Comment Letter re: Notice of Proposed Rulemaking – Pipeline Safety:

Gas Pipeline Leak Detection and Repair

Introduction

Bridger Photonics, Inc. ("Bridger") appreciates the opportunity to provide comments on the Pipeline and Hazardous Materials Safety Administration ("PHMSA") Notice of Proposed Rulemaking – Pipeline Safety: Gas Pipeline Leak Detection and Repair (31 FR 31890) ("NPRM"). Bridger is a technical and market leader in the detection, localization, and quantification of methane emissions. Bridger developed its aerial light detection and ranging (LiDAR) technology, Gas Mapping LiDAR™ ("GML"), with support from the US DOE's Advanced Research Projects Agency – Energy (ARPA-E). GML technology was then commercialized in 2019 as a data product offering, which has been rapidly and broadly adopted by the oil and gas industry in North America over the past four years. Bridger serves the entire natural gas value chain including all onshore facilities covered in the NPRM: gathering, transmission, and distribution pipelines; LNG facilities; and natural gas storage fields.

Bridger's experience optimizing GML technology to fit the needs of the oil and gas industry combined with our experience statistically evaluating methane emission measurements uniquely situates us to provide feedback on how NPRM provisions may be adjusted to best serve the public and industry. We recommend revisions to the proposed advanced leak detection program ("ALDP") requirements for pipeline leak surveys that (a) provide operators with the option to use the most appropriate leak detection technologies and (b) involve empirically justified performance standards.

Bridger commends PHMSA for proposing an ALDP with specific leak detection equipment requirements and program performance standards. This approach removes ambiguity in equipment selection and work practices and helps provide a consistent framework for all operators. With an appropriate ALDP framework, there is enhanced assurance that unintentional gas emissions will be effectively identified and mitigated.

Despite the advantages of requiring an ALDP with specific performance requirements, the NPRM hinders operators from selecting effective leak detection technology for transmission and gathering lines because it lacks a clear pathway for implementing aerially deployed remote sensing technologies ("Remote Sensing").[1] These technologies measure path-integrated gas concentration (i.e., ppm-m) and their sensitivity is typically evaluated by looking at the emission rate (in kg/h) of emissions that are reliably detected. Meanwhile, the NPRM, as currently written, proposes that leak detection technology must have a 5 ppm gas detection sensitivity.[2] This performance standard only directly applies to point sensors that evaluate gas concentrations for discrete volumes of gas. Therefore, this performance standard is ill-suited for Remote Sensing.

A significant extent of infrastructure subject to ALDP requirements in the NPRM may be impractical to screen for gas emissions using point sensors due to difficulty covering pipeline right of ways (ROW) and environmental challenges. Conversely, Remote Sensing is an optimal technology type for detecting gas leaks within long and potentially difficult to navigate ROWs while also improving worker safety and protecting sensitive corridors.

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[1] Handheld and ground vehicle mounted remote sensing technologies should be considered in the rulemaking but are not considered in this comment letter unless explicitly noted.

[2] § 192.763(a)(1)(ii)

Although PHMSA allows operators to use alternative leak detection equipment/performance standards for required surveys of gathering and transmission lines in Class 1 & 2 locations via § 192.18 provisions, this pathway provides insufficient structure and adds unnecessary burden to both operators and PHMSA. This is because for most gathering and transmission pipelines, Remote Sensing may be the suitable default leak detection technology and is hindered by implementation via an alternative regulatory pathway.

We urge PHMSA to update ALDP provisions to include standards for pipeline leak detection (most notably for onshore gathering and transmission pipelines in rural locations) that are directly applicable to Remote Sensing. To provide consistency with EPA rules and to address emissions reduction goals, these performance standards should be based on mass emission rate detection sensitivity. To ensure that technology field performance is considered, the standards should take the form of an emission rate that is detected with a specified probability of detection. Finally, the value of the emission rate detection sensitivity requirement should be selected because it is impactful and practical. Based on the analysis presented in this comment letter, we propose a detection sensitivity performance standard of:

4 kg/h with a 90% probability of detection

This performance requirement aligns with the national mission to curb greenhouse gas emissions, particularly in the form of methane emissions reductions. Based on the emission rate distributions presented in these comments, eliminating emissions ≥4 kg/h would eliminate >95-97% of GML-measured natural gas gathering line methane emissions. While the proposed 4 kg/h threshold would provide effective emissions reductions, we caution PHMSA to avoid an emission rate requirement lower than 4 kg/h in consideration of the following pitfalls:

- **Increased expenses without material environmental benefits**. There are diminishing returns for addressing smaller and smaller emissions. For example, in production basin b (Figure 2), 86% of measured natural gas gathering line methane emissions can be mitigated by eliminating emissions above 10 kg/h. Eliminating smaller emissions, down to 4 kg/h, only provides an additional 9% reduction in total emissions (as measured) while coming at the expense of needing to address nearly twice as many emissions sources. We urge regulators to finalize LDAR regulations so that they are practical, have a strong scientific basis, and are maximally impactful.[3]
- **Potential negative environmental impacts.** Repairing immaterial leaks may interrupt pipeline infrastructure that is necessary to carry away gas from oil and gas wells. This could increase venting and flaring upstream of pipelines. Meanwhile, blowdowns and other operations necessary for repairing a leak could outweigh the environmental benefits of eliminating the leak.
- **Reduced compliance solutions.** Although we anticipate the recommended 4 kg/h detection sensitivity requirement can be achieved by many LiDAR Remote Sensing technologies, decreasing the emission rate threshold could leave operators with few effective compliance tools, especially for transmission and gathering pipelines.

[3] For example, PHMSA recently granted $196 M to replace 270 mi of leak-prone natural gas distribution pipeline. This action was estimated to mitigate 212 metric tons of methane annually (https://www.phmsa.dot.gov/news/biden-harris-administration-announces-historic-funding-37-projects-improve-safety-fix-old). While this action may have been essential for public safety in the distribution sector, this nearly $200 M action achieves emissions reductions that are less than 1/3 of the average emissions estimated for typical transmission compressor stations, for which a large portion of emissions were estimated to be fugitive emissions and super emission events (*Environ.Sci.Technol.49, 9374–9383 (2015)*). Focusing on higher emitting sources is likely to be more economic and significantly more environmentally impactful than trying to eliminate extremely small pipeline emissions sources.

