld™ sensor units: FTIR spectroscopy

The scanfeld™ sensor units are remote sensing gas analyzers for the identification of a hazardous gas over long distances. The measurement principle of this optical measurement technology is based on passive FTIR spectroscopy. Passive means it makes use of natural infrared radiation, or heat radiation, that is present at all times day and night.

The FTIR spectrometer analyses the infrared radiation spectrally with a high frequency resolution over a wide spectral range. Each gas that is in the field of view of the instrument leaves a compound specific fingerprint in the measured spectrum. With this technology over 400 hundred different chemicals can be identified and mixtures of different gases can be analyzed for their composition.

FTIR spectroscopy needs no calibration and works over an exceedingly large concentration range from single digits ppm to double digits %. In the spectral region used by the scanfeld™ sensor units the system is fairly insensitive to water and atmospheric gases thus allowing distance measurements from up to 4 km distance.

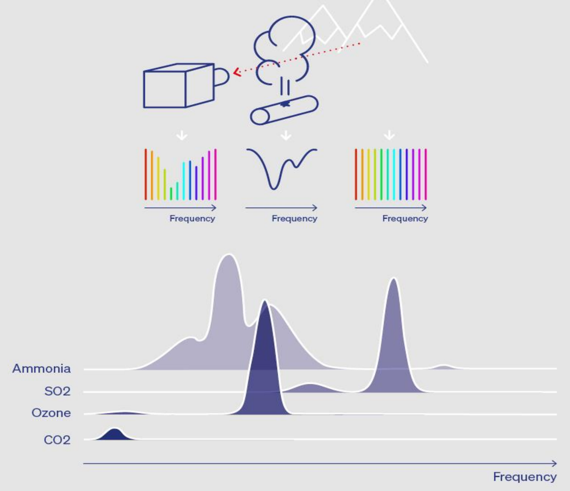

Fig 8: The use of passive FTIR spectroscopy allows chemical analysis of the gas cloud composition for >400 gases at kilometers distance.

Fig 7: The scanfeld™ sensor unit provides imaging remote sensing in all viewing directions.

The scanfeld™ sensor units are scanning imaging devices. They can be positioned in any direction. By scanning a defined area they analyze the gas composition in any viewing direction thus assessing the gas cloud distribution. The measurement example below shows a scan result that was recorded in less than 15 s. The red frame indicates the scanning area. Each point where a gas from the target compound list is identified, is marked red in the video image. As the visualization displays the result of the chemical analysis the information is very specific.

- → Leak detection without prior knowledge of the location of the leak
- → Spectral validation of identified ammonia
- → Visualization of gas cloud

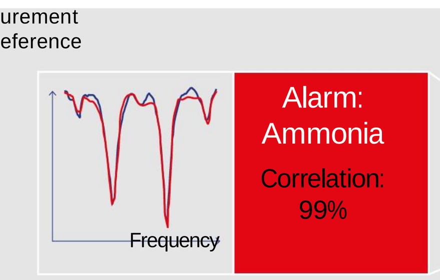

Fig 9: Measurement example of a small leak. The total amount of gas measured is less than 1g.

Rapid situation assessment UI

Key aspect of an early warning solution is the readability and usability of the information that it provides. Gas clouds that are detected in the early phase of the release and later tracked when moving over the site and into the neighboring community need easy-to-interpret visualization. The scanfeld™ user interface is designed to provide both the intuitive visualization and overview in rapidly evolving situations.

