ACHIEVING OPERATIONAL EXCELLENCE & REDUCED RISK THROUGH CONTINUOUS MONITORING: A NEW APPROACH TO LDAR COMPLIANCE

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ABSTRACT

Oil and gas operators face growing expectations to improve operational performance, manage risk, and demonstrate responsible emissions management. Finalized New Source Performance Standards (NSPS) rules for OOOOa and OOOOb sites enable a more efficient, data-driven approach to Leak Detection and Repair (LDAR) compliance. Under these regulations, operators can use traditional Optical Gas Imaging (OGI) surveys or new technologies approved under the advanced Alternative Test Methods (ATMs). Continuous, real-time monitoring qualifies as an ATM for periodic screening and improves operational efficiency while maintaining regulatory compliance.

This paper focuses on how continuous monitoring supports advanced emission management and operational excellence. Continuous monitoring shifts LDAR programs from reactive to proactive, and from a survey-based to a risk-based approach. By utilizing real-time data and actionable alerts, operators can locate, quantify and repair leaks in near real time. Operational teams can also prioritize field visits to remote locations based on actual site conditions instead of fixed LDAR schedules. This approach conserves both time and personnel.

Continuous emissions data enables robust desktop diagnostics. Operators validate equipment setpoint adjustments, confirm successful repairs without additional site visits, and quantify known operational activities. These efficiencies improve scheduling, reduce windshield time, and lower operational burden. We present a periodic screening program that leverages continuous monitoring to help operators meet or exceed compliance requirements and maintain constant visibility into site emissions. This approach minimizes the likelihood of undetected leaks and captures intermittent emission events that quarterly OGI inspections may miss.

Real-world implementation of a strategic periodic screening program has reduced required OGI inspection costs by 10 to 25 percent. Emissions trend data, combined with SCADA data, improves root-cause investigations and supports repair verifications. These results provide strong evidence of assurance for corporate sustainability

initiatives and commitments. Participants will gain a clear understanding of periodic screening requirements and practical guidance on program design and execution. They will also learn methods for conducting investigative analyses.

Continuous monitoring is an established enterprise-level strategic tool. Its multi-faceted value proposition includes operational efficiencies through real-time data and historical trending, stronger regulatory compliance assurance for informed decision making, and greater confidence for operational teams and leaders in delivering sustainable, responsible energy.

INTRODUCTION

Methane emissions from oil and gas production are a major focus for regulators, investors and the public. At the same time, methane reduction has become a core priority for responsible energy development because of methane's potent greenhouse gas impact. These factors have increased the pressure on oil and gas operations teams that are already expected to reduce costs and improve efficiency with limited field and contractor resources. On top of that, public and third-party scrutiny of methane emissions has changed the risk profile for companies, where large events can become public before they are detected and actioned internally.

Historically, LDAR compliance has been built around scheduled inspections, typically quarterly or semiannual OGI surveys. These traditional LDAR programs have served the industry well, but they are inherently based on a snapshot in time. Emissions that occur between inspections may go undetected for months, limiting the level of information available to support timely and informed decisions.

Under EPA's finalized NSPS for OOOOa and OOOOb sites, operators now have flexibility to use:

- Conventional inspections such as OGI or Method 21
- Periodic screening using approved ATMs
- Continuous monitoring-based work practices

These regulations aim to reduce environmental impact while encouraging the adoption of advanced monitoring technologies. Periodic screening using an approved alternative test method (ATM) such as continuous monitoring offers a data-rich, proactive path to regulatory compliance. It enables operations teams to move toward condition-driven dispatch, conserving time, reducing unnecessary travel, and improving the ability to intervene before issues escalate.

For the purposes of this paper, we focus on periodic screening using an approved continuous monitoring ATM. To understand how continuous monitoring supports operational excellence while maintaining regulatory compliance, it is first necessary to understand the regulatory framework for periodic screening that makes it possible.

REGULATORY LANDSCAPE: UNDERSTANDING PERIODIC SCREENING

Applicability

EPA's NSPS requirements establish standards for fugitive emissions monitoring which apply to specific types of facilities and components based on their construction date, modifications or reconstructions, and the site's classification. Defining the site type is key because it influences the applicable work practice and the screening or inspection frequency. Operations teams should begin by confirming which facilities are in scope, how those facilities are categorized, and which components are covered by their traditional LDAR program.

Table 1 – Site Type Definitions

Site Type	Definition
Single wellhead only well site	*A well site that contains only one wellhead and no major production and processing equipment.*
Multi-wellhead only site	*A well site that contains two or more wellheads and no major production and processing equipment.*
Small well site	*For purposes of the fugitive emissions standards in OOOOb §60.5397b and OOOOb §60.5398b, a well site that contains a single wellhead, no more than one piece of certain major production and processing equipment, and associated meters and yard piping. Small well sites cannot include any controlled storage vessels (or controlled tank batteries), control devices, natural gas-driven process controllers, or natural gas-driven pumps.*
Compressor station	*Any permanent combination of one or more compressors that move natural gas at increased pressure through gathering or transmission pipelines, or into or out of storage. This includes but is not limited to gathering and boosting stations and transmission compressor stations. The combination of one or more compressors located at a well site, centralized production facility, or an onshore natural gas processing plant, is not a compressor station for purposes of OOOOb §60.5365b(e) and OOOOb §60.5397b.*
Well sites or centralized production facility that contain major production and processing equipment	*Centralized production facility means one or more storage vessels and all equipment at a single surface site used to gather, for the purpose of sale or processing to sell, crude oil, condensate, produced water, or intermediate hydrocarbon liquid from one or more offsite natural gas or oil production wells.* *This equipment includes, but is not limited to, equipment used for storage, separation, treating, dehydration, artificial lift,*