In recognition of potential negative environmental outcomes and considerable economic burden without material environmental benefit, we further urge PHMSA to provide operators a pathway to monitor instead of immediately work to repair leaks with emissions rates ≤10 kg/h that are detected on rural gathering and transmission pipelines following appropriate analysis and justification.

Finally, to streamline regulatory compliance, we urge PHMSA to accept suitable EPA-approved alternative test methods for natural gas pipeline leak detection surveys.

Comment Letter Overview

In this comment letter, we illustrate the rationale for promulgating ALDP performance standards that make it easy for operators to use Remote Sensing for leak detection. In addition, we recommend performance requirements that we anticipate will be practical and effective. Bridger's comments are centered on the following areas:

(1) The advantages of Remote Sensing for gas pipeline leak detection;
(2) NPRM Revisions that would provide operators with an effective compliance tool for gas pipeline leak detection;
(3) Contextual background on Gas Mapping LiDAR technology and Bridger's capacity to help companies achieve ALDP regulatory compliance; and
(4) Aspects of the NPRM that merit clarification or minor modification.

Comment Area 1: Advantages of Remote-Sensing for Pipeline Leak Detection

Although the historical part 192 leak detection requirements did not specify performance standards for leak detection equipment or work practices, industry leaders have identified and implemented the best available technologies. Laser-based LiDAR Remote Sensing has been widely adopted for pipeline leak detection due to numerous prevalent advantages. Based on the following points, we urge PHMSA to consider ALDP requirements that embrace LiDAR Remote Sensing as a default technology for gathering and transmission pipeline leak detection. These points also illustrate that LiDAR Remote Sensing can be an effective component of distribution segments ALDPs.

Comment Topic 1.1: LiDAR Remote Sensing provides sensitive and reliable gas detection.

LiDAR Remote Sensors use a laser beam to sense the presence and quantity of gas molecules between the sensor and the ground. Lasers can provide consistent and high-intensity light, enabling sensitive detection of fugitive gas emissions through laser-absorption spectroscopy. Various spectroscopic techniques are available to LiDAR sensors that can strengthen the reliability of gas detection; for example, wavelength modulation which helps isolate measured change in backscattered light intensity due to gas absorption from changes in ground reflectivity.

Comment Topic 1.1 Summary: LiDAR sensors can sensitively detect gas pipeline leaks.

Comment Topic 1.2: Remote Sensing can provide excellent spatial coverage.

Compared to point sensors used in walking or vehicle-based surveys (ground-based or aerial), Remote Sensing provides increased spatial coverage. Point sensors evaluate gas concentrations of discrete volume(s) of air along the survey path. This means that the sensor must transect a portion of the gas plume for which its sensing capabilities will indicate a positive detection. This may be effective in the distribution sector where roadways are more likely to enclose emissions sources and gas is liable to pool up between buildings, increasing the likelihood that the sensor path with transect a gas plume. However, for transmission line ROWs and gathering lines, survey paths may not transect plumes or provide a suitable ‘fence’ around potential emissions sources when considering changing wind fields. In comparison, many remote sensing technologies provide more comprehensive spatial coverage during surveys, by scanning across a large footprint (or scan swath) underneath the aerial platform. GML’s scan swath is multiple times larger than the typical 50’ ROW.

Comment Topic 1.2 Summary: Extensive Remote Sensing spatial coverage improves the probability of detecting gas leaks.

Comment Topic 1.3: Remote Sensing technology can help operators effectively respond to emissions by imaging gas plumes and pinpointing emissions sources.

Certain Remote Sensing provides imagery of detected gas plumes and identifies the location of emissions sources. This helps operators quickly address detected emissions and enables distinction between emissions emanating from pipelines and those from adjacent infrastructure (for example emissions from oil and gas infrastructure can be expected to exist near gathering lines). Similarly, imagery/source localization can distinguish between which pipeline in a ROW is emitting.

Gas plume imagery, especially when overlayed on concurrently acquired aerial photography, can serve as a useful input to leak grading, potentially indicating whether gas has migrated to a location where it could cause a hazardous situation.

Comment Topic 1.3 Summary: Remote sensing gas imaging helps operators pinpoint emissions sources and distinguish their emissions from emissions occurring at adjacent infrastructure.

Comment Topic 1.4: Emission rate quantification by Remote Sensing allows operators to prioritize their response to identified emissions sources and facilitates emissions reporting requirements.

Certain Remote Sensing technologies quantify emission rates. Emission rate quantification can facilitate leak grading and other leak response procedures. In addition, emission rate quantification provides operators with empirical data to assess their cumulative emissions performance. The NPRM requires operators to report estimated aggregate emissions from leaks by grade and other emissions by source.[4] Quantification data from Remote Sensing could improve the accuracy of emissions volume reporting.

Comment Topic 1.4 Summary: Quantifying emission rates with Remote Sensing data helps pipeline operators identify high-priority leaks and helps operators report total emissions.

Comment Topic 1.5: Remote Sensing provides efficient leak detection and avoids access challenges.

Aerial Remote Sensing avoids the challenge of difficult to navigate ROWs and terrain around gathering pipelines. Furthermore, aerial deployment means hundreds of miles of pipeline can be covered in a single day, providing operators with a solution that is both effective and practical for the expanded pipeline leak detection requirements in the NPRM. PHMSA notes in the NPRM preamble that “an advanced [point sensor-based] mobile leak detection system could be an effective tool for detecting methane leaks in a suburban distribution system but may not be optimal for surveying service lines in an area with long setbacks or a transmission pipeline with poor road access.” Conversely, Remote Sensing is readily deployed in areas with challenging pipeline access.

Comment Topic 1.5 Summary: Remote Sensing efficiency provides operators with an effective pipeline leak detection compliance tool that can be deployed in difficult to access areas.

