PLANT ENGINEERING

How to proactively reduce leaks and emissions in oil and gas

Plant managers and engineers in process-focused industries are seeking ways to reduce fugitive emissions to provide a safer work environment and reduce their facilities' environmental footprint

BY VENKAT ESWARA DECEMBER 5, 2023

Courtesy: mPACT2WO, a Molex Business

Learning Objectives

- Discover the benefits of the new artificial intelligence of things (AIoT) for fugitive emission reductions while addressing current challenges.
- Understand the critical role of both "first mile" and "last mile" in the emissions monitoring process.

- Learn how a tank farm of one of the largest U.S refineries used AIoT technology for early leak detection and to make a timely, informed decision and repair — showcasing the effectiveness of continuous emissions monitoring.

Emission insights

- Modern oil and gas leak detection technology can benefit operators of refineries and other process facilities.
- Artificial intelligence of things (AIoT) technologies can play a pivotal role from the first mile to the last mile in converting extensive and intricate data into trusted insights.

Plant managers and engineers within industries in the process sector, encompassing oil and gas, refineries, chemical plants and petrochemical facilities, are facing escalating pressure to address their environmental footprint. One area of paramount concern centers around fugitive emissions, which were once relegated to the realm of manual routine operations but have now become the focus of intense scrutiny with a focus on what can be done better.

Fugitive emissions can emanate from a diverse array of sources, encompassing leaking valves, flanges and various equipment components, as well as venting and flaring activities. Within these emissions lie a spectrum of regulated compounds, including greenhouse gases, volatile organic compounds and other pollutants. Effectively controlling these emissions is important for facilities to improve efficiencies of operation and minimize potential impacts to their employees or neighboring communities.

Several challenges are inherent in current leak detection approaches, making it challenging to maintain effective leak detection systems. These challenges include:

- Complex industrial processes: The intricacy of industrial operations often makes it arduous to pinpoint the source of a leak. Multiple potential sources and the possibility of leaks occurring throughout the facility, including remote locations, add complexity.
- Limited access: Many process unit equipment and components are situated in hard-to-reach areas or under insulation, posing obstacles to the installation and maintenance of leak detection equipment.

- Detection sensitivity: Traditional methods may fail to detect small leaks and the sensitivity of detection systems can be constrained, leaving some leaks undetected.
- Environmental factors: Environmental conditions like temperature, humidity and wind can impact the accuracy of leak detection systems, leading to false alarms or missed detections.
- Risks and costs: Entrusting a reactive, time-based or schedule-based maintenance approach can leave plant operators exposed to amplified risks and financial burdens. This vulnerability arises from the possibility of emissions slipping through the cracks between scheduled intervals, demanding attention and resources that could have otherwise been conserved.
- Manual and error-prone: Manual monitoring approaches such as Method 21, coupled with inconsistent documentation and a lack of a clear investigative trail, can result in error-prone decision-making processes.

Addressing these challenges is crucial for enhancing the efficiency and reliability of leak detection systems in industrial settings. As the importance of reducing fugitive emissions becomes more widely recognized, many process industries are adopting innovative solutions and advanced technologies to monitor and mitigate their emissions. These cutting-edge solutions such as sensor-based systems, drone technology and machine learning algorithms, provide operators with near-real-time data to detect and address potential leaks quickly and efficiently.

Figure 1: First mile to last mile for emissions monitoring. Courtesy: mPACT2WO, a Molex Business

Emission reduction and monitoring

The new artificial intelligence of things (AIoT)-based leak detection approach uses strategically installed sensors and sophisticated artificial intelligence and machine learning algorithms, along with a wide range of operational and local environmental data, such as data about how air flows across the facility, to triangulate leak locations and predict the most likely sources. In addition, the new AIoT-based leak detection approach provides intelligence backed with operational and site awareness for emissions.

To facilitate more informed, timely decision-making, it's imperative not only to explore the potential of technologies like AIoT in addressing present emission reduction challenges but also to recognize the pivotal role played by the "first mile" of these technologies. Unlocking this potential from an AIoT-based approach hinges on simplifying the intricacies spanning from the first mile to the "last mile" (see Figure 1).

First mile to last mile

The first mile constitutes the foundational phase encompassing data collection, processing and transmission. This critical phase unfolds with the deployment of sensors, devices and equipment at the precise point of data origination, often spanning distributed and remote locations. The significance of the first mile is underscored by its capacity to empower organizations with real-time field data, paving the way for timely decisions that yield enhanced efficiency, cost savings and operational improvements.

