

On the Lookout for Gas Leaks – a Remote Sensing Approach for Detecting Dangerous Gas Emissions within Chemical Plants

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We report about recent applications of our scanfeld solution and novel application areas. scanfeld is a system for remotely detecting dangerous gas emissions in real time and it is improving the safety of ammonia installations and other chemical plants. The Grandperspective scanfeld system warns operators within seconds if ammonia or other gases are accidentally released.

The infrared optical measurement technology covers vast areas of more than 1 km² per sensor. Based on a passive spectroscopic technology the scanfeld sensors provides chemical identification and quantification of airborne substances, mainly gases that can present dangers to plant operators, the environment, and the immediate neighbourhood.

The practical application and verification are demonstrated for a particular use case – the Chemelot park in The Netherlands. Here the installation of two scanfeld units allows the 24/7 monitoring of multiple processing units handling ammonia, urea, and melamine. With the connection to the operator's DCS system the system is fully integrated in the operation of the plant and becomes an integral part of the plant management. The use of two units furthermore permits the localization and quantification of gas clouds in case of release events. The real time tomographic reconstruction of the clouds assists in providing precise warning of neighbouring areas and is a direct benefit for accident mitigation.

Two aspects of the scanfeld solution are presented in more detail. Firstly, it represents an early warning solution which enables plant operators or emergency responders to react swiftly in case of unexpected emissions. In addition to that, the system collects data continuously which allows the long-term evaluation of industrial installations. Statistical methods as well as big data analysis can provide more insight about technical emissions, long term trends, and operations in general, thereby providing data for the optimization of production and preventive maintenance.

Detecting gas emissions from the distance

A growing awareness of safety, combined with higher population densities in urban areas, add demands for emission monitoring and rapid emission detection in industrial sites that process, store, or handle dangerous gases. New markets such as ammonia as fuel and storage for hydrogen are emerging and create new challenges for public safety and the perception of the technology within the society.

Implementing large area surveillance for gas leaks is the only viable means of ensuring the continued operation of such industrial sites near populated areas. When production and storage areas become larger, stationary gas detectors prove ineffective at reliable early warning. Monitoring large areas for such emissions can only be accomplished with stand-off measurement technologies: Fourier transform infrared spectroscopy (FTIR) is well known from routine laboratory chemical analysis, but it is also an established technology for remote sensing. First responders and security forces use FTIR remote sensing for the supervision of large areas in the event of chemical releases or terrorist attacks.

The method is selective among hundreds of chemicals while being extremely sensitive to many organic compounds, ammonia in particular. The main advantage of FTIR remote sensing over other technologies is the fact that it can be used passively without lasers or the illumination of the target area. Like a highly sophisticated camera, it shows the gas even from miles away.

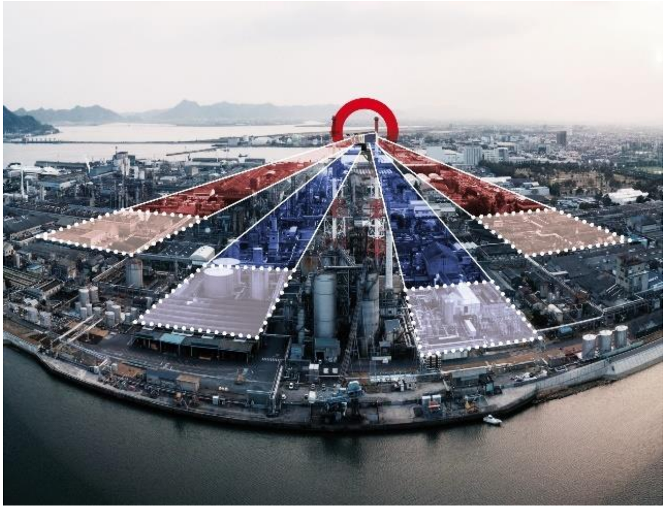

Figure 1 Remote Monitoring principle

The scanfeld® system from Grandperspective is a specially designed remote monitoring system that offers a high-level classification of different gas release events. By providing a real-time monitoring approach to gas leaks, scanfeld can be used to observe large industrial sites using just a few sensor units. Alongside providing early warning detection and real-time monitoring, the scanfeld system can also help with post-release safety procedures involving third parties (for example, health and safety inspectors or firefighters). In summary, the scanfeld system can help in multiple ways to keep industrial sites safe when chemicals are inadvertently released into the local environment.