Site Type	Definition
	combustion, compression, pumping, metering, monitoring, and flowline. *Process vessels and process tanks are not considered storage vessels or storage tanks. A centralized production facility is located upstream of the natural gas processing plant or the crude oil pipeline breakout station and is a part of producing operations.*

Traditional LDAR Compliance

The historic baseline for LDAR has been scheduled inspections using OGI and, where applicable, Method 21. These approaches are effective at locating leaks during a survey, but they can miss intermittent or short-duration events that occur between inspections. Quarterly or semi-annual frequency also require fixed scheduling regardless of site conditions, which can increase windshield time and contractor coordination burden, especially across remote assets.

The finalized rules introduce flexibility by leveraging alternative test methods that support a more strategic approach to compliance. Periodic screening is one such pathway. When implemented in accordance with the prescribed work practice and documentation requirements, it enables operators to use advanced technologies to reduce methane emissions equivalent to the Best System of Emission Reduction (BSER).

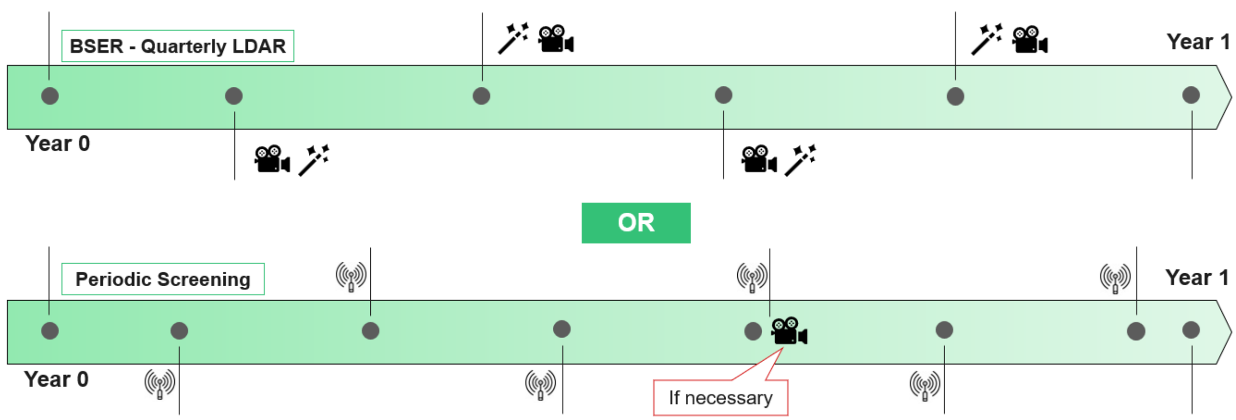

Figure 1 – New LDAR Work Practices are Equivalent to Traditional Practices. The key difference between quarterly LDAR (top) and periodic screening (bottom) is that the number of onsite inspections can be reduced in periodic screening to only trigger when emissions are detected. In this example, onsite inspections are reduced from four times to only once.

Alternative Test Methods (ATMs)

An ATM is an EPA-approved method that meets specified performance criteria for a given work practice. In periodic screening, a continuous monitoring system can qualify as an ATM if it maintains the required detection performance at the selected probability of detection (PoD) threshold and meets the screening period evaluation and reporting requirements. The chosen technology must be deployed and maintained in a way that supports the work practice; under-deployment or poor device health erodes confidence in the data collected and increases the likelihood of unnecessary follow-ups. A list of approved technologies is available on EPA's website.

Periodic Screening & Screening Periods

Periodic screening is a compliance work practice that uses screening events at the required frequency to determine whether a site is operating below a defined detection threshold. One framework we focus on for this paper evaluates a declared 7-day screening period and calculates a block-average emission rate for that timeframe. That average emission rate is then compared to the selected 90% Probability of Detection (PoD) threshold to determine a pass or fail outcome. A pass indicates that no additional actions are required for that screening period. A fail triggers follow-up requirements that include an OGI or Method 21 survey to identify and repair the source(s). Figure 2 illustrates examples of screening periods with pass and fail outcomes and resulting actions, if required.

