Carbon Management Canada

Methane Detection and Quantification Testing Protocol Canada

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Executive Summary

This protocol has been developed by Carbon Management Canada (CMC) by leveraging their experience in program delivery supporting alternative methane detection and quantification technologies by co-administering the Alberta Methane Emissions Program (AMEP), as well as being owner-operator of a test facility that conducts controlled releases of fugitive emissions for technology validation. The protocol was made possible through a grant bestowed by Natural Resources Canada (NRCan) to provide a standardized framework for evaluating methane emissions detection and quantification technologies through Controlled Release Tests (CRTs).

Methane emissions from oil and gas operations are a significant contributor to global greenhouse gas emissions, driving both regulatory scrutiny and technological innovation in emissions detection and quantification. Standardized testing protocols are critical to ensure that methane detection and quantification (LDAQ) technologies are evaluated consistently and rigorously across diverse test facilities and Technology types. This document presents a comprehensive protocol designed to guide CRT offerings at dedicated test facilities in Canada, providing a transparent and scientifically defensible framework for Technology evaluation.

The protocol outlines clear definitions for methane emissions sources, including vented, fugitive, and background emissions, ensuring a shared understanding for all stakeholders. It also establishes standardized processes for CRT design, operation, data collection, and performance evaluation. These processes cover all stages of testing—from test planning and Technology setup to operational testing and final performance reporting. Key infrastructure requirements for test facilities, such as controlled gas release systems and meteorological monitoring, are also specified to ensure tests reflect real-world operating conditions.

Performance metrics are central to the protocol, with a focus on detection probability (POD), minimum detection limits (MDL), quantification accuracy, and localization precision. These metrics ensure technologies are evaluated not only for their ability to detect methane emissions but also for their accuracy in determining emission rates and pinpointing emission sources. The protocol applies to a wide range of detection methods, including handheld survey tools, aerial screening technologies, and continuous monitoring systems.

This document builds on established best practices from existing controlled release testing programs, most notably the Emission Detection and Quantification Controlled Test Protocol developed by the Methane Emissions Technology Evaluation Center (METEC) at Colorado State University, as well as procedures and insights from Carbon Management Canada (CMC), which operates the Atmospheric Fugitive Emissions (AFE) test facility at their Newell County Field Research Station near Brooks, Alberta. AMEP has implemented a rigorous testing, reporting and analysis process and has funded extensive field-testing campaigns, the insights gained from this program have also influenced the Protocol.

Ultimately, this protocol supports not only the development and certification of new methane detection technologies, but also the continuous improvement of existing methods, ensuring that performance evaluations remain scientifically credible and practically relevant as Technology and regulatory landscapes evolve.

1 Introduction

This report presents the Controlled Release Test (CRT) Protocol developed by Carbon Management Canada (CMC). The objective of this report is to provide clear, standardized procedures for designing, executing, and evaluating methane emissions detection and quantification technologies through a series of CRTs. These tests aim to improve the quality of emissions data and support methane reduction efforts aligned with both regulatory and climate goals.

Standardized methane emission testing protocols are essential for ensuring consistency and comparability in emissions observational data and emission source location and release rate models. They also play a key role in evaluating the effectiveness of methane detection and quantification technologies. With the availability of diverse tools—such as ground-based sensors, airborne systems, and satellites—a consistent framework is needed to evaluate their performance. Standardized testing ensures these technologies are measured against the same criteria, allowing for a clearer understanding of their accuracy and suitability across different methane emission sources.

To develop effective protocols, it is important to first define the different sources of methane emissions, which fall into two primary categories: natural emissions, such as those from wetlands or geological seepage, and anthropogenic emissions, which result from human activities. Within anthropogenic emissions, a critical distinction exists between *vented volumes*—deliberate releases such as those from equipment blowdowns or maintenance—and *fugitive emissions*, which are unintentional leaks from faulty equipment or infrastructure. Effective testing protocols must account for both types of anthropogenic emissions, as well as the temporally varying natural background concentration, to ensure that the measurement captures the true emission signature of the source being tested.

Without these clear definitions and distinctions, inconsistencies can arise in the way methane emissions are detected, measured, and reported across different sources, regions, and sectors. This inconsistency makes it difficult to compare data across companies and countries. Implementing standardized protocols for leak detection and quantification (LDAQ) programs/initiatives ensures that all methane measurements and reporting provide reliable and comparable data. This is particularly important for regulatory compliance, as governments and international organizations are increasingly adopting methane reduction targets against a baseline year as part of climate policies.

Furthermore, standardized protocols foster collaboration across industries, governments, and researchers, facilitating a more coordinated global effort to reduce methane emissions. They enhance transparency and credibility, helping companies who operate oil and gas infrastructure to gain trust from regulators, investors, and the public, particularly in relation to methane emissions reporting. Finally, standardized testing enables operators to integrate quantification with reduction by accurately identifying key emission sources. For both social and economic reasons, efforts should be focused on where they are most needed.

In addition to academic literature, three organizations or programs which support and/or execute controlled release emissions testing influenced the development of this document.

1. A collaboration between Colorado State University's Methane Emissions Technology Evaluation Center (METEC) and TotalEnergies' Anomaly Detection Initiatives (TADI) produced the Emission Detection and Quantification Controlled Test Protocol, released April 2025[1]. The METEC ADED 2.0 test campaigns are conducted in accordance with this Protocol.

2. The Alberta Methane Emissions Program (AMEP) is an ongoing initiative jointly managed by CMC and the Sundre Petroleum Operators Group (SPOG). The objectives of the program are to advance measurement technologies, enhance data accuracy and support industry compliance with evolving environmental regulations.

3. CMC owns and operates the Atmospheric Fugitive Emissions (AFE) test facility at their Newell County Field Research Station near Brooks, Alberta. It is a controlled release field testing site for applied research and Technology validation of methane emissions detection and quantification technologies. CMC has conducted CRTs since 2017 and has developed procedures that fulfill various test objectives for Technology development and methods currently deployed in Fugitive Emissions Management Programs (FEMPs).

By focusing on providing clarity and consistency for test facilities, this protocol ensures that stakeholders—including Technology developers, researchers, and regulators—have a robust, standardized framework to guide CRT design, execution, and evaluation. While individual organizations and collaborative programs have developed procedures for these tests, standardization across the sector is still lacking. Through robust and transparent methodologies, this protocol not only enhances confidence in methane detection technologies but also supports broader industry, government, and research collaboration, ultimately helping industry achieve and surpass methane emissions reduction goals.

2 Definitions

The following comprehensive list contains a glossary of terms and definitions used throughout the document.

- **Background Emissions**: Methane originating off-site (e.g., nearby wells, livestock) and transported across the facility by wind. Forms part of the ambient concentration the technology must filter out.
- **Baseline Emissions**: Routine, on-site operating emissions (vents, exhaust, scheduled blowdowns) present under normal conditions and used as the business-as-usual reference, excluding leaks or controlled releases.
- **Close-Range Survey:** A methane survey using a method that enables source-level attribution and cause analysis. Close-range surveys are commonly performed by skilled technicians using optical gas imaging cameras (OGI), but other methods exist such as organic vapor analyzer (OVA). Required to confirm leak at component resolution.[2]
- **Component:** In emissions attribution, a component is the smallest scale of oil and gas infrastructure. Examples include valves, flanges, and threaded connections. Multiple components

comprise equipment (e.g., tanks, separators) and a site may have multiple pieces of equipment or equipment groups.