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[4] § 192.11 and § 192.17 (88 FR 31954, although not evident in the proposed regulatory text).

Comment Topic 1.6: Remote Sensing is noninvasive, helping to protect environmentally sensitive areas and protecting workers from onsite hazards.

Remote Sensing provides a leak detection compliance solution for environmentally sensitive ROWs that avoids negatively impacting the local ecosystem or disrupting agricultural use. It also prevents congestion of roadways otherwise used to access gathering lines for leak detection. NIOSH / CDC found that in 2017 (and qualitatively similar results in 2015-2016), vehicle accidents for oil and gas extraction related field operations were the leading cause of fatalities (42%).[5] Of these, the majority were on roadways to/from/between sites. Mitigating this hazard aligns with PHMSA's safety charter.

Comment Topic 1.6 Summary: Noninvasive Remote Sensing deployment can protect the environment and the safety of workers.

Comment Area 1 Summary: We urge PHMSA to implement default ALDP requirements that embrace Remote Sensing technology in consideration of the advantages outlined in this comment area.

Comment Area 2: NPRM Revisions That Would Provide Operators with an Effective Compliance Tool for Gas Pipeline Leak Detection

Bridger urges PHMSA to update requirements for detecting gas leaks in § 192.706 and § 192.763 so that operators have uncompromised access to Remote Sensing for effective gas leak detection across gathering and transmission lines. The same performance standards should also be referenced in § 192.723 because Remote Sensing can be an effective aspect of distribution pipeline ALDP. The following comment topics illustrate the rationale and recommendations for NPRM updates.

Comment Topic 2.1: Default ALDP and leak detection performance standards defined by emission rate would critically enable Remote Sensing implementation for gas leak detection. The existing requirements defined in ppm are not suitable for Remote Sensing.

Remote Sensing technology measures path integrated gas concentration (parts per million-meter, ppm-m) instead of what might be defined as "volume concentration" (parts per million, ppm), which is the measurement recorded by point sensors. This is because Remote Sensing measures light absorption by gas molecules along an entire light path. For LiDAR Remote Sensing, the light path extends from the sensor, down to the ground (where light is reflected) and then back up to the sensor. Conversely, ppm volume concentrations are assessed for discrete volumes of gas, and ppm values change at different points within a gas plume and outside of a gas plume. It is not straightforward to determine the ppm concentrations of gas along different portions of the light path assessed by Remote Sensing. Bridger provides greater detail on this topic in a blog post.[6]

Because Remote Sensing determines elevated gas concentrations by evaluating ppm-m (and does not measure ppm) the NPRM ALDP leak detection equipment requirement set forth in ppm hinders the implementation of Remote Sensing.[7]

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[5] https://www.cdc.gov/niosh/topics/fog/data2017.html
[6] https://www.bridgerphotonics.com/blog/understanding-ppm-and-ppm-m-gas-concentration-units
[7] § 192.763(a)(1)(ii)

In addition to having an ALDP element that requires leak detection equipment to have a certain ppm detection sensitivity, the ALDP requires that the "[combination of leak detection equipment and associated work practice] must be capable of detecting all leaks that produce a reading of 5 parts per million or more of gas when measured from a distance of 5 feet or less from the pipeline, or within a wall-to-wall paved area."[8] Rigorously demonstrating equivalence with the ALDP Performance Requirement set in ppm for Remote Sensing is subject to pitfalls including the need to demonstrate correlations between ppm and ppm-m measurements. This puts operators and technology providers in a deficient position where the best technology could go unused because of logistical burdens; or, alternatively, equivalence demonstration might be put forth using faulty logic (consider Figure 1).