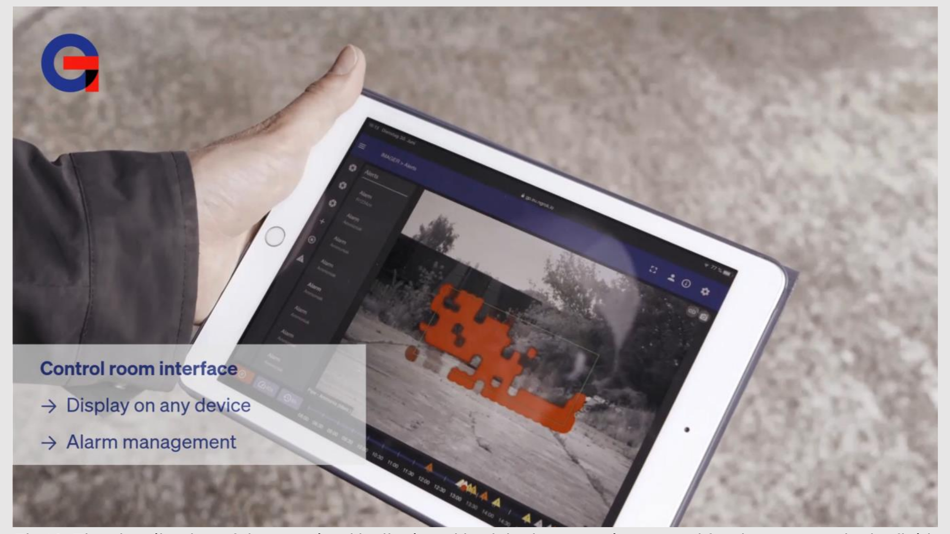

Fig 10: The visualization of the gas cloud is displayed both in the control room and for the operator in the field in real time. Alarm incidents are easy assessable and navigation along a time axis allows a quick understanding how a situation evolves.

The detection of a gas cloud triggers the visualization of the cloud and creates an alarm event that is logged and can be assessed at any time. For intuitive display of the situation at hand and the development that lead to the incident, the events are displayed in a timeline. The user can move the image timeline back and forth and watch the incident again in fast forward. Each alarm incident can be selected to jump to the incident view.

Integration

To exploit the full potential of situation assessment that comes with remote measurement, the approach demand a high level of automatization. Taking measurement data of a gas cloud alone would rely on the interpretation of data on behalf of expert personnel. Instead the solution is automated to a degree that the relevant information of where is how much of which chemical is provided for the expert to interpret.

The scanfeld™ solution is based on the deployment of the remote sensing units in cooperation with software modules that derive the chemical analysis and visualization of the gas cloud in real time, the classification of the measurement data on a high level that can signal the DCS and the automated tracking of a moving gas cloud. For this project, the software modules scanfeld™ CHEM Imager is used for the analysis and visualization in the control room.

Automatic Hazard Levels

- → Warning levels
- → Automatic distinction from technical emissions
- → DCS integration

Fig 11: The software module scanfeld™ CHEM Profiler classifies the detected incidents based on evaluation of the measurement data in both space and time.

Live Gas Cloud Tracking

- → Localization and tracking of moving gas clouds in real time
- → Map based representation of location and hazard zones

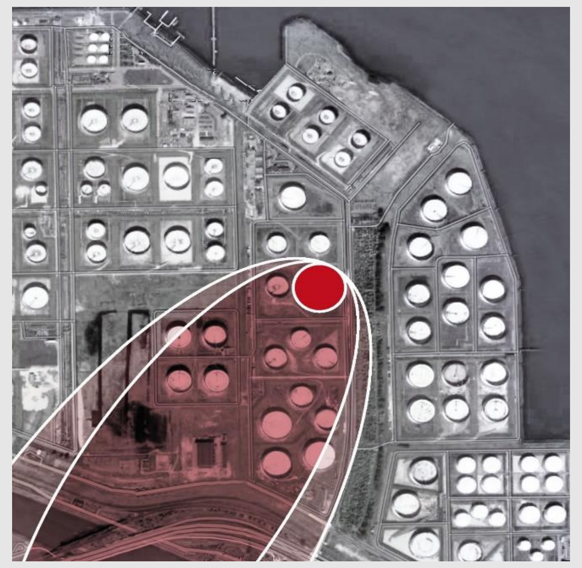

Fig 12: The software module scanfeld™ CHEM Tracker coordinates the movement of all sensor units to locate and track a moving gas cloud.

Contact

All information on the scanfeld™ early warning solution can be found on our website or on our microsite at AmmoniaKnowHow.com. If you request more detailed information please send me an Email.

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https://www.ammoniaknowhow.com/scanfeld-an-innovative-solution-for-leak-detection/

https://www.linkedin.com/company/28560004

[1] *Health and Safety Executive (HSE) Offshore Hydrocarbons Release database*