Scanfeld is based on the passive infrared technology FTIR to detect and identify airborne substances and gases that can present dangers to the plant operating staff, the environment, and the immediate neighbourhood. The monitoring solution uses scanning imaging remote sensing units. Covering the entire fingerprint region of the infrared, they detect and identify over 400 different chemical compounds, for instance ammonia or methane. The detection limit is a specific value for each chemical. For example: A 10 m wide ammonia cloud under normal ambient circumstances and at 1 km distance, the detection limit is in the order of 4 ppm. The identification algorithms and quantification techniques that can automatically identify and quantify a chemical compound in the infrared spectrum, are certified according to VDI4211. Due to the spectral region in the infrared over long distances the measurement technique is not affected by weather conditions such as rainfall or fog. Without the need for ambient light, the measurement technique also works day and night 24/7.

Figure 2 scanfeld system overlooking a chemical plant

An early warning solution that effectively minimizes the risk of exposure in case of an ammonia release needs to provide specific information of the localization and the distribution of the ammonia cloud.

Ammonia Detection at Chemelot Chemical Park Geleen

The Chemelot industrial park is located in a densely populated region near Maastricht, the Netherlands, and Düsseldorf, across the border in Germany. It is one of the largest chemical parks in Europe, with numerous companies – such as OCI, Arlanxeo, DSM and SABIC – present. The two major production streams onsite process naphtha/gasoil to hydrocarbons or plastics and natural gas to ammonia, fertilizers, and specialty chemicals. Within the Chemelot industrial park is the Brightlands Campus, a hub for start-ups, R&D facilities, and education with more than 3900 researchers, entrepreneurs and students. The campus is situated close to the production facilities; for example, the OCI Nitrogen ammonia and urea complex is less than 400 m (1300 ft) away.

Figure 3 Chemelot north with Brightlands campus (front)

The goal of the installation at the Chemelot Chemical Park in Geleen is to provide early warning for hazardous ammonia releases with specific situation assessment for the entire park within minutes. With this monitoring solution the overall risk of hazardous exposure to a toxic ammonia gas cloud for either personnel or neighbours shall be reduced significantly.

A hazardous event that has its root cause in an accidental gas release is the result of subsequent failures of preventive and mitigation measures. Risk analysis must take all stages of the incident into account and define safety measures to minimize risk. Figure 4 displays a fault tree model of the various stages of an incident. To prevent further escalation, each stage of the incident needs its own barrier. scanfeld establishes a barrier for each one of the stages by providing warning levels and detailed information when needed. Conversely, scanfeld™ helps to rapidly scale down alert levels once the immediate threat is gone and safe conditions are confirmed. Four barriers are put in place to prevent a hazardous situation in case of a large ammonia release. The real time situation assessment with alert levels, side view of the gas cloud forms each sensor unit perspective and real time gas cloud mapping provide an addition barrier to mitigate the effects of an incident.

The first principle of a reliable monitoring solution is the permanent monitoring of the production and storage areas in normal operation mode and early warning in case of an unexpected gas release.

In the early stage of the event, quick notice and correct situation assessment are crucial. Early warning of the gas release can prevent further escalation of the situation if the operators in the control room recognize the situation for what it is correctly. Measures taken at an early stage of an incident are most effective. But from an operator's point of view they are also the riskiest decision to make if measures taken eventually lead to down-time and loss of productivity. The need for quick action and the pressure to take moderate measures are conflicting especially in an early stage of the event. Operators are naturally hesitant to shut down, until the situation is clear. In order to prevent potentially hazardous situations, a significant gas release, as defined by (McGillivray & Hare, 2008) needs to be detected quickly and correctly assessed.

To fulfil the need for a solution that warns reliably in case of the unpredicted event, early warning monitoring must cover all relevant areas within the production site, the loading areas and all other critical infrastructure including pipelines. Remotely monitoring critical infrastructure is a more effective way of covering large areas with a small number of remote sensing units.