- **Controlled Release Test (CRT):** A type of experiment where emissions are intentionally created for the purpose of evaluating emission detection and/or quantification systems. During a CRT, the emissions rate, location, and duration of test interval are known to the Operator with well-understood accuracy.
- **Detection:** An alert provided by the Technology and/or Performer to the Facility Operator that an emission is present. An elevated gas concentration measurement alone does not constitute a Detection but instead must be accompanied by analytics to attribute the elevated concentration to a CRT.
- **Detection Resolution:** The resolution at which a Method can detect, locate and quantify an emissions source (e.g., component, equipment, facility, site, region).
- **Detection Thresholding:** The process of setting a quantitative limit (the Threshold) above which a Technology classifies a signal as an emission. This Threshold defines the minimum detectable signal needed to confidently distinguish Test Facility emissions from background emissions or non-emission signals.
- **Gas Mass:** The amount of matter in a gas, measured in units like grams (g) or kilograms (kg).
- **Equipment:** In emissions attribution, equipment is the second most granular piece of oil and gas infrastructure. Examples include tanks and separators. See the definition of the component for more details.
- **Facility:** Defined by the Alberta Energy Regulator (AER) as any structure, equipment, or activity involved in the exploration, development, production, processing, or transportation of energy resources in Alberta, Canada. Facilities are subject to Fugitive Emissions Management Program (FEMP) monitoring under AER Directive 060.
- **Far-field**: Refers to screening methods such as vehicle, drone, or aircraft-based approaches that detect emissions from a distance, in contrast to close-range methods that require proximity to the source.
- **Leak Detection and Quantification (LDAQ):** The process of identifying gas leaks and measuring the emission rate or volume.
- **Leak Detection and Repair (LDAR) Program:** A strategic plan used by industries to locate and fix equipment leaks, especially in facilities dealing with volatile organic compounds (VOCs) or other hazardous substances. The main objective of an LDAR program is to reduce fugitive emissions, which are unintentional discharges of gases or vapours into the atmosphere due to equipment leaks.
- **Localization:** Identifying the physical location of a leak source. Localization can be done at different scales (e.g., site-level, equipment-level, and component-level).

- **Localization Accuracy (LA):** The proximity between the estimated emission location provided by a Participant and the actual location of an emission source is measured. In this protocol, the LA is two-dimensional (2D). Three types of localization accuracies can be calculated based on: 1) an Equipment Unit, 2) a single latitude-longitude coordinate pair, or 3) a pair of coordinates representing a bounding box reported by the Performer.
- **Localization Precision (LP):** A measure of the area within which a Participant attributes an emission source. It reflects the spatial uncertainty or spread of the estimated source location, as opposed to LA, which measures the proximity of the estimated location to the true location. LP does not consider how close the estimate is to the actual release point (as LA does), but rather how specific or narrow the estimated area is. Two types of LP may be calculated based on: (1) an Equipment Unit or (2) a pair of coordinates defining a bounding box reported by the Participant.
- **Method:** Integrates a technological solution, a work practice, and analytical techniques to be applied within an LDAR program. It must explicitly define all required steps that constitute the work practice, as well as appropriate conditions for employing the Technology.
- **Method 21:** A U.S. EPA-approved procedure for detecting and measuring volatile organic compound (VOC) leaks using portable flame ionization detectors (FID) or photoionization detectors (PID).
- **Method Class**: A classification of methane detection technologies based on operational characteristics and deployment platforms [2] including handheld devices, fixed sensors, UAVs and aircraft. This framework supports selecting suitable tools for (LDAR) by comparing mobility, scale, and data output.
- **Minimum Detection Limit (MDL)**: The minimum rate at which a Technology can identify CH_4 emissions, usually expressed in terms of kilograms of CH_4 per hour.
- **Optical Gas Imaging (OGI):** A widely adopted method for identifying leaks that employ thermal infrared cameras to display the signature for methane and other organic gases. Typical OGI cameras capture images within a limited band of the mid-infrared spectrum, specifically between 3.2 to 3.4 µm wavelength, a range where methane and light hydrocarbons are known to absorb strongly.
- **Operator:** The company which is responsible for the daily operations of the Facility, assets, and equipment.
- **Performer:** The methane detection Technology company personnel participating in the CRT.
- **Probability of Detection (POD):** Methane emission POD curves demonstrate the likelihood or probability that a particular methane emission source or event will be detected by a monitoring system or measurement method. It represents the effectiveness of the detection system in identifying and capturing the presence of methane emissions.
- **Equipment Group (Process Block):** Equipment located and/or working together at the same location.

- **Quantification Accuracy (QA):** The disparity between the estimated emission rate provided by a Performer and the metered emission rate of a Controlled Release is measured. QA can be expressed as either an absolute difference or a percentage difference relative to the metered emission rate.[3],[4]

- **Quantification Precision (QP):** The difference between the upper and lower confidence limits reported by a Performer for an emission rate estimate is measured. [3],[4]

- **Site:** The AER defines a site as a single-surface lease (pads counted as one lease) where gas is flared or vented. At a site, there can be several licensed facilities with unclear boundaries. For instance, a multi-well battery may have tanks that belong to different facility licenses, yet they are all located in a single row within the same lease. In such cases, it is more convenient for the licensee to conduct screening and surveying activities for the entire site rather than attempting to differentiate between individual facilities.

- **Screening:** Aerial, satellite, and continuous monitoring (CM) are screening methods used in methane detection and quantification to quickly identify high-emitting sites, allowing for focused follow-up source diagnosis and root cause analysis. While CM is often used for rapid screening, it can also be considered its own category due to its ability to provide ongoing emissions data. An aerial monitoring campaign is an example of a commonly used screening method.[1]

- **Technology:** The gas sensing instrument, optionally configured with a deployment platform and/or ancillary instruments (e.g., positioning system, analytics) performing the CRT.

3 General Protocol Requirements

As part of Canada's broader efforts to reduce methane emissions from the oil and gas sector, individual provinces have developed their own regulatory frameworks to meet federal and provincial targets. Alberta, as a prominent Canadian jurisdiction with the largest provincial oil and gas industry, has played a particularly significant role in shaping these regulatory approaches.

In 2015, the Government of Alberta directed the Alberta Energy Regulator (AER) to develop requirements to reduce methane emissions from upstream oil and gas operations by 45%, relative to 2014 levels, by 2025. This led to the development of Directive 060: Upstream Petroleum Industry Flaring, Incinerating, and Venting, which came into effect on January 1, 2020. Directive 060 requires operators to develop a FEMP, including implementing a Leak Detection and Repair (LDAR) program. Directive 060 was updated most recently in April 2025 and is discussed in more detail in Section 7.2.2.

Regulatory compliance for FEMPs requires the use of approved methods and technologies, typically United States Environmental Protection Agency (EPA) Method 21 or optical gas imaging (OGI) cameras. Over the past decade, the number of methane detection technologies has grown significantly. Many of these Technologies offer the potential for equivalent or superior emission reductions, but demonstrating equivalency remains a challenge.

There is a variety of dimensions for incorporation of a robust Technology evaluation (Table 1).

