AI-Driven Leak Detection Best Practice Trends

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Refineries, petrochemical, and other process and manufacturing industries are accelerating their efforts to redesign their work processes to meet stringent demands on compliance and safety, by mainstreaming technology-driven operational improvement initiatives. AI-driven real-time leak detection is part of these work process improvement trends. Its adoption is increasing based on the widening range of benefits associated with its OT-centric approach.

By Peter Manos
Director of Research,
ARC Advisory Group

ARC Advisory Group

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Executive Overview

In this report, ARC Advisory Group highlights improvements in real-time leak detection capabilities that are the result of the work of industry leaders who have correctly shifted their ROI calculus and have embraced real-time leak detection improvements as part of their operational excellence and digital transformation initiatives. These leaders see significant benefits, including:

Industrial organizations can gain advantage by pursuing operator-centric solutions for minimizing fugitive emissions and leaks. The Artificial Intelligence of Things, or AIoT, provides an ideal way to meet near-term operational and financial goals, while also addressing critical longer-term challenges.

- Risk reduction
- Near-term better overall cost performance
- Long-term additional competitive advantages
- Environmental Stewardship and meeting ESG goals

The benefits are clear for organizations that have proactively embraced improvement efforts, as they are better positioned based on positive operational improvements.

In addition, risk reduction is becoming an increasingly positive benefit in its own right, since regulators are showing real teeth when it comes to the increasingly stringent requirements for reductions in VOC and GHG emissions, including fugitive emissions and leaks in industrial facilities, most notably in oil & gas, refineries, petrochemical, and energy- and asset-intensive sectors.

The New AIoT Leak Detection Path

The best uses of technology to gain competitive advantage involves organizations' leveraging the most important intellectual property they have—their people, including facility and plant Operations personnel.

It is the view of ARC Advisory Group that this initiative is a prime example of Artificial Intelligence of Things (AIoT) in action, as part of the energy transition. AIoT brings intelligence from the edge to the cloud in industrial environments, transforming data into useful information for an improved decision-making process, with processing done in a location where it is most needed.

AIoT is the democratization of AI and ML in the industrial domain by converging data science with IT, providing software at scale and context-specific OT domain expertise.

Characteristics of AIoT-based leak detection approach

The new AIoT-based leak detection approach uses strategically installed sensors and sophisticated Artificial Intelligence (AI) and Machine Learning (ML) 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.

The AIoT-based leak detection approach has the following key characteristics:

- An "operator-first" bottom-up approach that can enable ground-up transformation and then be scaled enterprise wide
- Optimal utilization of sensors and hi-fidelity data to produce real-time insights
- Proven processes that determine exactly where problems can be mitigated
- End-to-end solutions for effective courses of action to eliminate problems
- Operational and site awareness

This leak detection method replaces traditional methods involving periodic manual inspections that required personnel to carry heavy equipment to check for leaks, which often involved hard-to-access and potentially hazardous locations within the facility. Additional disadvantages of existing leak detection methods included the fact that inspections could not be timed to occur when a recent problem had started, and as a result, a new leak could remain undetected for an indeterminate period, and worsen significantly, if the problem happened to start right after the last scheduled inspection.

Operator-Centric AIoT Project Success Factors

In ARC Advisory Group's view, AIoT represents a shift for some industrial operators in the process industries world, a world where big

implementations of new technologies typically have an emphasis on IT-driven software implementations and have relied on outside SME-centric implementations.

The technology focus IT-driven, top-down approaches have often resulted in less favorable outcomes, due to low uptake on the part of operators on the plant floor, with numbers as low as 15 to 20 percent or less. In contrast, 80 to 85 percent uptake is more typical with operator-centric approaches.

Operational Challenges Require OT Level Solutions

The mPACT2WO AirCompliance Solution

An example of a proven AIoT leak detection and emissions reduction solution is mRegz™ AirCompliance, from mPACT2WO, a Molex business. Its design meets the above AIoT characteristics, and enables improvements in relation to Coverage, Speciation, and Isolation Time, which, taken together, represent the solution's three pillars.