Key aspects of the first mile include:

- Data collection: In the initial Phase of the AIoT journey, data originates at the source, primarily through the use of sensors, devices and specialized equipment. This data encompasses a wide spectrum of information, spanning sensor data encompassing status updates and performance metrics, environmental data that includes parameters like temperature, humidity and air quality and even rich visual content in the form of images and videos.
- Processing: Depending on the specific use cases, sensors and devices provide the capability to execute preliminary data processing, filtering and analysis, whether in local environments or within centralized locations like the cloud.

- Connectivity: Sensors and devices rely on connectivity to seamlessly transmit data to the subsequent stage for further analysis. This connectivity may be established via wireless technologies, including cellular, Wi-Fi, satellite or LoRa or through wired solutions like Ethernet. The choice depends on the distinct use cases and geographic considerations. Data transmission costs and latency significantly impact this critical "first-mile" stage.
- Data aggregation: Gateways serve as the orchestrators of data aggregation within localized areas of a facility. They seamlessly collect data from distributed sensors, consolidating information from multiple sources before transmitting it to the central data processing center for in-depth and advanced analytics.
- Computing: Sensors and devices, tailored to the specific use cases they serve, facilitate the execution of processing and analysis either at the data source itself or within centralized data centers/cloud infrastructure. This versatile capability empowers accelerated decision-making, finely attuned to the distinctive demands of each scenario.
- Analytics: As the volume of data generated by sensors and devices continues to grow, it has become increasingly important to use advanced analytics techniques like machine learning and statistical analysis, coupled with subject-matter expertise, to extract trustworthy insights from the data. These techniques can identify patterns and trends that are not easily discernible through traditional data analysis methods. With real-time or near real-time analytics, companies in process industry sectors can identify and address issues before they become major problems, allowing for more proactive and effective decision-making. Ultimately, advanced analytics is key to unlocking the full potential of AIoT and driving better business outcomes.
- Device management: Given the diversity of sensors and devices hailing from various vendors, each with its unique data formats, the concept of interoperability emerges as pivotal in achieving the seamless process of zero-touch onboarding while ensuring robust cybersecurity measures. Zero-touch onboarding, a transformative approach, empowers connected

devices to configure themselves automatically within a centralized system, entirely devoid of field support intervention. This approach extends to remote firmware updates, assuring that the latest security enhancements are promptly addressed from a remote standpoint.

The last mile refers to the final stage in the data analysis process where insights generated through analytics are transmitted to end-user devices or applications for decision-making. This stage is crucial because it completes the information dissemination process and allows plant managers and engineers to access the insights and make informed decisions. The last mile can be a challenging phase, especially when dealing with large and complex datasets.

However, by using workflows and other tools, teams can ensure that the insights are accurately and efficiently transmitted to the end-users. The success of the last mile hinges on the accuracy and consistency of the first mile. This means that all data should be processed and collected accurately from the beginning. It is essential to ensure that data cleaning and transformation is done correctly to prevent errors and inaccuracies later in the data-driven decision-making process.

Key aspects of the last mile include:

- Visualization: Effective visualization of data through graphical representation is a crucial factor when it comes to making complex data more accessible and understandable. It enables the identification of patterns, trends and insights that would otherwise be difficult to discern, leading to more informed decision-making.
- Workflows: Workflows help streamline and automate various tasks, ensure efficiency, consistency and reproducibility and ultimately lead to more accurate decision-making. Through the use of workflows, teams can achieve time savings, error reduction and enhanced data integrity verification. This becomes particularly advantageous for teams dealing with large and intricate datasets, as manual data processing can prove to be a daunting task.
- Investigation and repair: To effectively manage emissions, it's important to identify sources and take prompt action to address them. This can be achieved by quickly implementing necessary repairs or maintenance activities. In addition, the development and implementation of strategies to proactively prevent future fugitive emissions is of utmost importance. Such

strategies might include equipment upgrades, process improvements or enhanced maintenance protocols. By adopting a proactive approach to managing fugitive emissions, plant operators can minimize potential impacts to the environment, employees and neighboring communities.

- Documentation and reporting: Maintaining comprehensive records of emissions data, inspection findings and reporting is essential for regulatory compliance and transparency. The operations team plays a critical role in ensuring that these records are accurate and up to date. In addition, the team is responsible for reporting emissions data and findings to relevant regulatory agencies and stakeholders, as required by environmental regulations, to ensure that the company is operating within acceptable limits and minimizing the impact on the environment. By maintaining accurate records and complying with environmental regulations, the company can build a positive reputation and strengthen its relationships with stakeholders.