Table 1: Elements of robust Technology assessment

Technology Validation	Confirm the Technology's ability to detect and quantify methane emissions accurately under controlled conditions.
Performance Evaluation	Compare performance against established ground truth data to assess sensitivity, accuracy, and reliability.
Operational Limitations	Examine performance under varying environmental conditions (e.g., temperature, wind speed, humidity).
Quantification Accuracy	Evaluate the precision of methane quantification to ensure reliability for compliance and reporting.
False Positive/Negative Rates	Identify and quantify operational reliability regarding leak identification.
Regulatory Compliance	Verify adherence to relevant standards to facilitate industry adoption.
Usability and Practicality	Assess the ease of deployment, maintenance, and operational viability of technologies in the field.

Several academic studies have evaluated the detection capabilities of alternative Fugitive Emissions Programs (alt-FEMP) technologies that show advanced capabilities in detecting emission events. However, quantification and localization are still in early stages of development. Localization, while achievable with reasonable accuracy using handheld technologies, continues to pose challenges for broader screening solutions. Similarly, quantification is still difficult across most technologies, though some recent progress has been made [5].

Before the details of Test Facility infrastructure requirements are discussed, it may be helpful to set the progression of CRT development. Table 1 above lists the elements that must be considered as a CRT is planned. The phases of CRT illustrate the sequence of activities necessary to achieve this goal (Figure 1) ranging from the planning stage to develop a test plan that will enable the Performer to meet their specific objectives to the post-CRT step which may lead to certification or to identify areas for further technological improvement.

The Test Facility, in standardized methodologies discussed herein, can generate an unbiased dataset which accurately reflects Technology performance with a high degree of confidence. Using this framework, components I to IV are conducted through the Test Facility; however, performance review may be conducted either by the Test Facility or the Performer when proprietary algorithms for analysis are involved. Post-CRT certification processes are typically overseen by regulatory bodies, while Technology refinements and improvements are led by the Performer.

For example, in Alberta, the AER has developed specific equivalency matrices under Directive 060, which Performers can meet through CRTs. AMEP has played a key role in advancing alt-FEMP solutions, positioning Alberta as a leader in supporting regulatory acceptance of emerging technologies. While British Columbia and Saskatchewan do not currently have formal alt-FEMP programs like Alberta, both provinces have frameworks in place that allow for the use of alternative detection technologies as part of their methane reduction strategies. Approved alt-FEMP technologies give confidence to regulators and industry operators, while also offering the potential for lower-cost deployments, more efficient monitoring, and more accurate and detailed datasets.

Sections 5 and 6 cover in more detail the individual components of the CRT progression, shown graphically in Figure 1.

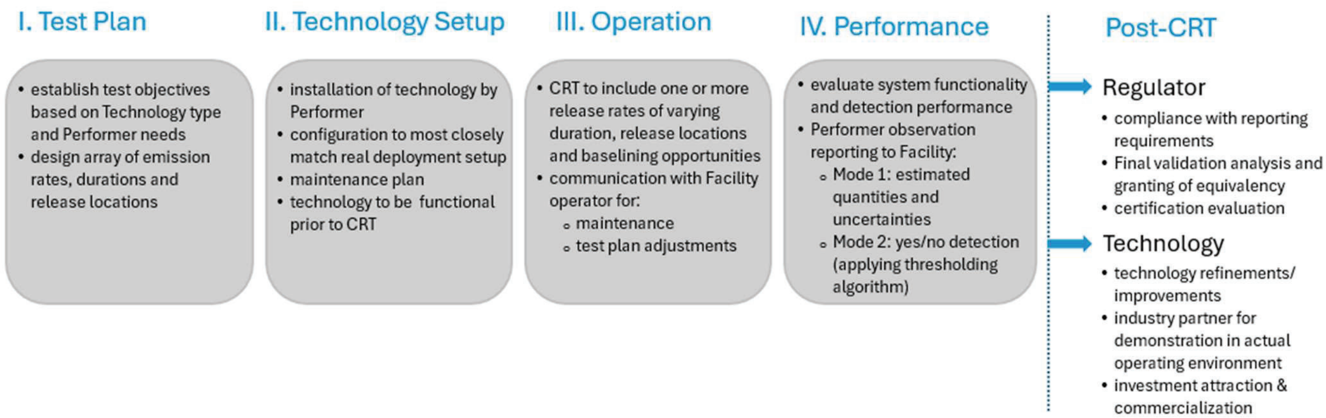

Figure 1: Overview of the Controlled Release Test (CRT) process, from test planning to performance evaluation and post-CRT reporting and certification.

By executing on Stages 1 to 4, controlled release (CR) test facilities in Canada, such as the AFE test facility, can demonstrate equivalency with the METEC/TADI ADED 2.0 protocol.

Case studies on PoMELO, a truck-based Technology, and LSI, an aerial Technology are presented in Appendix II to provide real-world examples of Protocol implementation.

3.1 Facility Infrastructure Requirements

Controlled release (CR) test facilities will span a range of capabilities. A CR from a single point in an open area will fulfill fewer test objectives than can multiple CRs from varying durations and rates in a simulated environment containing oil and gas equipment acting as flow path impediments can provide more realistic detection and quantification. Only once a facility is capable of delivering on Stages 1 to 4 (Figure 1) will ADED 2.0 equivalency be achieved.

Table 2 summarizes the various levels of site complexity. It is adapted from the ADED 2.0 draft Protocol Section 6.3.

Table 2: Test Facility complexity and associated test types

Complexity	Description of CRT	Test Type(s)
Low	• Single to multiple release points in an open area • Absence of flow path impediments such as oil and gas equipment	• Detection and quantification of far-field screening and continuous monitoring technologies; simple dispersion • Quantification of close-range handheld survey devices
Medium	• Multiple release points • Oil and gas equipment or simulated equipment; aerodynamically complex • Release points not hidden	• Detection and quantification of far-field screening and continuous monitoring technologies; complex dispersion • Quantification of close-range handheld survey devices
High	• Multiple release points • Oil and gas equipment or simulated equipment with realistic configuration and component density; aerodynamically complex • Gas supply tubing and release points are hidden	• Detection and quantification of close-range and far-field survey/screening technologies and continuous monitoring technologies; complex dispersion

Site complexity dictates the types of testing that can be conducted at a Test Facility, as profiled below.

3.1.1 Realistic Operating Conditions

Release patterns should simulate various operational conditions, such as fugitive leaks that are small and occur over long time periods or planned maintenance and safety-driven releases that are high-volume and low duration. For example, fugitive leaks can be simulated from equipment such as low-efficiency separator units or from wellhead surface casing vent flow (SCVF). Leaks can also be simulated from housing that surrounds oilfield equipment from a variety of egress points. Intentional releases can be simulated from a thief hatch on a tank or a blowdown (i.e., venting) on an isolated section of pipe.

To achieve a level of realism, release points should be placed in a way that simulate real-world operating conditions. The locations should be associated with a component on a piece of equipment in order to 'leak' from a specified source and from a height that reflects real-world operations.

Obstructions between the release point and the detection point disperse the plume creating realistic, aerodynamically complex patterns. For this type of environment, oilfield equipment is recommended. The examples provided below are routinely identified as sources of unintentional releases.

1. Above-ground:
    a. Upstream: flare stacks, tanks, separators, dehydrators, and pneumatic valves

    b. Midstream: compression facilities (especially reciprocating compressors) along major transmission pipelines; maintenance blowdowns
    c. Downstream: gas metering and distribution service lines to customers
2. Below-ground:
    a. Buried tanks
    b. Pipelines
    c. Wellbore

Canadian oilfield operations typically enclose sensitive equipment such as separators in shacks to provide protection from extreme weather. The Test Facility may simulate this realistic aspect of oilfield operations.