Gas releases in the open are fundamentally different from gas emissions in confined spaces. The gas coming from the release point is diluted more quickly in open field than in confined spaces, which reduces the risk. On the other hand, it also makes it harder to detect and map the distribution of a gas cloud. As propagation is subject to wind dynamics, there is the risk of local gas accumulation and the areas of high likelihood for accumulation are hard to predict. Especially among dense infrastructure like production facilities, wind dynamics are extremely complex (ProcessNet-Fachgemeinschaft „Anlagen- und Prozesssicherheit", 2017), (Lees, 2012). As a result, even the assumption that a gas heavier than air accumulates near to the ground is not necessarily true in the near field around the release point. Also, a gas lighter than air does not necessarily rise until complete dilution. The incident at the YARA facility in Rostock-Peetz, Germany 2005 (Bakli, Versteele, & Swensen, 2006) shows how a cloud of ammonia, which is lighter than air, was carried far before coming down again when the gas emissions could be smelled in a town 12 km from the incident.

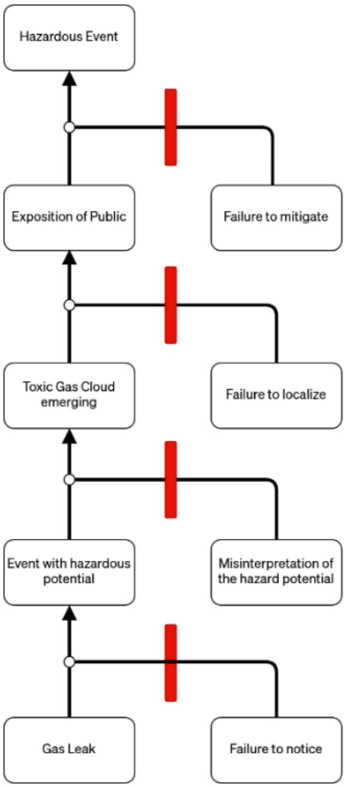

Figure 4 Fault tree model of a hazardous event with a gas release as root cause. Large area gas monitoring can provide barriers in all stages of the incident. They are drawn in red into the model.

Compared to field operation with gas sensors either hand-held or part of monitoring vehicles, remote sensing offers the possibility to map the gas concentration in the near field, without prior knowledge of the location and the propagation of the gas cloud. Monitoring near field distribution can be performed in seconds. It is thus quick enough to map the dynamic propagation behaviour of gas accumulations (Sabbah, et al., 2012).

(Karimi, 2019) compares the potential hazard of an ammonia release due to fire and the toxicity of the gas. The study finds that danger by the fire jet is imminent in a radius of appr. 300 m around the release point after ignition. Hazard potential due to the toxicity of the gas is less local around the release point. The study focuses on a release scenario with approx. 81 kg of ammonia and concludes that the concentration of the gas cloud at 1 km from the incident can still reach lethal levels of 1000 ppm.

Measures to mitigate the effects of an accidental gas release are most effective if they take the gas concentration within a wide radius of the incident into account. Without information on the location of a gas accumulation, wide areas of the compound need to be monitored continuously. Assessment of the gas concentration becomes more difficult the larger the area is that it needs to cover, until reliable situation assessment becomes impossible with common gas sensors.

Remote sensing early warning systems in comparison to common sensing technology provide both information on the location and concentration distribution of the gas cloud. In contrast to the deploying of gas sensors and filling the information gap by distribution simulation, remote sensing can be applied over wide areas within the field of view of the optical sensors. Remote sensing can continuously monitor and track the propagation of a gas cloud (Harig & Rusch, 2010). Due to their ability to continuously monitor large areas, a gas accumulation can be located and tracked from the moment of the release on. Over vast areas of up to several square kilometres the gas cloud propagation can be tracked, and the concentration distribution measured in real-time. Remote monitoring of the moving gas cloud works also in heigh elevation profiles, that conventional gas sensors cannot reach.

Information on the propagation behaviour of the gas cloud and the location of the gas while the event is unfolding are essential for a precise and fast understanding of the hazardousness of the situation and the coordination of mitigating measures. Fire brigades must know where to set up a water curtain to rain down a hazardous gas. Workers must know which gathering points or buildings are safe and within reach (Hofstra, 2002).