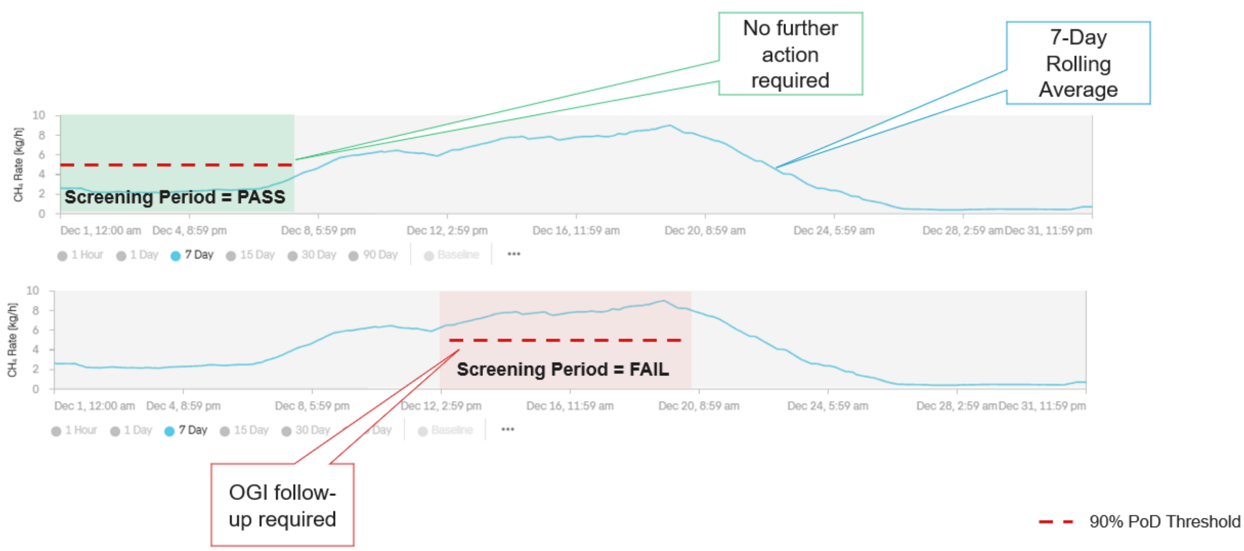

Figure 2 – Screening period example of pass (upper graph) and fail (lower graph) results using continuous monitoring.

Operators have discretion when to schedule a periodic screen based on their desired schedule, but it must occur prior to the end of the month it is required based on the selected work practice.

PERIODIC SCREENING PROGRAM IMPLEMENTATION

Deploy Continuous Monitoring System

Continuous methane monitoring is increasingly being adopted to support compliance, and sustainability goals. It detects and quantifies methane emissions in real-time to make informed decisions and provides a means of verification for repairs. However, not every site will deliver the same value from continuous monitoring. Higher priority sites are typically remote (requiring additional travel), operating with more complex equipment (tanks, VRUs, compressors, dehydrators, combustors), higher emissions variability, or a history of repeat maintenance issues. Starting with a representative set of sites rather than deploying uniformly everywhere is recommended to help teams learn what “normal” looks like, tune alerting and response work practices, and build field trust and understanding of the data before scaling.

Deploying a continuous monitoring system requires customization to the unique characteristics of each site. Continuous monitoring device placement should consider the site size and layout, major emission sources, prevailing local wind, potential obstructions or interferences from routine operations, and budget considerations for cost-effective coverage and system optimization. Planning should also consider how device health is monitored and repaired to avoid data downtime. Typically, centralized production facilities will require 4 to 5 devices to maintain the 90% PoD threshold for the selected work practices we will explore in this paper. An example of a deployment is presented in Figure 3.

Figure 3 – Example deployment plan of a centralized production facility.

Selecting a 90% PoD Threshold

Under the finalized NSPS rules for periodic screening, operators have flexibility to select a 90% PoD threshold that best fits the site and the intended compliance strategy. That selection should consider the site type and balance screening frequency, emissions performance, and operational constraints. Table 2 compares conventional monitoring compliance options to the new periodic screening compliance options available.

Table 2 – Conventional vs. Periodic Screening Compliance Options

	Conventional Monitoring Compliance Option (§60.5397b)		Periodic Screening Compliance Option (§60.5398b(b))		
Source Category	AVO[2] (/year)	OGI/M21 (/year)	90% PoD threshold[3] (≤ kg/h)	Screenings (/year)	OGI (/year)
Single Wellhead Only	4		1	2	
			2	3	
			10	3	1
			5	4	
			15	4	1
			15	6	
Multi Wellhead Only Sites	4	2	1	2	
			2	3	
			10	3	1
			5	4	
			15	4	1
			15	6	
Small Well Sites	4		1	2	
			2	3	
			10	3	1
			5	4	
			15	4	1
			15	6	
Compressor Stations	12	4	1 (3)[5]	4	
			2	6	
			10	6	1
			5	12	
			15	12	1
Major Well Sites or Centralized Production Facilities[6]	6	4	1 (3)[5]	4	
			2	6	
			10	6	1
			5	12	
			15	12	1

Within the periodic screening workflow, operators can select a monitoring strategy that best aligns with site conditions and compliance objectives. That may include continuing traditional OGI surveys at certain sites, applying a common PoD threshold across a defined asset area or basin, or selecting site-specific thresholds where warranted.

At the higher 90% PoD thresholds of 10 kg/h and 15 kg/h, the work practices require one mandatory annual OGI survey, in addition to the 6 or 12 annual screenings. At a lower threshold such as 5 kg/h, no mandatory annual OGI survey is required, and compliance is based on the 12 screenings per year (1 screening per month). Operators often benefit from starting with voluntary monitoring before moving to a compliance-driven program, as this helps determine the most appropriate threshold and improves implementation success. Technology providers can also help recommend a suitable work practice that balances the trade-off between sensitivity of technology, frequency of screening periods and the emission profile of each site.

Under a technology-driven periodic screening work practice, operators may also reduce or eliminate dedicated AVO inspections. Table 3 compares conventional monitoring OGI visits against three 90% PoD thresholds using actual continuous monitoring data collected over six months at four separate well sites with major production equipment. Even with three of the four sites failing one of the screening periods at the 15 kg/h threshold, the number of required OGI site visits was reduced by 13%.

Table 3 – A periodic screening compliance monitoring program reduced site visits compared to conventional OGI-driven monitoring program.