The test facility is required to provide spatial position coordinates and height of all release points as part of the dataset that will be provided to Technology providers post-testing.

3.1.2 Facility Flexibility for Multiple Technologies

The facility should be able to accommodate the deployment of a spectrum of emissions detection and quantification technologies, broadly categorized in Table 3.

Table 3: Technology categories

Stationary	• Fence line • Equipment • Pole height
Mobile	• Aerial: drone, plane, satellite • Mobile: vehicle, truck-mounted • Handheld devices: optical gas imaging cameras, organic vapour analyzers

Power and Data Transfer: Performers may have to supply their own power systems, or work with the Test Facility for access to power as a part of facility-specific offerings. This also applies to data recording and wireless networks for transmission of data.

Location and Configuration: Performer's Technology should be set up such that the simulated environment most closely matches the anticipated set up in an operating environment. Where possible, the Test Facility can make best efforts to provide this configuration. However, there may be limitations due to safety hazards, such as releasing flammable and explosive gas in an enclosed space (i.e., separator shack). In addition, accommodations may have to be made in the case of two Performers on the site simultaneously.

Weather conditions may negatively influence Technology performance. Performers need to ensure that their equipment can withstand a variety of weather events and temperature extremes.

3.1.3 Gas Release Controls

The volumes of released gas must be a known input with a high degree of confidence. Standard equipment necessary to achieve this include:

- source of compressed natural gas, typically a canister at high pressure
- pressure gauges as well as a regulator valve
  - discharge pressure gauges are a safety measure as well as protection for flow controllers.
  - Joule-Thomson cooling effect in the flowlines due to reduction in pressure when canister gas is released mean that there is a threshold below which equipment is at risk of failure; depending on site configuration and operating limits of equipment, this lower threshold should be adhered to and stated clearly in the facility-specific standard operating procedure.
- heat exchangers incorporated into the release system design will reduce the temperature difference between the CNG and ambient air.
  - in high-release-rate scenarios, the Joule-Thomson cooling effect may alter gas dispersion of the detection performance of Technologies – heat exchangers will mitigate the gas expansion ratio.
- gas flow metering equipment: either mass flow controllers or flow meters
  - mass flow controllers provide measurement and control of mass flow rates, whereas flow meters provide measurement only.
  - desired release rate is set and recorded at the desired frequency.
  - uncertainty in metered flow rates should be reported, accounting for variables such as gas composition, meter accuracy and flow stability.
- release points that represent operating conditions; simulation at different heights and obstructed/unobstructed depending on test objectives (aerodynamic complexity)

The compressed natural gas should be of known methane composition and verified each time the storage tanks or cylinders are filled. A typical methane composition for CNG would range between 90-95%, which is important data for correct conversion of volumetric to mass flow rates. Where feasible, the gas should closely emulate production natural gas in composition—including saturation levels and the presence of heavier hydrocarbons—to better represent real-world conditions. Use of odorized distribution gas (e.g., containing mercaptan) should be avoided unless justified and documented, as it may affect sensor responses.

The Test Facility should have a maintenance plan that includes yearly calibration by certified providers of flow controllers—uncertainty estimates should be reported as well. Pressure and temperature gauges/transmitters should undergo yearly calibration.

3.1.4 Meteorology

Environmental conditions must be accounted for by the Performer in the analysis of Technology performance. They present uncontrollable factors that impact accurate quantification of emissions. Test facilities should have weather instruments that measure various meteorological conditions. For example, anemometers measure wind speed and direction which yield valuable information on plume dispersion patterns.

Weather instruments, either mobile or in fixed position enable the collection of some or all of the following parameters:

- Wind speed and direction
- Humidity
- Temperature
- Barometric pressure

Normalizing detection limits in terms of mass flow per unit wind speed, expressed in kg/h, can provide a standardized evaluation metric. Given that wind speed varies with altitude, it is best practice to measure it at a standardized altitude, such as 10 metres above ground level, for consistent normalization and analysis.

Performers also may have onboard meteorological sensing equipment or may make use of local (within 10 km) or regional (>10 km) weather station data.

Sky and ground conditions (i.e., clear, cloudy, light to heavy rain, snow cover) are particularly important to make note of as these may represent confounding factors for certain types of sensors.

The Test Facility should have a clearly stated operating envelope in which CRs can be performed, such as the lower limit of ambient temperature mentioned above. These limitations can be for reasons of site infrastructure, safety, or operational constraints.

3.2 Data Recording and Management

To ensure transparency, accuracy, and accessibility, standardized procedures are followed for data collection, storage, and sharing. These measures help maintain data integrity and facilitate meaningful analysis across different technologies.

The following data fields and tables have been adapted from AMEP. Results from CRTs conducted at the Newell County Field Research site through AMEP will be made available on the Data Hub (AMEP PUBLIC DATA HUB), with a one-year embargo period from the date of testing before the data is publicly accessible.

Not every Technology or Performer tested will populate all fields in these tables. However, the level of data completeness can itself serve as an evaluation metric, reflecting the maturity and readiness of a Technology in real-world applications.

3.2.1 Technology Identifiers

Before any CRT takes place, the Test Facility will maintain a Technology Identifiers table containing data provided by the Performer (Table 4). This table will document each unique Technology along with its respective performance metrics. All asserted performance metrics and supporting materials must undergo an initial review by the Test Facility.

The Test Facility provides environmental conditions data, with further details available in Section 3.1.4 Technologies may also include their own onboard anemometers. The results and final report will document all environmental data sources used by the Performer, who must specify each source, the date of access, and its purpose. This is a key consideration when evaluating a Technology.

Table 4: Technology identifier data fields

Technology Identifiers		
Display Name	**Description**	**Format / Acceptable Values**
Method Name	The commercial or internal name of the method.	Text
Method Description	A brief description of the method, including the methane detection Technology(ies), platform(s), work practice, analytics, quantification method, and LDAR activity procedure.	Text
Technology Provider	The name of the company that manufactures the detection Technology used in the method. If more than one Technology is used, separate the names by a semicolon.	Text
Last Calibration	The date of the most recent calibration of the method.	YYYY-MM-DD
Calibration Frequency	The manufacturer-defined calibration frequency of the detection Technology in months.	Integer
Software Version	The version number of the method software used, if applicable.	Text
Method Class	The method class as per the definition in Fox et al. 2019 (e.g., handheld, fixed sensor, unmanned aerial vehicle, aircraft).	Aircraft Fixed Sensor Handheld Instrument Mobile Ground Lab (MGL) Other Satellite Unmanned Aerial Vehicle (UAV)
Method Subclass	The method subclass based on the sensor detection system (e.g., active, passive, point, other). Select all that apply.	Active Passive Point Other
Type of Detection Sensor	The type of sensor used in the method (e.g., metal oxide, TDLAS, open-path, CRDS, OGI). Select all that apply.	CRDS Metal Oxide OGI Open-Path Other TDLAS
Asserted Detection Resolution	The method's asserted detection resolution (e.g., component, equipment, facility)	Component Equipment Facility
Asserted Localization Accuracy (m)	The method's 2D localization accuracy.	Numeric value to 2 decimal places
Asserted Localization Uncertainty (m)	The method's 2D localization uncertainty.	Numeric value to 2 decimal places
Asserted 50% Probability of Detection (kg/hr)	Mass emission rate at which a 50% probability of detection occurs under expected environmental and operating conditions in kg/hr.	Numeric value to 3 decimal places
Asserted 90% Probability of Detection (kg/hr)	The mass emission rate (in kg/hr) at which the Performer claims a 90% probability of detection under expected environmental and operating conditions. This assertion should be based on documented evidence, such as results from previous field or controlled testing, that supports the expected performance under standardized CRT conditions.	Numeric value to 3 decimal places
Quantification (Y/N)	Does the method quantify emissions?	Y/N
Quantification Method	The quantification method.	Calibrated Bag CRDS Full Flow Meter High-Flow Sampler Metal Oxide Open-Path QOGI TDLAS Other
Asserted Upper Quantification Bound Uncertainty (+%)	The method's 95% confidence interval upper bound quantification uncertainty (+%).	Integer