Technical realization and integration

The number and the positioning of the sensor units is determined by the scope of the monitoring plan. Each individual sensor unit can cover a radius of up to 4 km. Large-area monitoring of an entire facility can thus be accomplished by just a few sensor units. The installation at Chemelot focuses on fast early warning within minutes and a quick monitoring of the emission into the Brightlands campus. The scanfeld solution sequentially monitors the four stacks of the OCI melamine plant OMM, including the urea plant for real-time detection of an accidental gas release. The two sensor units also oversee the entire Brightlands campus area to monitor any emission to the campus. The total monitoring area is approximately 350.000 m².

The first unit is installed at the highest point within the production complex that oversees the entire facility. Figure 5 shows the installation points for the two sensor units and the viewing areas that map the four potential emission points of OMM. The Brightlands campus is partly shown in the satellite image and marked yellow.

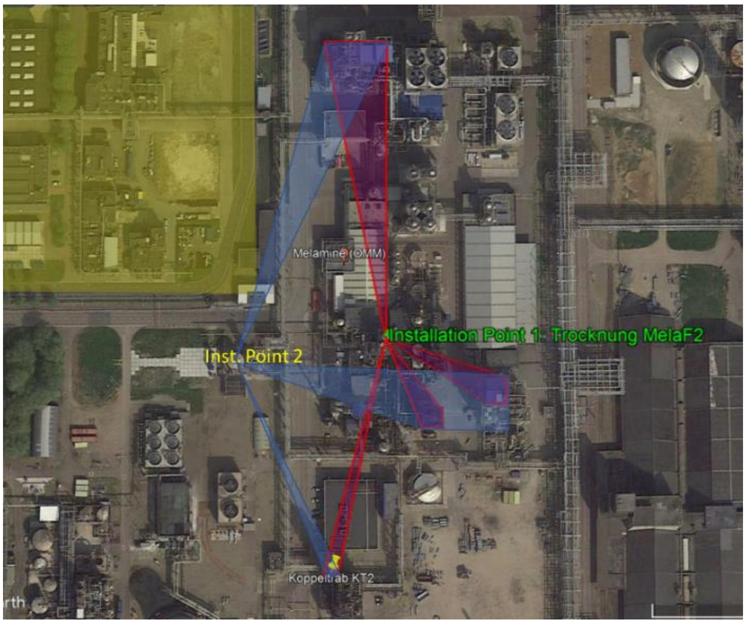

Figure 5 Installation point for sensor unit #1 at an elevated point within the production complex (the viewing areas are marked magenta) and sensor unit #2 at close distance outside the production site (blue viewing areas). The relatively close distance of the sensor unit to the target allows a fast release detection and a high spatial resolution

Based on the evaluation of the total amount of gas and an analysis of an event over time, an incident is automatically classified in three alert levels. The incident level is calculated based on the amount of gas that is detected in each scan and a quality criterion for the identification including the signal-to-noise ratio and the confidence value for the target gas identification. The indication levels are also subject to a persistence criterion in time, that filters single identifications which are subject to cross-sensitivity or fugitive emissions. Both calculations are specific for both the target gas and the known behaviour within the viewing areas. This feature enables the monitoring solution to learn the normal behaviour of the plant over time and self-adapt.

Beyond providing an alert about the event, the scanfeld software, specifically the chemical profiler, also gives further insights into the type and severity of the gas leak. One of the other key features is that the profiler provides a validation of the identified compound, and this enables the warnings and alerts to be accurately classified and seen by the user on a browser-based interface. The chemical profiler also provides a validation in time and spatial distribution, and if multiple sensors are used on the site, the profiler can cross-validate single points to ensure the highest degree of accuracy for the correct warning level.

There are a number of different alert levels generated by the chemical profiler which are based on the severity of the gas release event. Alert level 0 means that there has been no significant detection of a gas, however, once the profiler detects gas in one of the designated scan areas, it triggers an alert which is categorized as either a low (level 1), medium (level 2), or high (level 3) alert level. For an alert to be triggered by the profiler, the gas must be detected for a prolonged period of time to ensure that it is a real threat. Once the gas has been detected for long enough, the profiler will automatically measure both the type of gas and the column density of the gas by comparing it with gas signatures stored within its database.