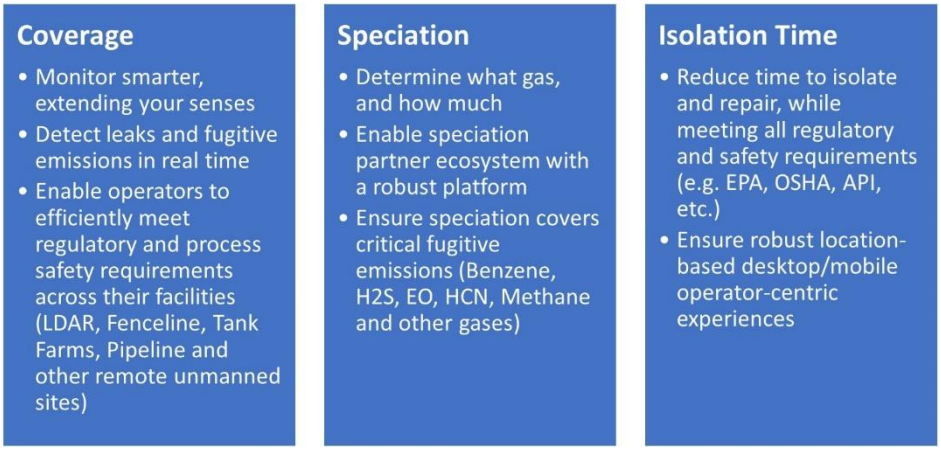
Generally, the key features of mPACT2wo's AirCompliance emissions monitoring and leak detection solution include:

- Continuous and automated monitoring
- Area coverage to address full range of leaks, from small, to medium, to large leaks
- Digital recordkeeping for traceability
- Single source of truth, for insights and investigations
- Solid pathways from data collection to insights to corrective actions

- Holistic solution for a wide variety of emissions monitoring and leak detection requirements across industrial site

The solution also enables process benefits as well, beyond the technology benefits already mentioned. The following tangible positive changes and related benefits experienced by users of the AirCompliance solution are noteworthy:

- Fast time to isolate leaks
- Optimization of corrective actions
- Easy access to digital records with contextual insights
- Improved traceability
- Freeing up of Operations personnel to focus on new benefits areas leads to a cultural shift toward greater continuous improvement



mPACT2WO's AirCompliance Solution For Leak Detection And Emissions Monitoring Was Designed To Meet The Above Criteria

Considering Hard and Soft Benefits for AIoT-Based Leak Detection

The above-mentioned benefits associated with freeing up of operations personnel to solve new problems, and the move toward a culture of more continuous improvements, are examples of "soft" benefits which can end up yielding significant unplanned additional "hard" benefits. Fundamentally, by detecting leaks earlier, major damage to equipment is often prevented, but freeing up personnel to focus on bringing even greater value is an additional game-changer. Asset owner/operators can expect these sorts of mixed hard and soft benefits, when utilizing best-practice leak detection systems, including ones that go beyond the highly valuable operational reliability

improvements stemming from the reduced likelihood of outages or equipment damage.

Best practice leak detection systems are easier to maintain as well. This yields savings due to the decrease in direct and indirect costs and negative impacts associated with the older solutions' inefficiencies. The new solution also feeds into Asset Performance Management (APM) and / or Enterprise Asset Management (EAM) solutions, yielding greater benefits from inside and beyond those enterprise software systems already in place.

There is, finally, an additional set of People-based soft benefits associated with increases in job satisfaction. In contrast, with old systems there are higher expenses associated with job turnover created by onerous manual inspections and new employee onboarding and lower job retention in the aggregate.

Design Fits Operator Work Processes

Flint Hills Resources (FHR) Utilization of mPACT2wo

mPACT2WO's AirCompliance solution is being used by Flint Hills Resources (FHR) and has been providing FHR significant direct benefits by enhancing safety, reducing emissions, and improving cost structures and competitiveness across its facilities.

FHR is among the top ten largest US refiners with operations primarily in the Midwest and Texas. FHR operates the Pine Bend refinery in Rosemount, Minnesota and two refineries in Corpus Christi, TX with a combined crude oil processing capacity of more than 700,000 barrels per day. The company produces, markets and transports refined products including gasoline, diesel, jet fuel, asphalt and heating oils. Flint Hills Resources also owns and/or operates more than 4,000 miles of pipelines that transport crude oil, refined

petroleum products, natural gas liquids and chemicals that are delivered through a distribution system of more than forty terminals throughout the Midwest and Texas.