Asserted Lower Quantification Bound Uncertainty (-%)	The method's 95% confidence interval lower bound quantification uncertainty (-%).	Integer
Asserted Operational Envelope - Max Wind (m/s)	The maximum wind speed that the method can safely and effectively operate in.	Numeric value to 1 decimal place
Asserted Operational Envelope - Min Temperature (°C)	The minimum temperature that the method can safely and effectively operate in.	Integer
Asserted Operational Envelope - Max Temperature (°C)	The maximum temperature that the method can safely and effectively operate in.	Integer
Maximum Precipitation (mm/hr)	The maximum precipitation that the method can safely and effectively operate in.	Integer
Maximum Distance (m)	The maximum distance from the emission source that the method can confirm the presence of an emission. Note that this should be incorporated into the method's work practice to ensure effective deployment for an LDAR program.	Integer
Method Speed (m/s)	Specific to mobile method classes (UAV, MGL, aircraft), the speed at which the LDAR activity will be performed, in m/s.	Integer
Method Flight Height (m)	Specific to aerial method classes (UAV, aircraft, satellite), the height above ground level at which the LDAR activity will be performed, in meters.	Integer
Method Swath Width	The method's detection swath width, if applicable, in meters (e.g., an aircraft method flying at a speed of x m/s and a height of x m has a detection swath that is x m wide).	Integer
Cost Unit	The method's cost unit (e.g., site, hour, day).	Day Hour Site
Asserted Time to Notification (min)	The time from when a detection is made by the method to when a notification of an emission is sent to the facility operator.	Integer

3.2.2 CRT Identifiers

For meaningful, post-CRT analysis, accurate, spatially referenced data is essential. The Test Facility personnel will capture key data for each release to ensure precise record-keeping and reliable assessment of detection and quantification performance (Table 5).

Table 5: CRT identifier data fields

CRT Identifier		
Display Name	**Description**	**Format / Acceptable Values**
Site Latitude (Center)	Latitude of the center of the CRT site.	6 decimal places (NAD83 decimal degrees)
Site Longitude (Center)	Longitude of the center of the CRT site.	6 decimal places (NAD83 decimal degrees)
CRT Trial #	Specific to the Technology Development stream, the CRT trial # refers to the test trial number.	Integer
CRT Number	The test number within the test series (e.g., If multiple CRTs occur over multiple days as part of a test series. Then the first CRT on day one would be 001 and so on).	3-digit numeric value
Test Control	The type of test control (e.g.: informed, single blind with respect to location, single blind with respect to rate, etc.).	Double Blind wrt Rate and Location Informed Single Blind wrt Location Single Blind wrt Rate
Methane Composition	The percent composition of methane in the test gas.	Numeric value to 1 decimal place
Gas Composition (Attachment)	If a gas analysis was performed, attach the file here. File naming convention: GA##	GA##
CRT Latitude	Latitude of the CRT emission.	Numeric value to 6 decimal places (NAD83 decimal degrees)
CRT Longitude	Longitude of the CRT emission.	Numeric value to 6 decimal places (NAD83 decimal degrees)

CRT Location Uncertainty (m)	The location uncertainty, as determined by the measurement source.	Integer
Release Height (m)	The vertical distance from the ground directly beneath the release point to the location of the controlled release, measured in meters. Ground level is defined locally for each release point, meaning the height is quantified relative to the surface or platform directly below that specific emission source.	Numeric value to 2 decimal places
Volumetric Release Rate (m^3/day)	The CRT average mass flow rate in standard m^3/day, as measured with a flowmeter, using the following STP reference values: STP: 15.00°C and 1 atm (101.325 kPa)	Numeric value to 1 decimal place
Methane Volumetric Release Rate (m^3/day)	The methane volumetric flow rate in standard m^3/day, as measured with a flowmeter, using the following STP reference values STP: 15.00°C and 1 atm (101.325 kPa) calculated for methane when gas composition is available (e.g., 91.1% methane)	Numeric value to 1 decimal place
Mass Release Rate (kg/hr)	The CRT mass emission rate.	Numeric value to 3 decimal places
Methane Mass Release Rate (kg/hr)	The CRT mass flow rate in kg/hr, as measured with a flowmeter. AMEP uses the following STP reference values: STP: 15.00°C and 1 atm (101.325 kPa) calculated for methane when gas composition is available (e.g., 91.1% methane)	Numeric value to 3 decimal places
Input Gas Temperature (°C)	The input gas temperature measured with the flow controller when available.	Numeric value to 1 decimal place
CRT Date	The date of the CRT.	YYYY-MM-DD
Release Start Time	Release start time in the following 24-hour clock format (HH:MM:SS). The release start time refers to when the CRT gas started flowing.	HH:MM:SS
Release End Time	Release end time in the following 24-hour clock format (HH:MM:SS). The release end time refers to when the CRT gas was stopped or turned off.	HH:MM:SS
Environment Conditions	The file containing the time-series data from the source of environmental conditions.	EN##
Wind Direction Index	A value to indicate if the wind was blowing in the sensor's direction during the release. Value ranging from 0-1, with 1 being the most favorable and 0 being the least favorable. To be calculated from the CRT environment time-series file.	Numeric value to 1 decimal place
Flow Controller Time-series File	The file containing the time-series data from the flow controller or flow meter.	FC##

3.2.3 CRT Performers Data

This section documents detection outcomes from Technology Performers during CRTs. The data captured here reflects how well each Technology detects, quantifies, and reports emissions (Table 6).