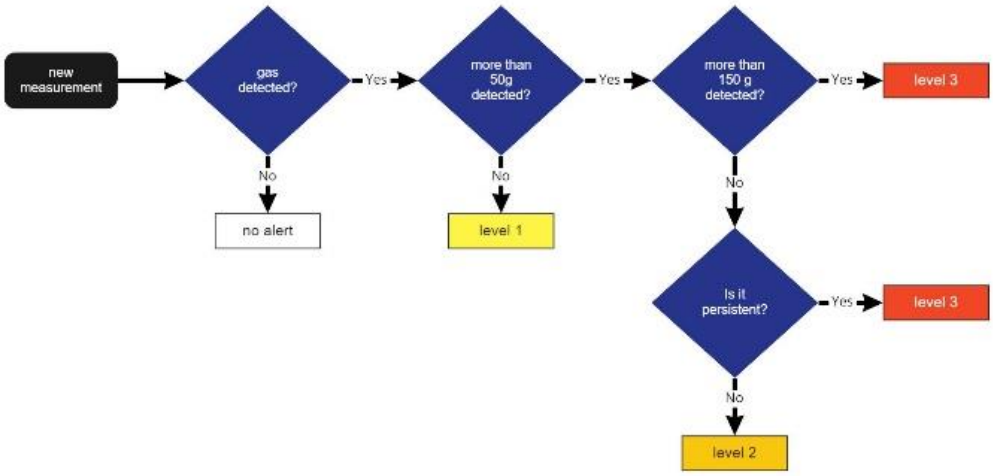

Figure 6 Profiler decision tree for alert classification

The severity of the alert is determined by comparing the concentration of gas against pre-defined threshold levels, and once this threshold is reached, the alert is generated. If the concentration of gas further increases over time and passes a higher pre-determined threshold level, then the alert level will be increased appropriately. On the other hand, if the gas levels go below the pre-determined threat levels, the alert levels are reduced accordingly. The different alert levels also have a designated colour coding based on the severity—yellow for low, orange for medium and red for high—for ease of tracking.

Once the user has been provided with an alert on the user interface, there are a number of functions which are available to the user. In the user interface, coloured alert triangles and alert lists are two ways that the threat level is displayed. If the user hovers over their cursor over a specific alert, or clicks on one of the alert triangles, then the compound being released are displayed and the details of the current alert level will be shown. When an alert has been clicked on, the display will show both a text description about the alert as well as a still image. The user can click on the 'play' button and the interface will play a series of image stills from before the current image and from after the incident.

In operation a reasonable trade-off must be made between speed and resolution in order to provide high spatial resolution and good coverage on one side and on the other side a fast turn-around time. The turn-around time governs the time-to-alert and is therefore an important parameter for the early warning functionality.

Results and operational experience

Following the installation of the scanfeld units an initial operation phase was started. In this phase the functionality of the system is tuned to best meet the demands of the users. The scan areas are chosen, the list of substances is refined, and the data collection is started. During this phase a working compromise between turn-around time, special resolution, and number of scan areas was determined. Here, the configuration results in a turn-around time, i.e., the time needed to scan all relevant scan areas, of about 5-10 minutes. The scan areas do not only include the plant, but also the neighbouring Chemelot campus.

The system is set up to detect ammonia, nitric acid, natural gas (methane), and nitrogen oxides. Further substances can be included anytime since no hardware change is necessary. The user interface is made available to all relevant users including the control room by a web interface. All data is stored on site and remains accessible for later analysis such as trend investigations.

Using the collected data, the profiler module was set up to generate alerts when certain conditions are met. These are substance specific and are based on detected amount and persistence of the release. Alert levels are chosen to minimize insignificant events while rapidly escalating large detection events in order to maintain the focus of the operators. Technical emissions and small-scale incidents are therefore rated differently than a large gas cloud.