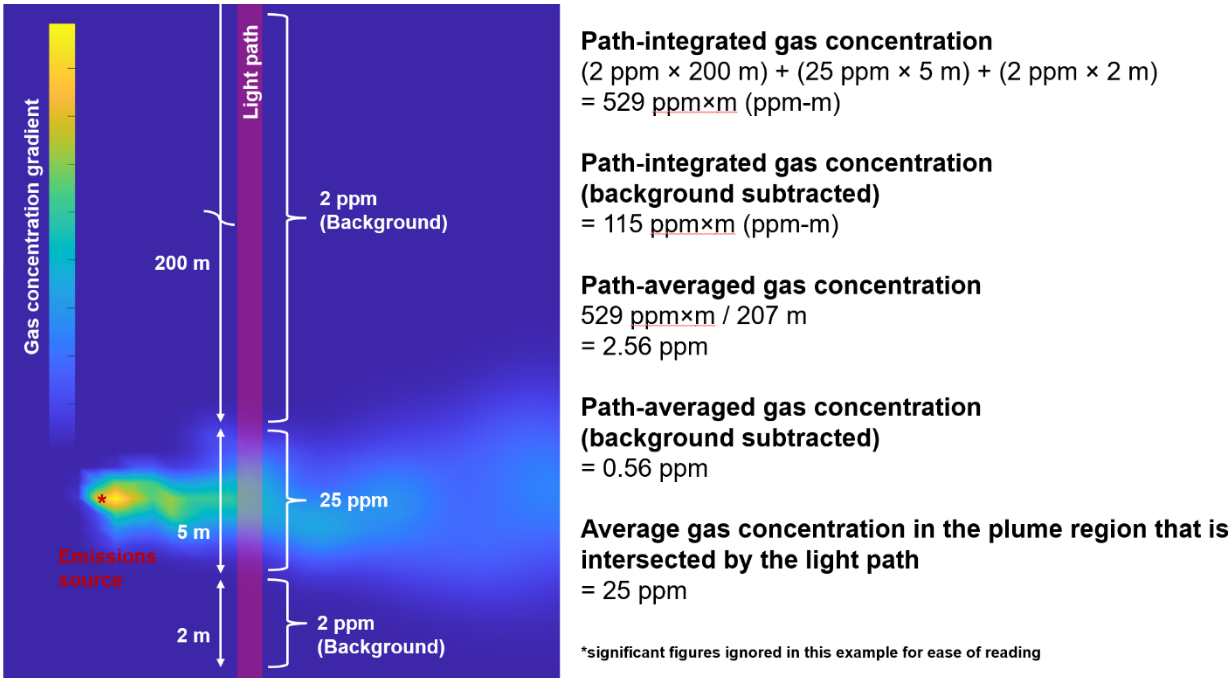

Figure 1. Illustration of how path-integrated gas concentration measurements and the path-averaged value relate to the concentration of gas within a detected gas plume. Remote Sensing measures cumulative gas concentration across an entire light path (in this case, the light path is 207 m). Both background gas (at 2 ppm concentration) and elevated gas (at an average concentration of 25 ppm) is detected, providing a path-integrated gas concentration value of 529 ppm-m. Dividing this value by the light path length provides a value in units of ppm (2.56 ppm), but this value does not correspond to the concentration of gas within a detected plume and simply refers to the average value of gas across the entire light path. The elevated gas concentration is averaged out with the background concentration. If the background is subtracted, an even lower path averaged value is reported because zero values are included in the average. Technology qualification should not be based on path averaging of Remote Sensing measurements because these values not directly correspond to the concentration of gas in the plume that was detected.

One option to demonstrate equivalency could be through gaussian plume modeling where a boundary condition is set for there to be a 5 ppm gas concentration 5' from the emissions source. One can then evaluate wind speeds and emissions rates that would provide this plume property and investigate whether the corresponding model plume would be detected by a Remote Sensing technology. Although this type of modeling could give a suitable pathway to qualify technologies, it is essential to make sure that models adequately represent physical systems, and it may require considerable expertise to evaluate modeling results from various technology systems to make sure modeling results are valid.

[8] § 192.763(a)(b)

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Bridger recommends that PHMSA avoids ambiguity and pitfalls associated with an equivalency demonstration implemented through § 192.18. Instead, we urge PHMSA to provide clear ALDP performance requirements in § 192.763 (and referenced/recapitulated in § 192.706 § 192.723) that are appropriate for Remote Sensing. **This standard should be defined by a leaker mass emission rate (e.g., kg/h) with an associated probability of detection (PoD)**. We recommend this approach because:

(a) Emission rate is a fundamental property of leaks;
(b) Emissions reduction goals are evaluated using emission rates;
(c) Emission rate detection sensitivity has been established as a standardized way to assess leak detection technology efficacy; and
(d) This approach is consistent with the EPAs' framework for implementing advanced methane sensing technology.

a. Emission rate is a fundamental property of leaks. An emissions source emission rate describes how much gas is released to the atmosphere over a period of time, which is the core issue addressed by the NPRM ALDP. Even for an emissions source with a relatively constant emission rate, the gas concentration 5' from the pipeline will be different depending on the environmental conditions at time of survey. During low wind, there would be a higher concentration of gas next to the source but if the pipeline is surveyed when stronger winds disperse the gas, that same leak could be missed if leak detection technology was deployed according to a gas concentration performance standard. To clearly identify the size of leak that must be detected according to the ALDP, it is best to use a mass emission rate probability of detection.[9]

b. Emissions reduction goals are evaluated using emissions rates. At a high level, emissions reduction goals can be assessed by: (1) reduction in total emission rate to the atmosphere from gas pipeline systems and (2) elimination of leaks above a certain size threshold to ensure public safety and reach environmental goals (see comment Topic 2.4). Emission rate distributions are frequently observed to be heavy-tailed meaning that larger emissions contribute an outsized proportion to total emissions.[10] When considering environmental goals, one looks at emissions rate distributions to assess what emission rate threshold accounts for the vast majority of emissions, thereby providing an emission rate detection threshold that can be specified in a regulatory or voluntary frameworks for effective emissions mitigation.

c. Emission rate detection sensitivity has been established as a standardized way to assess leak detection technology/methods. Technology testing has focused on evaluating the probability of detecting an emission based on emission rate.[9,11] In general, this testing has been designed to represent field performance of the technology, and therefore considers if the work practice/protocol for using selected equipment detects a controlled release emissions source. The combination of leak detection equipment and protocol for equipment use may be referred to as a "test method" (or "leak

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[9] Conrad, B. M.; Tyner, D. R.; Johnson, M. R. Robust Probabilities of Detection and Quantification Uncertainty for Aerial Methane Detection: Examples for Three Airborne Technologies. Remote Sensing of Environment 2023, 288, 113499. https://doi.org/10.1016/j.rse.2023.113499.

[10] Kunkel, W. et al.. Extension of Methane Emission Rate Distribution for Permian Basin Oil and Gas Production Infrastructure by Aerial LiDAR; preprint; Environmental Monitoring, 2023. https://doi.org/10.31223/X5BS9V.

[11] Tian, S.; Riddick, S. N.; Cho, Y.; Bell, C. S.; Zimmerle, D. J.; Smits, K. M. Investigating Detection Probability of Mobile Survey Solutions for Natural Gas Pipeline Leaks under Different Atmospheric Conditions. Environmental Pollution 2022, 312, 120027. https://doi.org/10.1016/j.envpol.2022.120027.; Bell, C. et al.. Single-Blind Determination of Methane Detection Limits and Quantification Accuracy Using Aircraft-Based LiDAR. Elementa: Science of the Anthropocene 2022, 10 (1), 00080. https://doi.org/10.1525/elementa.2022.00080.

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detection method") and it is ultimately the test method that results in leak detection as opposed to leak detection equipment on its own. Test methods should meticulously govern the operational parameters and environmental conditions under which leak detection procedures are performed to ensure method performance (see comment Topic 2.8).

d. Using emission rate detection sensitivity to qualify leak detection approaches is consistent with the EPAs' framework for implementing advanced methane sensing technology. The EPA's proposed oil and gas methane rule ("EPA Proposed Rule")[12] provides operators the option to use approved alternative test methods for emissions monitoring at well sites, centralized production facilities, and compressor stations. Test methods are implemented based on their mass emission rate detection sensitivity (at 90% probability of detection). We urge PHMSA to revise the NPRM to be consistent with the EPA Proposed Rule (see Comment Topic 2.9) and enable leak detection methods to be used that provide detection sensitivity described by emission rates. This alleviates unnecessary technology qualification burdens and would streamline the availability of leak detection compliance solutions. Considerable efficiencies can be gained by using the same monitoring for EPA-regulated infrastructure and PHMSA regulated infrastructure.