Table 6: CRT Performers data fields

CRT Performers Data		
Display Name	**Description**	**Format / Acceptable Values**
Survey Start Date/Time	The date/time when the survey was started.	YYYY/MM/DD HH:MM:SS
Survey End Date/Time	The date/time when the survey was completed.	YYYY/MM/DD HH:MM:SS
Survey File	The data obtained during the survey. May include geospatial, video, or tabular data files.	SF##
Detection (Y/N)	Did the participant detect emissions from the CRT?	Y/N
Detection Date/Time	Time of detection.	YYYY/MM/DD HH:MM:SS
Notification Date/Time	The time when a notification of a detection is sent to the CRT operator.	YYYY/MM/DD HH:MM:SS
Detection Latitude	The estimated latitude of the detection.	Numeric value to 6 decimal places (NAD83 decimal degrees)
Detection Longitude	The estimated longitude of the detection.	Numeric value to 6 decimal places (NAD83 decimal degrees)

Distance From Detection (m)	The distance between where the measurement was taken and the source of the emission.	Numeric value to 2 decimal places
Detection Height (m)	The estimated height of the detection, above ground level.	Numeric value to 2 decimal places
Max Methane Concentration (ppm)	For methods that measure methane mixing ratios, the maximum concentration of methane detected.	Integer
Mass Emission Rate (kg/hr)	The estimated mass emission rate of the controlled release.	Numeric value to 3 decimal places
Mass Lower Quantification Bound Uncertainty	The 95% confidence interval lower bound quantification uncertainty for the estimated mass emission rate.	Numeric value to 2 decimal places
Mass Upper Quantification Bound Uncertainty	The 95% confidence interval upper bound quantification uncertainty for the estimated mass emission rate.	Numeric value to 2 decimal places
Volumetric Emission Rate (m^3/day)	The estimated volumetric emission rate of the detection.	Numeric value to 2 decimal places
Volumetric Lower Quantification Bound Uncertainty	The 95% confidence interval lower bound quantification uncertainty for the estimated volumetric emission rate.	Numeric value to 2 decimal places
Volumetric Upper Quantification Bound Uncertainty	The 95% confidence interval upper bound quantification uncertainty for the estimated volumetric emission rate.	Numeric value to 2 decimal places

4 Method Class

Methane detection and quantification technologies can be categorized into distinct classes, each with specific capabilities and applications. These technologies broadly fall into screening, continuous monitoring, and survey methods. Together they provide complementary approaches to managing emissions.

Each of these technologies has distinct strengths and limitations, making them suited to different stages of methane management. Screening technologies, in addition to continuous monitoring, enable rapid detection of high-emitting sites, while survey methods provide the precision needed for effective repairs.

By integrating these technologies into a Comprehensive Monitoring Program (CMP), methane management efforts can be optimized. Screening tools enable quick identification of emission hotspots, while survey methods ensure detailed, accurate assessments. This combined approach enhances detection efficiency and supports effective emission mitigation.[2]

4.1 Survey

Survey methods involve detailed, component-level analyses to pinpoint specific emission sources. These methods are typically performed using handheld instruments such as those specified in Method 21 or OGI cameras that can offer greater quantification accuracy. Refer to Appendix III for more information on established Standards.

Method 21 detects volatile organic compound (VOC) leaks by measuring gas concentrations near components, with detection limits typically in the range of a few parts per million by volume (ppmv), depending on the calibration gas and instrument sensitivity. While Method 21 does not measure leak rates, it remains highly effective for identifying small leaks, making it a valuable tool for methane detection and repair programs.

OGI cameras, on the other hand, visualize gas plumes in real-time, with detection sensitivity influenced by environmental conditions and operator expertise. However, their sensitivity can be affected by factors like wind speed, background temperature contrast, distance from the source and operator expertise. Under optimal conditions, modern OGI devices can detect methane emissions as low as 19 grams per hour (g/h), which is sensitive enough to meet EPA Standards.[6]

The disadvantages with Method 21 devices or OGI cameras lie with labour-intensive operation, skillset of operator, and require close-range access to individual components. These factors limit their suitability for large-scale surveys but remain indispensable for follow-up investigations after screening technologies have flagged potential emission sites.

4.2 Screening

Screening technologies are designed to rapidly identify high-emitting sites, enabling targeted investigations for repairs and compliance. These methods include mobile ground labs (MGLs), piloted aircraft, satellites, and Unmanned Aerial Vehicles (UAVs).

MGLs integrate GPS with methane sensors to map concentration gradients along road networks, making them particularly well-suited for site- or regional-scale surveys. Detection limits vary widely depending on the system and environmental conditions, and standardized detection boundaries are not universally established in the literature.

Piloted aircraft cover vast areas efficiently, ideal for detecting super-emitters across large regions. Under optimal conditions, aircraft-based systems can detect emissions below 100 kg/h, and in some cases, as low as 10 kg/h.

Satellites excel in global-scale monitoring, with detection limits around 1,000–1,500 kg/h for wide-area instruments, while targeted systems such as GHGSat have achieved detection limits below 100 kg/h. [7]

Aerial systems, such as UAVs, enhance these methods by offering high-resolution, close-range monitoring. In optimal conditions, some UAV-based systems have demonstrated detection limits as low as 0.03 g/s, depending on factors such as altitude and wind speed. [8] While these systems are limited by flight durations and weather, they excel at detecting emissions across diverse terrains and infrastructure that may be difficult to access or be restricted by site operators.

Together, these screening technologies provide rapid and efficient identification of methane emission hotspots, enabling effective resource allocation for mitigation efforts.

4.3 Continuous Monitoring

Continuous monitoring (CM), provides real-time data on methane emissions, enabling rapid detection and response. Unlike screening technologies, which periodically scan for emissions, CM offers ongoing measurements, making it particularly valuable for high-priority locations such as compressor stations or densely packed infrastructure.

CM systems include fixed sensors, which monitor emissions continuously at stationary sites, and mobile CM setups, which can be deployed dynamically to track emissions across varied locations. Fixed sensors are highly effective for localized detection, alerting operators when methane concentrations exceed set thresholds. However, they have limited spatial coverage, making them less suitable for expansive or dispersed oil and gas fields. Fixed CM systems can detect methane emissions with sensitivities as low as 0.4 kg/h, with detection probabilities reaching up to 90% under certain conditions, though performance depends on sensor placement, meteorological conditions, and testing protocols.[9] To achieve comprehensive coverage, mobile CM can complement fixed sensor networks, particularly in challenging terrains and dispersed infrastructure layouts.

5 Test Method

This section is heavily based on the METEC ADED 2.0 Protocol, particularly its structured methodology outlined in Section 4. Testing is conducted through a systematic process comprising three distinct phases: Setup, Operation, and Reporting. Each phase is meticulously designed to replicate real-world conditions and rigorously evaluate the performance of detection, localization, and quantification technologies.

5.1 Setup Phase

The Setup Phase aims to replicate real-world deployment conditions at the Test Facility. The configuration and deployment of each Technology solution must closely resemble typical field deployments to maintain the validity of the test results. This includes matching sensor density, sensor type, software versions, personnel involvement, and operational procedures. Any deviation from standard deployment practices may render the results invalid for certifications, regulatory compliance and equivalency, or contractual applications.

Performers should:

- install system components to align with operational guidelines of the Test Facility
    - subject to established safety protocols and hazard assessments as communicated by Test Facility personnel
    - must not obstruct roadways or high-traffic pathways
    - adhere to surveyed areas and boundaries of the Test Facility
- power their Technologies using the same systems intended for field operations
    - the Test Facility may or may not offer access to power
- provide their own data communication systems, consistent with their typical deployment configurations
- design their system components to withstand environmental conditions, such as extreme temperatures, high winds, and precipitation.
- provide complete documentation of system components and configuration, including model numbers, power configurations, software versions, and physical locations to the Test Facility

If systems interfere with each other—such as overlapping data transmission frequencies or conflicting network protocols—the Test Facility will mediate and decide on necessary adjustments to ensure all technologies operate without disruption.

For CM Technologies, setup time covers both installation and maintenance activities. Survey and Screening Methods must also have setup efforts tracked, and certifications (such as drone pilot licenses) may be required.

5.2 Operation Phase

The Operation Phase follows the structured methodology used in the METEC ADED 2.0 Protocol, providing a robust framework for evaluating detection, localization, and quantification technologies. While this approach is not obligatory, it represents a comprehensive and effective method for assessing methane emissions performance. As industry standards evolve, this methodology is expected to play a key role in shaping future testing and measurement practices.