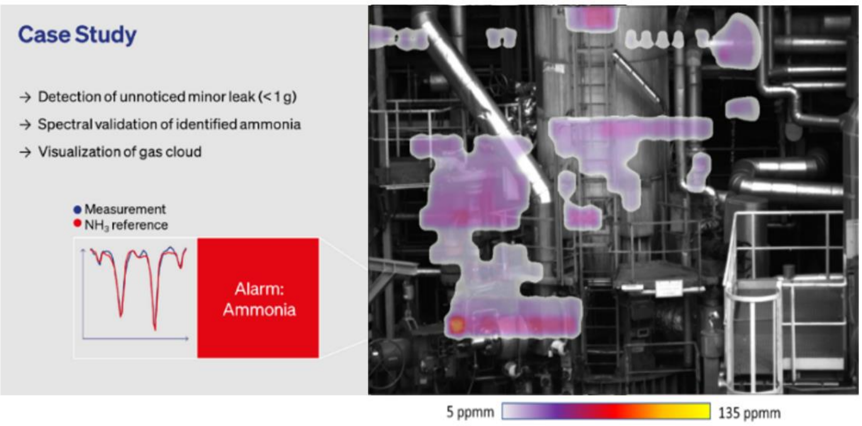

Figure 7: Measurement example: Detection of minor ammonia leak from 100 meters distance. Left: Ammonia is identified by spectral analysis and automatic comparison to a proprietary library of gases. Right: The concentration distribution is displayed in false colours. From the point of view perspective of a sensor unit the column-density is the product of concentration and cloud depth

Concluding the initial phase, site acceptance tests were performed. The profiler functionality was verified using a large test cuvette with pre-defined concentrations of ammonia. The cuvette was placed into the field of view of the scanfeld units at different distances and correct response of the unit verified. A range of concentrations and distances was recorded, and the expected alerts were generated by the system. To realistically simulate a leakage a small amount of ammonia water was exposed to air outside of the installation. **Error! Reference source not found.** shows the response of the system in the graphical user interface with the correct classification as a lowest level release event.

Since then, the units are in continuous operation with a high availability. Furthermore, a DCS connection was established which sends high level alerts and basic information about the detection events to the plant's DCS system. The Distributed Control System (DCS) is the operating window of the plant, all relevant status information and warning events are managed and controlled there. The transmission of the alert events into the DCS is achieved by using the OPC-UA standard: An OPC-UA server is implemented on the scanfeld side that is interfacing to an OPC-UA client at the DCS side. The physical layer is

Figure 8 Small scale release experiment with ~100 ml of 25% ammonia water in an open container. To sensor units capture the area and the Profiler identifies a „Low Alert" (yellow triangle in the timeline).

realized via the Ethernet network on site.

Gas release alert events generated by the scanfeld system now immediately notify the control room operators through the DCS providing the essential "What", "Where", "When" and "HoW much" directly to the heart of the plant. Once an alert is logged in the DCS it has to be acknowledged and is stored for the record. No alerts can get missed and immediate actions can be taken if necessary. In addition to the notification the operator can observe the alert details in the scanfeld User Interface to get the broader picture. They are put into the context of the neighbouring scan areas and can be traced back in time.

In case of an alert event, the following information is sent:

- Title and Description: Descriptive information on the event
- Alert Level: Low, Medium or High Alert
- Compound Name: Identified Compound
- Scan Area Name: Name of the Scan Area, where the compound has been identified

- Timestamp: Time of the event.

The scanfeld system follows the OPC UA industry standard (Open Platform Communication Unified Architecture) for highest compatibility to easily interface with common DCS systems.

Real time gas cloud mapping in release event situations

Gas releases in the open are very different from gas emissions in confined spaces. In the latter, a gas detector can pick up the rising concentration no matter where the source is located. In the open, however, the gas coming from a release point becomes rapidly diluted, so tracing back the source with a stationary gas sensor is next to impossible. Finding flammable or toxic gas leaks requires a near-field monitoring of the entire area around a potential point of release to ensure timely and accurate results. With respect to the dynamic gas distribution, it must operate in real-time.

Compared to field measurements with hand-held sensors or vehicles, remote sensing allows for near-field mapping without prior knowledge of the location and the wind situation. Monitoring the gas distribution can be performed within seconds. The scanfeld unit is therefore fast enough to map the dynamic propagation of gas releases for early warning of gas leakages.