FHR views its utilization of mPACT2WO's AirCompliance as a key enabler to achieve superior outcomes for environmental compliance and operational excellence. With the AirCompliance solution, FHR now uses sensors to detect leaks across its facility's 250,000 hardware components and leverages the solution to alert maintenance teams in real time. The solution eliminated time-intensive tasks which required technicians to perform manual monitoring in challenging industrial environments.

On AIoT-driven leak detection and fugitive emissions reduction pathways, benefits associated with an operations-centric approach include greater workforce engagement in ways that cut across silos and drive real-time collaborations that help to increase asset productivity, monitoring, and control.

The success of this project is confirmed by the EPA's February 10, 2023 Notice of Final Approval for the above capabilities, under an Alternative Means of Emission Limitation (AMEL) for FHR refineries based in Corpus-Christi, Texas.

Recommendations

Aside from it being easy to answer "No" in response to the question "Is the 'do nothing' option viable?" there is nothing easy about answering the questions that industrial decision-makers must answer when it comes to how best to proceed in meeting operational and business goals while addressing the challenges associated with the energy transition, decarbonization and effective implementation of ESG (Environmental, Social and Governance) initiatives, including leak detection and fugitive emissions monitoring.

It is not simply a matter of how dramatically direct regulatory requirements in terms of emissions reduction are on the rise. In addition, the B2B benefits of being proactive, and liabilities of not being proactive, will increase significantly up and down the supply chain, in terms of required upcoming improvements in Scope 2, and 3 reporting, which will include the energy suppliers' fugitive emissions (the suppliers' Scope 1) as part of the suppliers' customer's downstream emissions footprint.

Complexities and risks are more reliably reduced with AIoT-based solutions in this area, owing to the operator-centric approach which should be at the center of any evaluations of new emissions reduction and leak detection technology options. In this regard, based on ARC Advisory Group research and analysis, we recommend the following actions for asset-intensive industry owner-operators:

- Consider more than just the short-term costs when it comes to evaluating leak detection versus the costs of maintaining older labor-based periodic inspection solutions.
- Potential disruptions in labor allocations or inspection contracts are temporary, while improvements associated with new AIoT leak detection solutions are permanent and free up operator resources to address higher-value tasks issues, thereby creating additional cost-saving and productivity-improving opportunities.
- Beneficial increases in resiliency and the capacity for more nimble operations stand in stark contrast to the detrimental operational and financial impacts associated with delayed diagnosis and resolution of leaks, especially given the portion of leaks that can worsen quickly if not detected early.
- Leveraging the OT domain expertise of operators on the plant floor is in line with transitioning to the more sophisticated continuous leak detection capabilities that are now available.

The direct benefits are clear in terms of enabling more rapid detection and correction of leaks, but the indirect benefits which have been mentioned should be included in evaluations, given the value gained when one frees up operators to focus on other improvements. Also, the negative aspects of the prior methods are removed, as the new capabilities do not have the prior safety and reduced productivity issues associated with them.

ARC Advisory Group recommends that asset owner/operators do not underestimate the benefits of improved leak detection and fugitive emissions reduction. The benefits that are easily underestimated include avoidance of the higher costs of capital, legal liabilities, insurability and insurance expense issues, and brand damage that can occur when major safety or operational mishaps are not avoided. The correct solutions are the ones that minimize installation, training and ongoing maintenance costs while maximizing operator uptake and safety, operational efficiency, worker efficiency, and emissions reductions.

Analyst: Peter Manos
Editor: Larry O'Brien

Acronym Reference:

AMEL Alternative Means of Emission Limitation
AIoT Artificial Intelligence of Things
CAA Clean Air Act
DRF Detection Response Framework
EPA Environmental Protection Agency
FEMP Fugitive Emissions Management Plan
GHG Greenhouse Gas emissions
IT Information Technology
LDAR Leak Detection and Repair
LDSN Leak Detection Sensor Network
OT Operations Technology
VOC Volatile Organic Compounds

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ARC Advisory Group, Three Allied Drive, Dedham, MA 02026 USA • 781-471-1000 • www.arcweb.com

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