The Operation Phase involves the execution of the test program, designed to collect performance data for detection, localization, and quantification metrics. Testing consists of Baseline Periods, which simulate normal facility emissions, and can be included depending on the test objectives. Simulation Periods involve CRs that replicate leak scenarios over and above baseline emissions allowing for thorough evaluation of a Technology's response to varying emission conditions.

The Test Facility collaborates with Performers to design programs that include diverse emission rates, durations, and release points. However, the specific details of CRs remain undisclosed to Performers to ensure unbiased evaluation. CRs are carefully structured to simulate both Baseline Controlled Releases (BCRs) for normal operations and Failure Controlled Releases (FCRs) for unexpected leak events. The entirety of the simulation period is the sum of BCRs and FCRs. These emissions vary in size, duration, and frequency to challenge detection, quantification, and localization capabilities under realistic conditions.

Operational testing may be interrupted due to equipment failures, maintenance needs, safety concerns, or adverse weather conditions. All interruptions are logged and managed by the Test Facility and form a part of performance evaluation. Performers are solely responsible for maintaining their systems, including following appropriate calibration procedures consistent with those used in field deployments. All maintenance activities, calibration events, and downtimes must be documented.

For CM Technologies, autonomous operation is expected. Performer access should be limited to scheduled maintenance. Survey and Screening Technologies must follow scheduled Survey and Screening intervals, with procedures and personnel involvement consistent with standard field practices. Surveys and Screenings must be completed within the designated timeframes, and the Test Facility defines their operational boundaries to maintain standardization across evaluations.

5.2.1 Key Operational Principles

The Test Facility offers various controlled release test scenarios designed to evaluate Performer technologies under differing levels of information disclosure—ensuring an unbiased scenario under which performance can be assessed. CRs are conducted under four levels of disclosure, as shown in Table 7.

Table 7: Controlled release test scenarios

Informed Testing	Performers are provided with both the location and rate of the controlled release before commencing the CRT.
Single Blind with Respect to Rate	Performers are aware of the release location but not the emission rate. To maintain the blind, only the Test Facility has access to the flow controller and its data.
Single-Blind with Respect to Location	Performers know the emission rate but not the location. Release locations must be discreet to not reveal the exact positioning to the Performer.
Double-Blind with Respect to Rate and Location	Performers are unaware of both the location and rate of the controlled release. Similar to the single-blind location scenario, this setup demands select Technologies and rigorous protocols to prevent inadvertent disclosure.

Blind testing is critical to ensuring that evaluation remains objective and free from bias. By limiting access to test details these methodologies prevent external factors from influencing results. To further enhance test integrity, the Test Facility will communicate their safety protocol that should require all personnel to complete site-specific safety training and use appropriate personal protective equipment (PPE).

To maintain data integrity, Performers are prohibited from sharing information during testing, ensuring that evaluations remain impartial and credible. Furthermore, comprehensive maintenance documentation is mandatory, with Performers required to log and report all maintenance activities and system downtimes, promoting transparency and accountability throughout the CRT process.

5.3 Test Reporting Phase

The Reporting Phase focuses on the accurate and timely submission of data for comprehensive performance evaluation. Reporting is divided into two categories: Technology Status, which documents the operational conditions of the system (Table 4), and Technology Observations, which documents detected emissions (Table 6). These categories ensure that both system functionality and detection performance are properly assessed.

Performers must report data using two approaches. The first approach reports estimated emission quantities, including emission rates, durations, and source locations. The second approach consists of binary detection reports (yes/no) to assess detection probability and time-to-detection metrics. Performance metrics are calculated as either Sample-Based Metrics, which compare reported emissions to controlled releases over the same period, ensuring accuracy at the event level. Integrative Metrics, on the other hand, evaluate cumulative emissions over extended durations, providing insight into long-term detection and quantification trends.

All data must be submitted in machine-readable formats, excluding PDFs or handwritten reports. Reports must detail start and end times, gas type, detection status, emission estimates, and equipment/component locations that are identified as the emission source. Offline Reports must be submitted to document system downtimes, including specific reasons such as maintenance or equipment failure. Performers are also encouraged to provide threshold algorithms that define detection conditions. However, this is not mandatory, as its necessity depends on the Test Facility's capacity and expertise in assessing such algorithms. When provided, the Test Facility applies them to assess detection accuracy and calculate relevant performance metrics.

An integrated approach to the Setup, Operation and Test Reporting workflow ensures the Technology validation process is both rigorous and fair providing a robust foundation for the evaluation of methane detection and quantification technologies.

6 Performance Metrics

Technology performance metrics are derived by systematically comparing Technology-generated observations with Test Facility reference measurements. This structured evaluation ensures an objective and standardized assessment of a system's ability to detect and quantify emissions under controlled conditions.

By applying consistent evaluation methods, these metrics provide a comprehensive performance assessment, enabling fair comparisons across different technologies. The following sections detail the methodologies used to evaluate detection, localization, and quantification capabilities.

6.1 Detection-Based Testing

This section outlines the process and methodologies used to evaluate methane detection technologies. The focus of detection-based testing is the assessment of how accurately and promptly various technologies can identify methane releases under controlled and varied environmental conditions. The core objectives include:

- Assessing Detection Probability, Detection Accuracy, Sensitivity, and Reliability: Verifying a Technology's capability to accurately detect methane emissions across different scenarios.
- Quantifying Detection Limits, Response Times, and False Detection Rates: Establishing thresholds for detection performance, including how quickly and accurately emissions are detected.
- Evaluating Performance Across Environmental Conditions: Understanding how environmental variables like wind, temperature, and humidity impact detection efficiency.

6.1.1 Detection Test Design

For detection-based technologies, CRTs are carefully designed to align with the specific objectives of the evaluation. They incorporate a wide range of emission rates—from very low to high—to thoroughly assess detection performance. These tests include emission rates near, below, and above the anticipated detection threshold to evaluate the Technology's sensitivity and reliability under realistic operating conditions. Additionally, periods with no emissions (i.e., null releases) are integrated to measure false positive and false negative occurrences, ensuring a rigorous evaluation of detection accuracy.

In some cases, two separate periods may be considered—one to characterise baseline emissions (routine on-site sources) and another to characterise background concentrations (up-wind off-site sources), further refining the assessment.

Reliance on inferred or regional "average" background atmospheric concentrations should be avoided. Both tests and operational monitoring typically occur in settings that, at various scales, can contain other and temporally variable methane emission sources. For example, upwind natural and anthropogenic vented and fugitive emission sources, such as intensive agricultural production, municipal solid waste management sites or other petroleum facilities can result in significant variations in background emissions that can impact test results, if not properly accounted for. This comprehensive testing methodology ensures that detection-based technologies are accurately evaluated while minimizing false alarms, leading to more reliable methane monitoring in real-world conditions.

6.1.2 Data Processing for Detection: Alignment and Thresholding

For methane detection technologies assessed using detection-based metrics, a thresholding process is applied to incoming observation reports. This process classifies each report as either a detection or non-detection, producing binary outputs (yes/no) for both the Technology's data and the Test Facility's controlled release data. While thresholding is optional for the Technology under evaluation, it is mandatory for calculating detection-based metrics to maintain consistency.