		Well Sites with Major Production Equipment					
		Site 1	Site 2	Site 3	Site 4	Total	% Reduction Compared to BSER
BSER	BSER OGI Visits Required - Annual	2	2	2	2	8	
90% PoD 5kg/h	Periodic Screenings Required - Annual	6	6	6	6	24	
	Periodic Screenings that Require Follow-up - Annual	2	0	2	3	7	
	OGI Required (dedicated OGI as part of program) - Annual	0	0	0	0	0	
	Total Site Visits - Annual	**2**	**0**	**2**	**3**	**7**	**13%**
90% PoD 10kg/h	Periodic Screenings Required - Annual	3	3	3	3	12	
	Periodic Screenings that Require Follow-up - Annual	0	0	1	1	2	
	OGI Required (dedicated OGI as part of program) - Annual	1	1	1*	1*	4	
	Total Site Visits - Annual	**1**	**1**	**2**	**2**	**6**	**25%**
90% PoD 15kg/h	Periodic Screenings Required - Annual	6	6	6	6	24	
	Periodic Screenings that Require Follow-up - Annual	1	0	1	1	3	
	OGI Required (dedicated OGI as part of program) - Annual	1*	1	1*	1*	4	
	Total Site Visits - Annual	**2**	**1**	**2**	**2**	**7**	**13%**

Practice then Implement

Implementation is where most programs succeed or fail. Continuous monitoring technology can be effective, but without clear ownership and disciplined workflow, operations teams can accumulate unnecessary alerts without action or lose confidence in the data and system. After deploying continuous monitoring, practicing the periodic screening process before shifting to a compliance-based program helps build internal alignment, and integrate emissions data into daily operations. It also helps identify which sites are strong candidates to shift into a periodic screening compliance program, while learning emission patterns with routine or non-routine operational activities.

Continuous monitoring delivers the most value when it is integrated into the workflows teams already rely on, including production meetings, maintenance planning, routing, and equipment reliability reviews. Implementing a tiered alert and response protocol prevents alarm fatigue and helps identify equipment issues and leaks faster. A practical approach is to start with a desktop review to prioritize emissions data with known operational activities or correlate with SCADA information to form a hypothesis about likely causes. Only a subset of emission events should result in prompt field dispatch. This makes field work more targeted and efficient, while emissions trends can be used to verify repairs and track recurring equipment issues, or “bad actors”, for data-informed root cause analyses. Over time, this closed-loop process reduces repeat field visits and improves operational effectiveness by showing teams the outcomes of field actions.

Compliance Confidence & Readiness

Compliance readiness is achieved when operators can clearly show what was planned, what was performed, what the screening results were, what follow-up actions were taken, and how repairs were verified and documented.

A compliant monitoring plan should identify the sites covered, the approved method and its spatial resolution, the procedures for conducting screenings, the timelines and procedures for follow-up when emissions are detected, and the recordkeeping and reporting requirements. When a screening fails, follow-up inspections and repairs must be completed within the prescribed timeframes. In certain cases, an investigative analysis must also be initiated to determine underlying causes and prevent recurrence. Continuous monitoring data strengthens this process by supporting operational troubleshooting, justifying capital equipment upgrades, and providing measurable feedback on operational decisions to continually improve and minimize emissions.

CASE STUDIES: OPERATIONAL EXCELLENCE & CONTINUOUS MONITORING

The case studies presented in this paper all come from operated sites in the Delaware basin in West Texas.

Case Study 1: Regulator Malfunction Impacting Emissions & Periodic Screen Period

Site Information: Central tank battery & compression station with five continuous monitoring devices.

Challenge: Continuous monitoring sensors detected elevated emissions from the tank battery pushing the 7-day rate towards the periodic screening threshold of 15 kg/h, triggering alerts and indicating an operational upset to be addressed.

Detection: Continuous monitoring devices recorded elevated emissions around the tank and separator areas of the facility. When emission monitoring data were reviewed alongside tank pressure data from SCADA, the operator confirmed abnormal emissions activity and excess gas routing to the tanks. Because pressures did not exceed the thresholds of the control devices, including the thief hatches, Enardos, and flare, the operator determined that there was a primary failure of one of those systems, alongside the root cause of excess gas exacerbating the emission levels.

Investigation: Operations reviewed emissions trends together with SCADA data and identified a malfunctioning back pressure regulator on the flash gas separator of the dehydration skid. The resulting pressure imbalance pushed gas to the tanks and contributed to emissions from a leaking thief hatch alongside corroded Enardo sealing surfaces.

Resolution: The periodic screening was pushed back to the last week of the month while the regulator was replaced and repairs to the damaged thief hatch and Enardo components were completed. Afterwards, emission levels returned to normal operating conditions.

Figure 4 – Case Study 1: Regulator malfunction at a central tank battery and compressor station.

Case Study 2: Evaluating BTEX Coil Control Valve Performance & Combustor Purchase

Site Information: Central tank battery & compression station with five continuous monitoring devices

Challenge: The operator was looking to understand emissions events related to BTEX coil operation after reviewing emissions data of the associated area. It was suspected that the purchase and installation of a new combustor system may be required to handle the BTEX gas not being burned by the reboiler.

Detection: Continuous monitoring devices recorded emissions levels during periods when the BTEX system was on and the reboiler was burning BTEX gas. The emissions data provided clear visibility into system performance during these events.