In addition, security and privacy should be key considerations for all data transmission and usage, especially during the first and last mile. The first and last mile are often the most vulnerable points in the data transmission process, making it essential to implement robust security measures to safeguard sensitive data. Plant operators can safeguard data by using encryption, authentication and access controls to maintain the integrity of the data and ensure that only authorized individuals have access to it.

Taking a proactive approach to security and privacy not only helps operators comply with regulations but also enhances environmental stewardship. By safeguarding sensitive data organizations can prevent data breaches, build trust with their stakeholders and maintain the confidentiality of sensitive information.

In pursuit of leaks

At the tank farm of one of the largest U.S. refineries, a conservation vent, which is an authorized emission source, experienced an abnormal condition that could have persisted for several weeks, increasing the risk of fugitive emission exposure. The oil refinery used AIoT technology to detect the issue and notify the operations team with an alert that highlighted the problem on the sitemap in red (see Figure 2). This enabled the control room personnel to quickly determine and implement an appropriate troubleshooting approach.

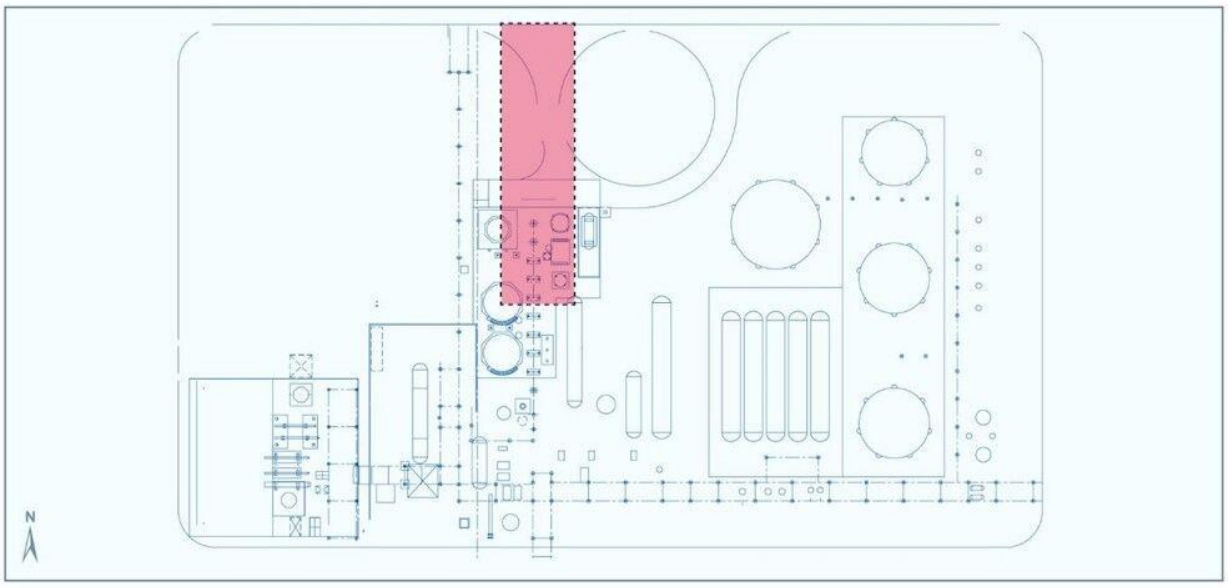

Figure 2: Early emission detection at a conservation vent. Courtesy: mPACT2WO, a Molex Business

The operations team used an infrared camera to locate the emission source and within four hours of initial notification, the issue was addressed, significantly reducing fugitive emissions from the tank due to the abnormal condition. Early detection of the leak enabled operations to make an informed decision and perform a timely repair, demonstrating the effectiveness of continuous emissions monitoring in mitigating environmental risks.

In the pursuit of fugitive emissions reduction and to provide a safer work environment, process industries must proactively address emissions issues. By minimizing emissions, the risk of exposure to hazardous compounds is reduced, making the workplace safer for all. Cutting-edge technologies such as AIoT play a pivotal role in converting extensive and intricate data into actionable insights.

To obtain dependable and actionable data for emissions reduction, it's imperative to design a continuous emissions monitoring solution that spans the entire spectrum, from the first mile to the last mile. This approach empowers plant operators to pursue their emissions reduction and stewardship goals with enhanced precision and confidence.

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