Comment Topic 2.1 Summary: We urge PHMSA to provide default leak detection requirements (for leak detection equipment, leak detection practices, and the ALDP performance standard) in terms of mass emission rate because this will streamline the use of Remote Sensing, help the nation achieve emissions reduction goals, and provide consistency between PHMSA and EPA regulations.

Comment Topic 2.2: the ALDP should recognize that the considerations for leak detection are different for gathering/transmission versus distribution pipeline.

The gas gathering and transmissions industry segments are notably different from the distribution industry segment and consequentially have different considerations for gas leak detection. The NPRM already provides different survey requirements for onshore gathering and transmission pipeline (§ 192.706) versus distribution pipeline (§ 192.723). In addition, the NPRM allows for an alternative ALDP performance standard to be used for gas transmission and gathering pipelines in Class 1 and 2 locations via the approval process provided in § 192.18.

It is Bridger's understanding that the ALDP 5 ppm gas leak detection sensitivity requirement is based on the sensitivity that could be expected from a point sensor used during a walking survey. While walking surveys or equivalent leak detection approaches may be suitable in the distribution sector, it is unlikely that they are practical for transmission and gathering line leak surveys, especially considering that the NPRM dramatically expands the scope of gathering and transmission pipeline that must be evaluated with leak detection equipment (see Comment Area 1). Bridger urges PHMSA to consider the leak detection sensitivity requirements that we anticipate are suitable for transmission and gathering pipelines (see Comment Topic 2.4).

Comment Topic 2.2 Summary: We urge PHMSA to avoid a one size fits all approach for ALDP requirements because leak detection considerations for gathering, transmission, and distribution pipelines are different.

Comment Topic 2.3: The ALDP should be constructed to directly enable the implementation of Remote Sensing for leak detection instead of relying on § 192.18 provisions.

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[12] 87 FR 74702

As described in Comment Topic 1.1, Remote Sensing is an effective incumbent leak detection approach and the ALDP should allow operators to implement Remote Sensing without an auxiliary equivalency demonstration or approval process.

§ 192.763(c) of the Advanced Leak Detection Program: *Alternative Advanced Leak Detection Performance Standard* specifies that "For gas pipelines other than natural gas pipelines, and for natural gas transmission, offshore gathering, and Types A, B, and C gathering pipelines located in Class 1 or Class 2 locations, an operator may use an alternative ALDP performance standard with prior notification to, and with no objection from, PHMSA in accordance with § 192.18. PHMSA will only approve a notification if operator, in the notification, demonstrates that the alternative performance standard is consistent with pipeline safety and equivalent to the standard in (b) for reducing greenhouse gas emissions and other environmental hazards". Meanwhile in the preamble, the NPRM states "PHMSA expects that it would consider the use of such technologies [including LiDAR Remote Sensing] under the § 192.763(c) process or as supplement to other equipment satisfying the minimum sensitivity performance requirements proposed herein". This approach disincentivizes operators from using Remote Sensing for leak detection because an equivalency demonstration and additional approval process are required.

Comment Topic 2.3 Summary: We urge PHMSA to revise the NPRM to enable operators to use Remote Sensing for their ALDPs without auxiliary approval requirements because Remote Sensing is a logical default leak detection approach.

Comment Topic 2.4: For transmission and gathering pipelines, we propose the requirement to detect gas emission rates of 4.0 kg/h with 90% probability of detection.

To determine an effective sensitivity threshold for midstream pipeline, Bridger assessed emission rate distributions of methane emissions from natural gas gathering pipelines as measured by Bridgers' Gas Mapping LiDAR technology (Figure 2).[13] In production basin **a**, 97% of cumulative emissions were constituted of emissions with rates ≥ 4 kg/h. Meanwhile, in production basin **b**, 95% of cumulative emissions were constituted of emissions with rates ≥ 4 kg/h. Based on this result, Bridger recommends default ALDP performance requirements for leak detection methods to achieve ≥90% probability of detecting leaks with rates of emission to the atmosphere of 4 kg/h. Note that transmission pipelines are typically observed to have fewer leaks than gathering lines and we anticipate that these requirements would also be sufficient for the transmissions sector.

Not only does the proposed emission rate detection sensitivity threshold provide effective emissions reductions, but we anticipate that it can be readily achieved by routine deployment of a variety of LiDAR Remote Sensing gas leak detection solutions.

[13] Stated sensitivity for these measurements was 3 kg/h with ≥90% probability of detection.