Investigation: Operators analyzed emissions patterns while testing different control valve configurations on the BTEX system. It was initially thought that the system was generating more BTEX gas than the reboiler required or could process – thus requiring an additional combustor. However, it was determined that the PSV on the BTEX coils themselves was leaking and needed to be replaced. Once this was completed, the emissions stopped.

Resolution: Continuous monitoring data informed the operator's evaluation of a combustor purchase and installation. With real-time emissions data available, the team was able to identify and implement a less costly solution and make a more informed capital planning decision.

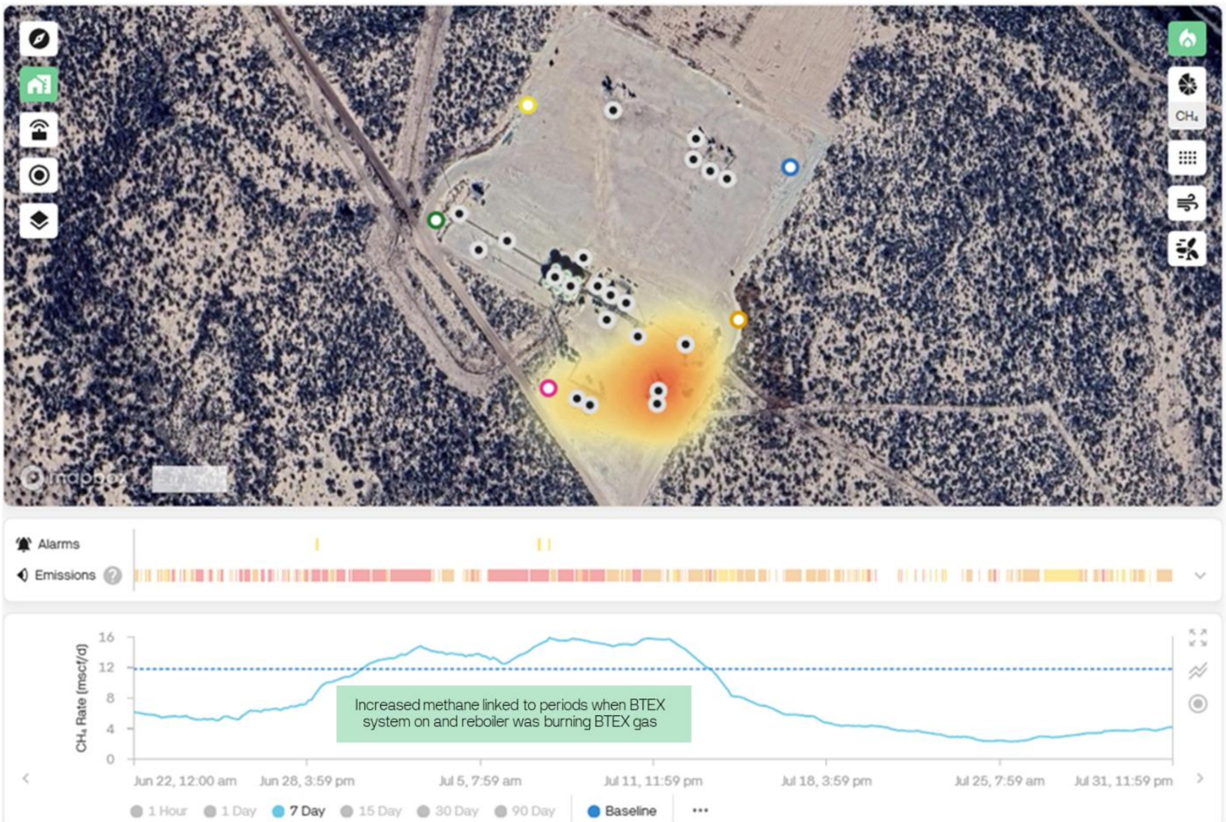

Figure 5 – Case Study 2: Monitoring BTEX coil control valve performance.

Case Study 3: Flaring Performance During Increased Midstream Downtime

Site Information: Central tank battery with five continuous monitoring devices.

Challenge: Midstream compression downtime increased significantly compared to the previous month, resulting in increased flaring and raising questions about combustion efficiency.

Detection: Continuous monitoring identified increased emissions localized to the flare, despite flare tip temperatures being normal.

Investigation: Operators compared emissions data with operational records and determined the flare blower was operating at a constant speed and not controlled by a Proportional-Integral-Derivative (PID) controller to adjust blower speed to gas flow rates. At higher flare volumes, this imbalance likely resulted in incomplete combustion and increased emissions.

Resolution: Operational adjustments were made to improve air-to-gas balance at the flare. Continuous monitoring confirmed emissions decreased, and combustion performance improved following these changes. Adding CO sensors to the continuous monitoring system could also help detect and identify possible incomplete combustion.