Measures for mitigating the effects of an accidental gas release are most effective if they accurately represent the gas concentration across a wide radius of the incident. Without information on the location of a gas accumulation, wide areas of the compound need to be monitored manually. Assessment of the gas concentration becomes more difficult as the affected area grows larger, making reliable situation assessment with common gas sensors impossible. The concentration of the gas can be low at a certain location but rise dramatically when the wind sweeps the gas cloud in another direction. Therefore, the reading of a local gas sensor can create a false interpretation of safety when the location of the gas cloud is unknown.

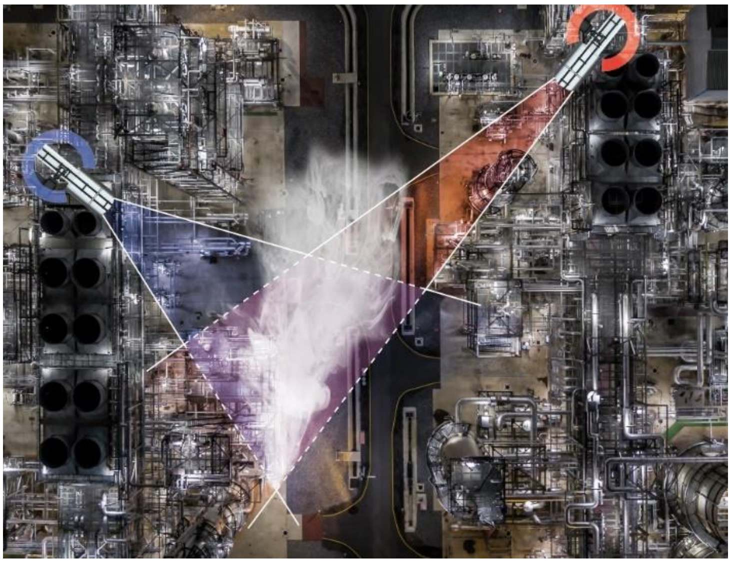

Figure 9 Cloud mapping by tomographic reconstruction of data from two sensor units

Being able to map the gas cloud dynamics across a wide area is a key factor in why scanfeld is so effective, as it allows the gas concentrations to be determined across a wide radius of the incident. This allows the appropriate measures to be put in place to mitigate the effects of the leak. These analyses can all be done without any prior knowledge regarding the location of the gas accumulation, or the wind conditions, and allows for much wider areas of a chemical plant to be monitored automatically. Assessing the gas concentration becomes inherently more difficult as the gas spreads and the affected area becomes larger. As the wind sweeps the gas cloud in different directions, the localized concentrations can rapidly change, and this is where local gas sensors become very ineffective as they present a false interpretation of the concentration of the gas cloud and a false sense of safety in the local area. This is where the wide field mapping function showcases the value proposition of the scanfeld system, as any widespread gas cloud can be continuously mapped and monitored in an ever-changing environment.

Figure 10 Measurement of an ammonia cloud from two measurement positions. The concentration distribution is displayed on a map.

The localization and assessment of the gas cloud dimensions, and the distribution is vital for first response in case of a large ammonia emission. So far situation assessment has to rely on distribution modelling based on the amount of gas that is released and the wind speed and direction. The Chemelot chemical park has a gas dispersion modelling solution in place that allows fire brigades and control room operators to determine the severity of the incident and the potential outcome of a gas cloud that travels outside the perimeters into the neighbouring cities. The uncertainty of the model is within the reliable determination of the total amount of gas that was released in case of an event. Local gas sensors that are in place can only provide very scarce information with a high degree of uncertainty as they only provide concentration information at the location of the sensor, which is in arbitrary distance to the event. The assessment of the situation is therefore on the shoulders of operators and first responders. With the scanfeld monitoring solution a real time assessment of the total amount of gas is provided in real time. This monitoring solution provides precise information in highly dynamic situations.

Leak detection and emissions control

Low detection limits are necessary but not sufficient criterion for reliably detecting small, but relevant leakages. The installation experience shows that emissions form ammonia water were regularly detected at >100 m distance from the source. The low detection limits that are necessary feature for the early warning of a gas leak leads to false positive alerts without further data processing. The aim of the installation is to localize the location of the gas emission. The quantitative emission monitoring technique that provides the column density of the gas cloud independent from the background provides a signal that is directly related to the leak location. The point of highest column density is assumed to be the leak source.