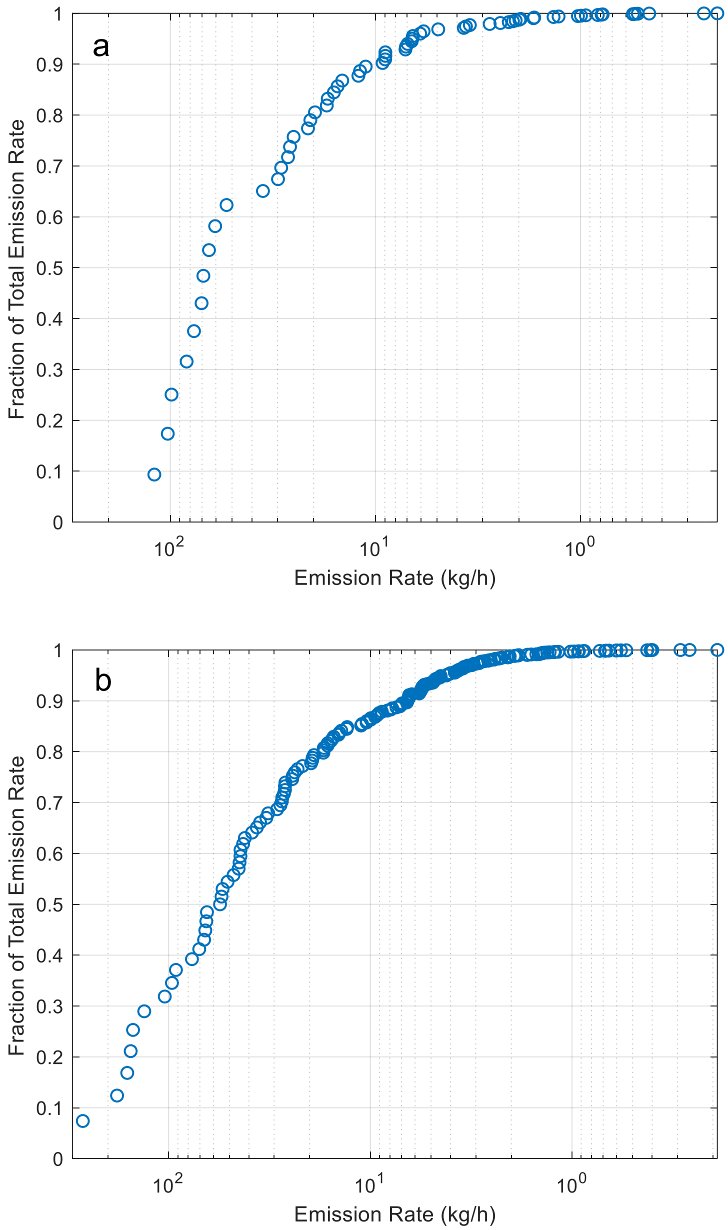

Figure 2. Cumulative emission rate distributions for gathering line methane emission measurements by Gas Mapping LiDAR in two production basins. In production basin **a**, emissions above 4 kg/h account for over 97% of measured emissions and in basin **b**, this threshold accounts for over 95% of measured emissions. Note the reversed x-axis which makes it easy to evaluate the sensitivity required to detect a given fraction of total measured emissions.

Comment Topic 2.4 Summary: We urge PHMSA to provide default ALDP performance requirements for transmission and gathering line leak detection methods described by the requirement to achieve a 90% probability of detecting emissions sources with emission rates to the atmosphere of 4 kg/h because this practical threshold enables effective emissions reduction.

Comment Topic 2.5: The ALDP performance standard recommended in Comment Topic 2.4 should be defined as emission rate detection sensitivity for the rate of emission to the atmosphere.

Because Remote Sensing (like other vehicle-based surveys, OGI surveys, and EPA Method 21 surveys) detects gas that is emitted to the atmosphere, the performance standard for using remote sensing should be defined according to emission rate detection sensitivity for gas emitted to the atmosphere. This point of distinction is important because gathering and transmission lines are often buried underground, but the relationship between gas emitted underground and gas emitted to the atmosphere can be complicated. It can also be difficult to accurately meter the rate of gas emissions to the atmosphere from an underground controlled release. Furthermore, the emission rate threshold recommended in Comment Topic 2.4 is based on rate of emission to the atmosphere.

For practitioners to reliably demonstrate that a leak detection method achieves the ALDP performance standard proposed in Comment Topic 2.4, the performance standard should be defined such that the leak detection method is required to achieve a 90% probability of detecting emissions sources with emission rates to the atmosphere of 4 kg/h. Leak detection method approval requirement recommendations are delineated in Comment Topics 2.8-2.10.

Comment Topic 2.5 Summary: We urge PHMSA to define emissions rate detection sensitivity requirements for Remote Sensing according to emission rates to the atmosphere because Remote Sensing (and most or all leak screening methods) detects elevated gas concentrations in the atmosphere.

Comment Topic 2.6: To make the ALDP requirements meaningful, detection sensitivity requirements must be tied to a probability of detection.

Sensitivity should be evaluated as the probability of detection (POD) for identifying emissions sources with a given emission rate because detecting emissions is a probabilistic/statistical process. If one leak is detected at an emission rate of 1 kg/hr, that does not guarantee the next leak of the same size will be detected. It also does not guarantee that every emission smaller than 1 kg/hr will be missed (although detection sensitivity typically decreases with decreasing emission rate).

Methane sensing technologies may put forward a minimum detection limit (MDL) as a detection sensitivity. This is a poor representation of a technology's emission rate detection capabilities as the MDL might represent a rare detection event under extremely favorable conditions or very specific controlled laboratory conditions. A similar emission may be unlikely to be caught in field deployment. MDLs do not adequately represent technology field performance.

Comment Topic 2.6 Summary: We urge PHMSA to implement ALDP emissions rate detection sensitivity requirements that specify a 90% probability of detection to make the requirements meaningful.

Comment Topic 2.7: Detected pipeline leaks in rural locations with emission rates of ≤ 10 kg/h should have alternative grading and response options.

The environmental benefits of fixing pipeline leaks could be outweighed by negative environmental outcomes and economic burdens. Pipeline repairs may require blowdowns or other operations that could be a greater detriment to the environment than the leak itself. In addition, pipeline infrastructure repairs could disrupt collection of gas upstream of the pipeline leading to increased venting and flaring. Meanwhile, repairs of very small leaks may provide immaterial environmental benefits while presenting considerable economic burdens. For example, in production basin b (Figure 2), 86% of measured gathering line methane emissions can be mitigated by eliminating emissions above 10 kg/h. Eliminating smaller emissions, down to 4 kg/h, only provides an additional 9% reduction in total emissions (as measured) while coming at the expense of needing to address nearly twice as many emissions sources. Based on these considerations, we urge PHMSA to give operators the option to perform alternative leak grade classification and response procedures with appropriate environmental and economic rationale. These procedures would allow the operator to monitor instead of immediately work to repair detected leaks with emission rates below 10 kg/h.

Comment Topic 2.7 Summary: In consideration of potential negative environmental outcomes and considerable economic burdens, we urge PHMSA to provide operators with a pathway to monitor instead of immediately work to repair detected gas pipeline leaks with emissions rates below 10 kg/h following appropriate analysis and justification.

Comment Topic 2.8: The ALDP sensitivity requirements should be simplified to be addressed by an emissions detection "method", which is an approach that is consistent with the EPA Proposed Rule.