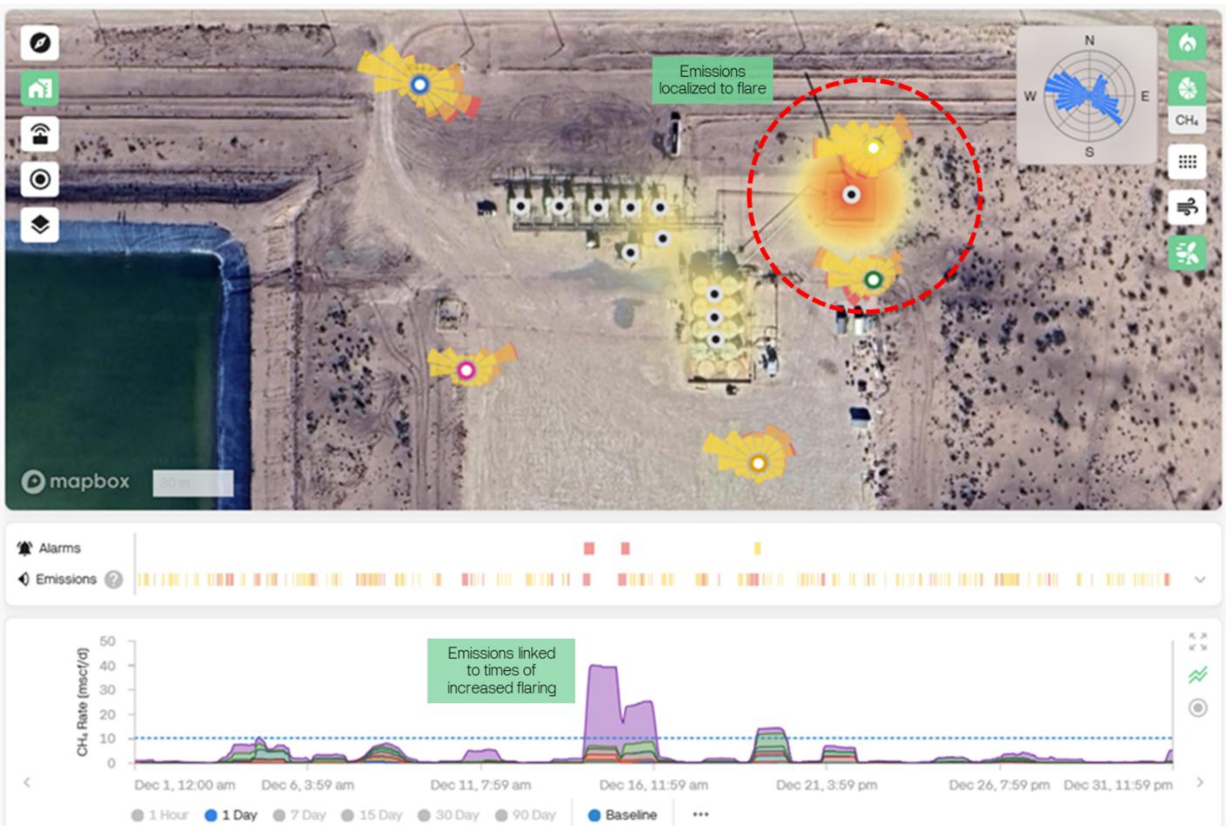

Figure 6 – Case Study 3: Flaring performance during increased midstream downtime.

Case Study 4: Oxygen Intrusion During Truck Loading

Site Information: Central tank battery with five continuous monitoring devices.

Challenge: Mitigating oil hauling emissions that reappeared after a new oxygen analyzer disrupted the established process for handling truck loading vapors.

Detection: In early September, continuous monitoring devices detected elevated emissions in the truck loading and tankage areas. Analysis of emissions and SCADA trends confirmed that these events aligned with times the truck loading Lease Automated Custody Transfer (LACT) unit was running.

Investigation: The established process, as part of the air permit and CSV, was for truck loading vapors to be routed back into the tanks, and then to either the flare or VRU. It was evident this process wasn't being followed. The reason – truck vapors introduced enough oxygen into the tanks that it was routinely exceeding the new O_2 analyzers setpoint and shutting down the VRU. To prevent this, operations had instructed drivers to not use the truck vapor recovery connection any longer.

Resolution: Engineering and operations agreed to re-plumb the truck loading vapor return line downstream of the main Enardo going out to the flare. This allowed truck loading vapors to be destroyed as intended by the CSV and air permit, without introducing any oxygen into the tankage that could cause the VRU to shut down or potentially create a safety risk.