The inspection of the spectral database that is acquired over days allows LDAR inspection of small leakages. Processing larger datasets that are acquired over days significantly lowers the detection limit and increases the precision in localizing small leakages. The combination of gas flow rates that are calculated based on the wind speed and direction and the spatial information provides a map of all small leakages. Current development of the scanfeld solution is aiming at an automatic LDAR reporting tool. Taking into account even larger datasets acquired over months, the total emission profile of the plant can be assessed. Sustainability goals for the large volume production of inorganic compounds such as ammonia need the assessment of the total emission from all fugitive and diffuse emissions and stack emission. The scanfeld monitoring solution provides the database for an automatic measurement of all diffuse and channelled emissions of the plant.

Monitoring the entire facility from the distance creates a variety of measurement scenarios. A gas cloud with at a high emissivity can be measured in front of a cold sky as background, or the same gas cloud with a high absorption is measured in front of a hot oven with a high emissivity. The resulting information to the operator should be the same in all those cases. Therefore, the signal of the monitoring solution needs to be directly reflecting the amount of gas of the gas cloud independent of the background. The radiative transfer model that is used in this installation models the entire influx of radiation from random emitters in the background of the target gas cloud as well as the specific radiation emitted by the gas due to the gas temperature. Thus, the column density of each measured voxel is determined independent from the profile of the background. In this way the total amount of gas of a gas cloud can be directly assessed from a single scan, an information much more useful for situation assessment that a concentration value. With the assumption that in the near field within the source of emission, the gas flow is mainly determined by the wind direction and speed and that distribution is dominant over dilution, the flow rate from the gas leak can be calculated. Initial testing confirms the sensitivity to ammonia leakages with an order of magnitude of grams per minute, fractions of grams under ideal conditions.

In addition to that, the system collects data continuously which allows the long-term evaluation of industrial installations. Statistical methods as well as big data analysis can provide more insight about technical emissions, long term trends, and operations in general, thereby providing data for the optimization of production and preventive maintenance.

Conclusion: Three perspectives on permanent emission monitoring: Early warning, LDAR, Total emission monitoring

By the installation of the scanfeld system monitoring the Brightlands campus the risk of harmful exposure to an ammonia gas cloud has been significantly reduced. Any larger ammonia release within the monitored area is detected within the turnaround time of the installation at latest. For the current setup with a turnaround time of 5-10min was chosen as an ideal compromise between detection speed and spatial resolution.

The permanent monitoring of a chemical plant with spectroscopy monitoring techniques provides a large dataset on the emission profile of hundreds of technical gases. The information depth of a single spectrum provides the information of the composition of a all gases within the field of view, this information can be assessed at all times. In real time, the monitoring solution provides an early warning solution for the control room. It introduces 4 barriers for hazard situation prevention and additional mitigation barriers in case of a larger ammonia release. The inspection of the spectral database that is acquired over days allows LDAR inspection of small leakages. Processing larger datasets that are acquired over days significantly lowers the detection limit and increases the precision in localizing small leakages. The combination of gas flow rates that are calculated based on the wind speed and direction and the spatial information provides a map of all small leakages. Current development of the scanfeld solution is aiming at an automatic LDAR reporting tool.

Considering even larger datasets acquired over months, the total emission profile of the plant can be assessed. Sustainability goals for the large volume production of inorganic compounds such as ammonia need the assessment of the total emission from all fugitive and diffuse emissions and stack emissions. This applies in particular to major greenhouse gases such as methane and nitrous oxide. The scanfeld monitoring solution provides the database for an automatic measurement of all diffuse and channelled emissions of the plant.

Outlook

With the scaling of the monitoring solution to monitor the entire north side of the Chemelot chemical park, a 3D gas cloud modelling will be introduced to provide a more precise situation assessment for first response. Based on the measured gas emission rate, future software releases will interface with predictive gas dispersion modelling, that allows to predict the gas cloud distribution over the next hours. This model will be extremely important to predict the outcome of any major incident for the neighbouring community.

Automatic leak detection for the early localization of small leakages is currently in a working prototype phase. This tool for LDAR services will provide a mapping of all small leakages on a daily basis. Observation of known leakages over time allows more precise maintenance scheduling and risk evaluation.

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