It is the combination gas sensing technology with emissions detection practices that ultimately determines if an emissions source will be identified during a leakage survey. Numerous instrument, operational, and environmental factors influence detection sensitivity of an emissions detection method (e.g., signal to noise thresholds for positive detections, sampling rates, survey speeds, instrument fields of view, ground windspeed, ground reflectivity, survey speed etc.). Suitable emissions detection methods provide a reliable detection sensitivity for gas sensing equipment during its actual deployment. PHMSA should simplify ALDP sensitivity requirements to be the sensitivity of the emissions detection "methods" that are employed. This approach provides consistency with EPA's proposed alternative test method implementation of advanced methane sensing technology for emissions screening of oil and gas infrastructure.[14]

Comment Topic 2.8 Summary: To simplify leak detection requirements, we urge PHMSA to combine ALDP leak detection equipment requirements and associated leak detection work practice requirements into an inclusive leak detection method requirement, which aligns with both the ALDP performance standard and EPA regulations.

Comment Topic 2.9: PHMSA should allow EPA-approved alternative test methods for leak detection at natural gas pipelines.

We urge PHMSA to allow suitable EPA-approved alternative test methods for leak detection of natural gas pipelines.[15] As described in Comment Topic 2.8, emissions detection methods encompass the deployment of leak detection technology to identify leaks. By implementing approved alternative test methods that provide suitable detection sensitivity, PHMSA will provide operators with compliance tools in a timely manner and without the burden of extensive additional performance demonstration. There are also considerable safety, environmental, and economic benefits to allowing operators to use the same leak detection methods for pipeline scans as they are likely to use for compressor station scans and for scanning infrastructure surrounding natural gas gathering lines.

Comment Topic 2.9 Summary: To improve the availability of compliance tools and provide consistency with the EPA Proposed Rule, we urge PHMSA to accept suitable EPA-approved alternative test methods for ALDP leak detection.

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[14] Proposed 40 CFR §60.5398b

[15] Proposed 40 CFR §60.5398b(d)

Comment Topic 2.10: PHMSA should require gas sensing technologies to be qualified based on 3rd-party testing according to standardized testing protocols.

To ensure that emissions detection method performance is transparent and upholds high scientific standards, blind testing by an approved third party should be required to demonstrate detection sensitivity. The METEC Advancing Development of Emissions Detection (ADED) initiative provides defined blind testing protocols that could be modified to best represent pipeline leak detection performance.[16] Adhering to ADED protocol guidelines presents an opportunity to achieve consistent and transparent technology qualification.

Comment Topic 2.10 Summary: To increase the transparency and rigor of leak detection method performance demonstrations, we urge PHMSA to require 3rd party testing using standardized protocols under conditions that are suitable to demonstrate field performance.

Comment Topic 2.11: Until correct inputs are available, Bridger supports the twice-yearly leakage survey requirement for transmission and gathering pipelines outside Class 4 locations.

Bridger supports the biannual leakage survey requirement that is specified in the NPRM for most gas gathering and transmission pipelines. To recommend alternative frequencies, additional information would be needed.

Although we urge PHMSA to accept suitable EPA-approved alternative test methods for ALDPs, we do not recommend the use of less sensitive technologies used at a higher frequency on the basis of modeling that was done in the EPA Proposed Rule. This modeling was used to provide a periodic screening matrix that specified scan frequencies as a function of detection sensitivity. The FEAST emissions model that was used to model leak detection efficacy involved emission measurements and leak generation rates specific to the infrastructure affected by that rule.

Herein, we recommend a detection sensitivity threshold based on empirical emission rate distributions for pipelines (see Comment Topic 2.4), but we do not present the leak generation and leak persistence data that would be needed to determine the change in emissions reductions from different scan frequencies. If pipeline leaks propagate more slowly than leaks at upstream infrastructure, then higher frequency scans of pipelines will be comparatively less useful.

Comment Topic 2.11 Summary: Without specific data on pipeline leak generation rates, Bridger supports the requirement to perform leakage surveys of gathering and transmission pipelines outside of Class 4 locations twice a year.

Comment Area 2 Summary: to provide operators with effective pipeline leak detection compliance tools, we urge PHMSA to provide default ALDP requirements that embrace Remote Sensing. The requirement for Remote Sensing to detect leaks with emission rates to the atmosphere of 4 kg/h with 90% probability is our recommendation for effective leak detection programs for transmission and gathering pipelines.

[16] *Advancing Development of Emissions Detection*, Colorado State University Energy Institute – Methane Emissions Technology Evaluation Center, https://energy.colostate.edu/metec/aded/

Comment Area 3: Contextual Background on Gas Mapping LiDAR Technology and Bridger's Capacity to Help Operators Achieve ALDP Regulatory Compliance

Comment Topic 3.1: Bridger's Gas Mapping LiDAR technology is an effective leak detection approach already used by natural gas pipeline operators for regulatory compliance.

Bridger's Gas Mapping LiDAR (GML) technology uses active, laser-based remote sensing instrumentation that is deployed on aircraft. The sensor scans eye-safe range finding and gas measurement lasers across oil and gas infrastructure and surrounding terrain. Laser spectroscopy is performed to determine path-integrated methane concentrations using laser light returned to the sensor by topographic backscatter. The laser is tuned to the 1651 nm absorption line of methane and has negligible interference from other suspect gas species. Concurrently with ranging and atmospheric methane measurements, the sensor acquires digital photography for the target area. An onboard Global Navigation Satellite System – Inertial Navigation System is used to georeference collected data to geodetic coordinates.