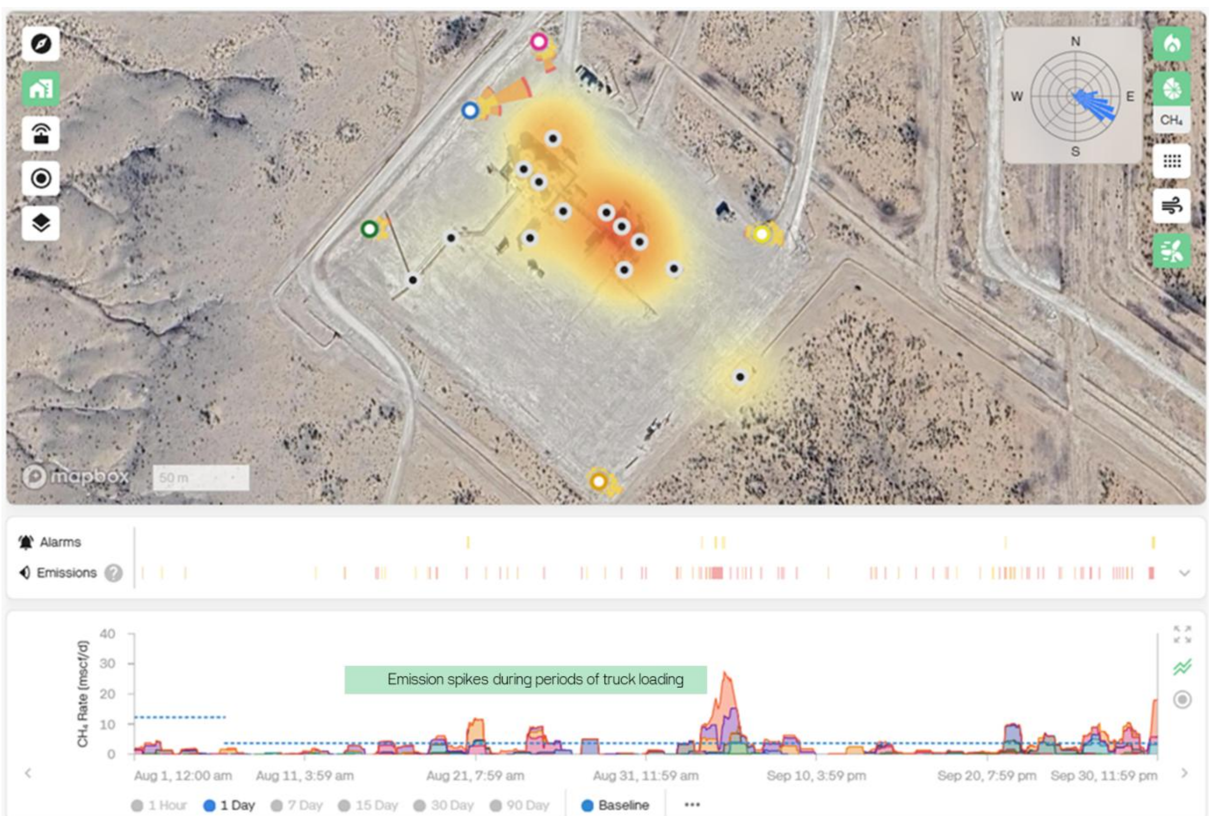

Figure 7 – Case Study 4: Oxygen intrusion during truck loading.

Case Study 5: Compression and Equipment Issues During Winter Storm Conditions

Site Information: Multiple standalone central tank batteries and central tank batteries with compression stations. Five continuous monitoring devices deployed per site.

Challenge: Severe winter weather caused equipment to freeze and ice blockages that disrupted normal operations. As a result, compression equipment was repeatedly cycled on and off, and each restart required a blowdown to atmosphere.

Detection: Continuous monitoring identified abnormal emissions events during freezing and winter storm conditions.

Investigation: Review of field reports confirmed ice plugs in compression equipment and separators with frozen control systems and pressure sensors. This resulted in wells being shut in temporarily and inconsistent gas available for compression. Compression being cycled on and off was also contributing to increased emissions. Every time compression was restarted, the units were being blown down to atmosphere.

Resolution: Once freezing conditions were addressed and equipment repairs completed, emissions returned to the baseline levels expected with high compression mechanical availability. Because the continuous monitoring data during this extreme environmental condition provided the data to quantify the emissions related to this practice, an engineering solution was identified and implemented to eliminate emissions related to compressor start-ups. All compression at this site was re-plumed so that units are blown down to the facility sales line or flare (depending on line pressure).

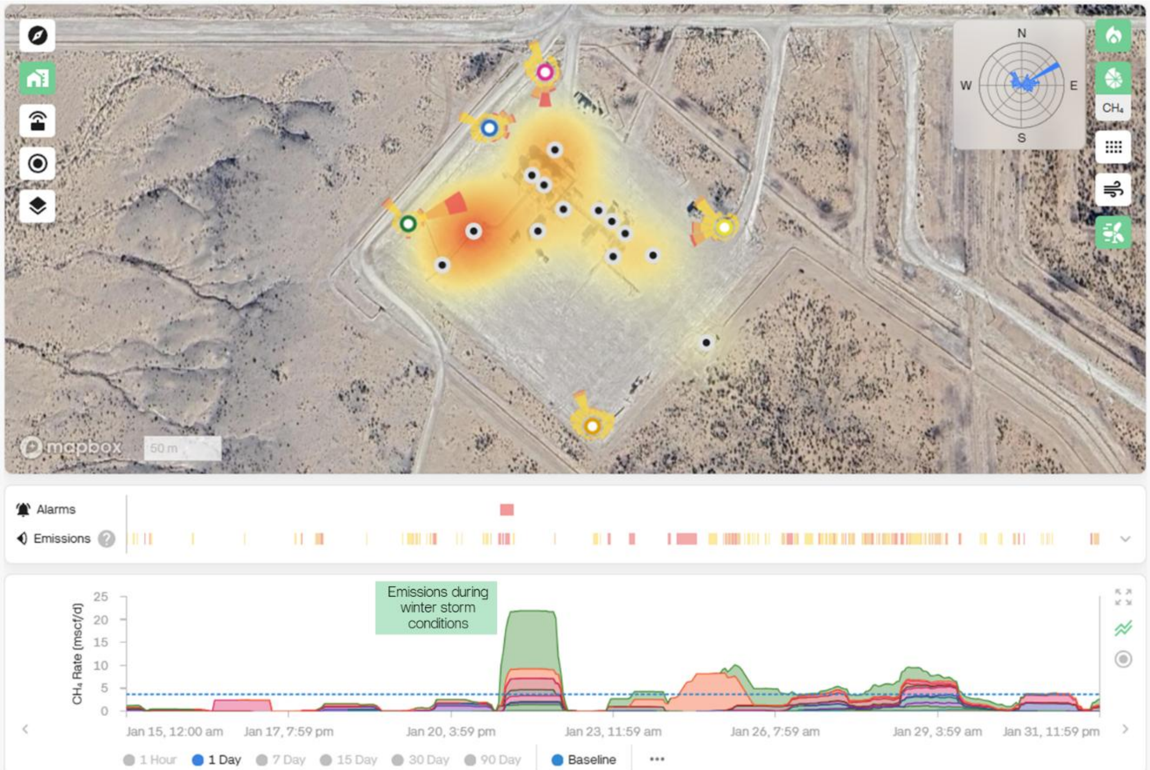

Figure 8 – Case Study 5: Compression and equipment issues during winter storm conditions.

THE FULL CYCLE IMPACT & ECONOMIC JUSTIFICATION

In the case of the operator referenced in the case studies; the annual LDAR costs for their sites equipped with continuous monitoring, and where periodic screening was implemented, were reduced by 75%. This is representative of going from quarterly inspections to a single inspection dictated by the 90% PoD threshold of 15 kg/h and a monthly periodic screening cadence.

Including the average installation cost and recurring platform subscription, the simple economic payout for this project was inside of three years. It should be noted that these sites are located in one geographic area and LDAR inspections were being completed for all sites in one single day. For operators with sites spanning larger geographic areas, or requiring return trips from LDAR technicians to verify repairs, these economics only get better.

The benefit of having real-time continuous monitoring emission data to identify equipment issues in a timely manner can generate other indirect cost savings. One specific example from this operator is identified in Case Study 1. By catching the broken regulator on the flash gas separator on the dehydration unit skid, the operator was able to avoid dry pumping issues early. If left unfound for 4 or 5 days the full glycol storage system would have been pumped away. This is valued at $6,000. Additionally, damage to the glycol pumps themselves could have necessitated a swap out costing $3,000.

While it’s true that conventional tried and true AVO methods for operating facilities can and will catch most leaks; equipping operations teams with more tools and information to understand and quantify the systems they operate will always result in improved efficiency and value.

The incredible troubleshooting and problem-solving efforts of an engaged operations team generated an **82% reduction in overall emission volumes** and a **93% reduction in site normalized average emission rate** over a 12-month period. Continuous monitoring data can empower improved operational and environmental performance, demonstrating sustainable, responsible energy development.

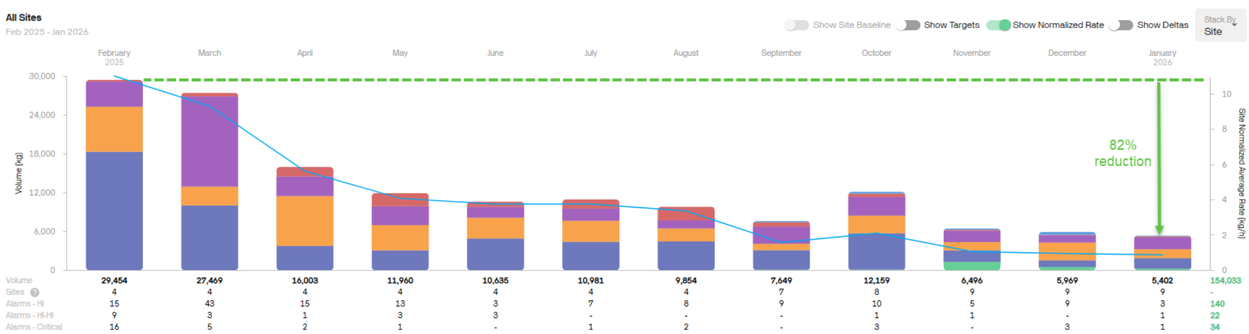

Figure 9 – Emissions reduction visibility and operational excellence in practice

CONCLUSION

Regulatory flexibility under NSPS enables operators to innovate and adopt new technologies. Periodic screening supported by continuous monitoring can satisfy compliance requirements while driving operational excellence. Strategic program design starting with site selection, technology coverage, careful threshold selection, response protocols, and operational integration determines whether continuous monitoring data drives operational excellence or not. Disciplined implementation turns continuous monitoring data into daily habits: desktop triage with SCADA data, targeted dispatch, verified repairs, and documented outcomes.

Many benefits of continuous monitoring are “intangible” until operational teams experience them: fewer return trips, better scheduling, and faster learning about what drives emissions. These benefits require active involvement in the data. If the system is deployed but not used, the program becomes just another dashboard rather than a better and more efficient way of operating.

It is also normal to encounter cultural pushbacks. Some teams worry that real-time data will reveal issues they would rather not see or know about, or that being above a threshold implies poor performance. In reality, these issues exist and can persist whether they are fully visible or not. Continuous monitoring data simply enables faster intervention, reduces the chance of repeat issues or leaks, and provides a mechanism for feedback and learning. Using continuous monitoring to educate and better understand emissions helps field teams succeed rather than just assign blame. It fosters a culture of improving environmental performance over time.

When done well, continuous monitoring becomes more than a compliance tool. It becomes a performance tool that reduces costs, catches issues or leaks faster, strengthens repair verification, and lowers the risk of large or publicly visible events. Operational excellence is achieved when compliance, efficiency, and accountability reinforce each other. Strategic periodic screening programs built on real-time data provide a practical, defensible pathway to do exactly that.

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