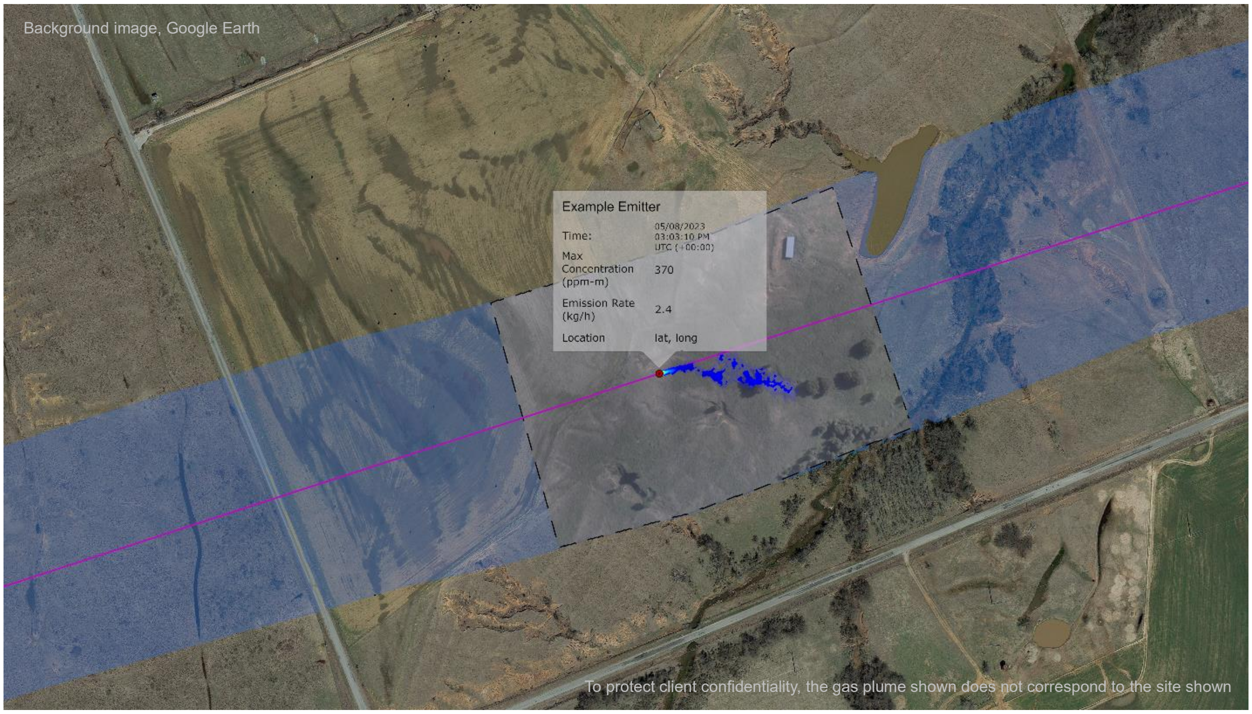

Figure 3. Example of several Gas Mapping LiDAR (GML) data attributes for natural gas pipeline emissions scans. A hypothetical pipeline is shown in purple. A methane plume is mapped using a color gradient to demonstrate the change in path-integrated methane concentrations measured throughout the plume. Several metadata elements for the methane plume are shown in the text balloon. Underneath the methane plume, aerial photography is shown, which is acquired during emissions scans to provide contextual information. The measurement audit (shown in transparent blue) documents the actual area that was scanned for methane emissions. Note the coverage gap over standing water where light does not backscatter to the GML sensor.

During deployment, the GML laser is scanned in a circular pattern below the aerial deployment platform. As the platform moves forwards, a large swath of terrain is evaluated for elevated methane concentrations. Methane measurements are then used to generate methane gas plume imagery (Figure 3). Detected methane plumes are also analyzed to determine emitter attributes including the emissions source location, emission source height, the maximum path integrated methane concentration, and the estimated emission rate. GML scans are designed and confirmed to provide coverage of target areas enclosing the infrastructure that is to be monitored for methane emissions. The topographic backscatter of laser light to the sensor is used to provide a scan swath audit.

Bridger's GML technology has already been adopted by many operators of natural gas gathering, transmission, or distribution pipeline that use our technology to sensitively identify methane emissions. As part of this work, GML is being used for part 192 leak detection compliance under existing regulations.

Comment Topic 3.1 Summary: Gas Mapping LiDAR is a powerful technology for natural gas pipeline leak detection that is already broadly adopted by industry and used for part 192 compliance.

Comment Topic 3.2: Bridger is ideally situated to provide the natural gas pipeline industry with a compliance solution for the NPRM pending suitable revisions.

Pending suitable revisions to the NPRM to streamline the implementation of Remote Sensing, Bridger is ideally positioned to enable the natural gas pipeline industry to achieve regulatory compliance with GML. GML's second generation sensor was engineered to be highly manufacturable, and the sensor capacity is available to scan the expanded scope of pipeline leak detection requirements. Data processing workflows are heavily automated, and Bridger is situated for the upcoming workload. Bridger subcontracts sensor deployment with numerous trusted flight providers and our sensors are ready to be mounted to ubiquitous workhorse aircraft across the US. Our sensor operators are leak-detection qualified and ready to serve the industry.

Comment Topic 3.2 Summary: Gas Mapping LiDAR technology is available at the necessary scale to scan pipelines subject to this NPRM.

Comment Area 3 Summary: Bridger's Gas Mapping LiDAR technology is an effective natural gas pipeline leak detection solution that is situated to serve operators subject to the NPRM.

Comment Area 4: NPRM Provisions that Require Updates or Clarification

Comment Topic 4.1: Leak detection personnel should not need to have training in other fields of leakage response.

PHMSA should clarify that leak detection operators don't also have to be qualified for leak grading and other tasks that are not directly part of leak detection. Proposed § 192.769 states, "only individuals qualified under subpart N of this part may conduct leakage survey, investigation, grading, and repair. Individuals qualified under subpart N must also possess training, experience, and knowledge in the field of leakage survey, leak investigation, and leak grading, including documented work history or training associated with those activities."

Many leak detection solution companies do not participate further in leak investigation, grading, and or repair. These tasks may be independently handled by the operator that receives gas emissions data. Therefore, leak detection personnel should not be required to have training in these separate workflows (and vice versa).

Comment Topic 4.1 Summary: We urge PHMSA to update or clarify the NPRM regulatory text to indicate that personnel involved in leak detection do not need to also be qualified for leak investigation, grading, or repair if they do not engage in those actions.

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