The Test Facility may provide standard thresholding templates, but this is not required. Technologies may also implement custom thresholding algorithms, provided they meet complexity guidelines and are compatible with the Test Facility's systems. Thresholding ensures that the number of detections reports exactly matches the number of input reports, preserving data integrity. Technologies may incorporate additional data fields in their detection logic; however, the same algorithm must also function with Test Facility data, which may not include these extra fields.

Before thresholding can be applied, observation data must first undergo alignment to ensure accuracy:

1) Temporal Alignment: Time values must match the Test Facility's resolution and time zone to synchronize detection records.
2) Spatial Alignment: Reports must correspond to defined facility boundaries, ensuring data is correctly mapped by adjusting spatial boundaries (such as 3D bounding volumes) or filtering for relevant areas.

6.1.3 Detection Performance Metrics

After temporal and spatial alignment, each observation report is compared with the Test Facility's emission measurements, generating two classification tables. These tables provide a structured evaluation of the Technology's detection accuracy:

- Technology Detection Table: Records whether the detection Technology classified either an event or an observation as detected or not detected.

- Test Facility Detection Table: Indicates whether the Test Facility's controlled release measurements correspond to detection or non-detection.

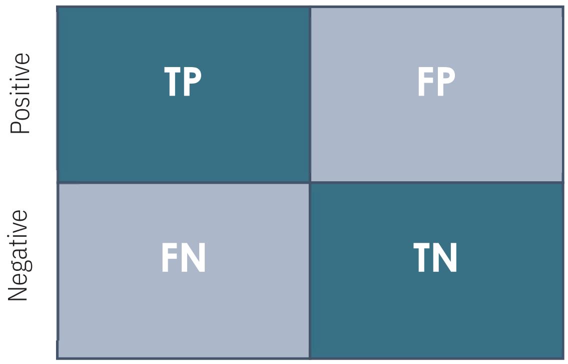

Figure 2: Confusion matrix.

This comparison results in four generally possible outcomes graphically shown in Figure 2.

True Positive (TP): The Test Facility releases an emission, and the Technology detects an emission.

False Positive (FP): The Test Facility does not release an emission, but the Technology detects an emission. False Positives may occur for several reasons, two being that the background concentration at the time of the event or observation is underestimated or that non-ideal wind or the gas/air temperature contrast inhibit the ideal dispersion of the release.

True Negative (TN): The Test Facility does not release an emission, and the Technology does not detect an emission.

False Negative (FN): The Test Facility releases an emission, but the Technology fails to detect an emission. False negatives may have several causes including non-ideal wind conditions or an overestimation of the background concentration.

These classifications form the foundation for key performance metrics, such as probability of detection, false alarm rates, and detection sensitivity, ensuring a standardized and consistent evaluation across different technologies.

6.1.3.1 Probability of Detection (POD)

The Probability of Detection (POD) represents the likelihood that a detection system successfully identifies an actual methane emission under specified conditions. This metric evaluates a Technology’s ability to detect emissions and notify users when action is needed. It is represented as a curve or surface, depending on whether one or multiple independent variables —such as emission rate, wind speed, or source-receptor distance— are considered. These factors, which significantly influence detection performance, have been highlighted in prior studies of both ground-based and airborne methane detection methods. [9],[10] Because POD varies with these operating variables, it cannot be fully characterized by a single global ratio of true positives (TP) to all actual positives (TP + FN). Instead, the ratio must be evaluated as a function of the conditions, x, under which it is assessed, as expressed in Eq. 1:

$$\boldsymbol{POD}|_x = \frac{\boldsymbol{n_{TP}}}{\boldsymbol{n_{TP}} + \boldsymbol{n_{FN}}} \,|_x \qquad \text{(Eq. 1)}$$

For robust POD evaluation, sufficient data must span a representative range of conditions, capturing variations in release rate, wind speed, source-receptor distance, and, for continuous monitoring systems, emission duration. [11],[12]

To generate POD curves or surfaces, analysts typically apply binomial logistic regression or similar generalized linear models are applied, accommodating binary data while ensuring asymptotic behavior approaching 100% detection. Test planning, including CRT design, should align these variables with the expected capabilities of the Technology under evaluation. Early discussions with Performers can help ensure test conditions are relevant to the Technology's design and anticipated performance.

6.1.3.2 Minimum Detection Limit (MDL)

The Minimum Detection Limit (MDL) is the minimum rate at which a Technology can identify CH_4 emissions, usually expressed in terms of kilograms of CH_4 per hour. This threshold marks the point where detection transitions from consistent to sporadic, for example, when a release is detected in only 2 out of 5 passes. The MDL can fluctuate throughout the day and across different days due to varying environmental conditions. Prior to testing, the Performer provides the Test Facility with an expected minimum detection limit (MDL) to help design the initial test plan, ensuring it spans a reasonable range of release rates. During testing, flow rates are systematically adjusted throughout the day, with ongoing communication between the Performer and the Test Facility to review detection results at different flow levels and refine the understanding of the actual MDL under varying environmental conditions. Detection outcomes generally fall into three categories:

- Complete non-detection – The release is too minimal to be detected, as an event or as individual observations collected during an event.
- Sporadic detection – The release is detected inconsistently across multiple attempts. In other words, individual observations fail to detect the expected plume, which should result from the combination of the release rate, the sensor's distance from the source, and the wind dispersion model.
- Consistent detection – The release is detected in every trial.

To challenge the detection system and pinpoint the MDL, tests should begin with higher emission rates that gradually decrease until Technology can no longer reliably detect the release. This process involves conducting multiple passes over or around the release point, like those commonly performed by mobile systems like UAVs or ground-based sensors using EPA Other Test Method 33A [13], to evaluate consistent detection performance. However, the MDL obtained from CRTs at the Test Facility cannot be directly extrapolated to actual oil and gas facilities, as these values can vary significantly due to the same factors mentioned above — including release characteristics, environmental conditions, and facility complexity.

Background emissions, originating from sources outside the facility or site (e.g., agricultural activities or nearby facilities), must be distinguished from baseline emissions, which refer to operational routines or equipment failures within the facility. Identifying and documenting these external sources is crucial to ensure accurate assessments and to minimize interference.

Testing should be repeated throughout the day and on different days to ensure consistent results and to account for variability in environmental factors such as wind speed and direction, temperature, and humidity, all of which can significantly impact detection capability. CRs must be conducted under diverse environmental conditions to fully assess the robustness of the Technology and its sensitivity to external variables. This comprehensive testing approach helps generate POD models that reflect how detection performance varies with these influencing factors. Regulatory bodies—including the AER and the EPA—now use evaluation matrices that translate a Technology's reported MDL into the emission rate at which POD is at least 90 %. These matrices provide a common yardstick for determining regulatory equivalency and for comparing technologies across test programs. In fact, some studies recommend using the emission rate at which POD reaches 90% or 95% as a more reliable performance metric than MDL, as it provides a clearer indication of practical detection capabilities under variable conditions (Figure 3). [10],[14]

Figure 3 is a schematic representation of a typical Probability of Detection (POD) curve, illustrating the cumulative detection probability as a function of emission rate. This schematic is intended for illustrative purposes only and does not represent the performance of any specific Technology or dataset.

Finally, the detection Technology must be properly calibrated to prevent inaccurate readings. Calibration should closely mimic expected field conditions to ensure the Technology operates reliably during testing. Accurate calibration is critical to obtaining accurate and meaningful MDL assessments.

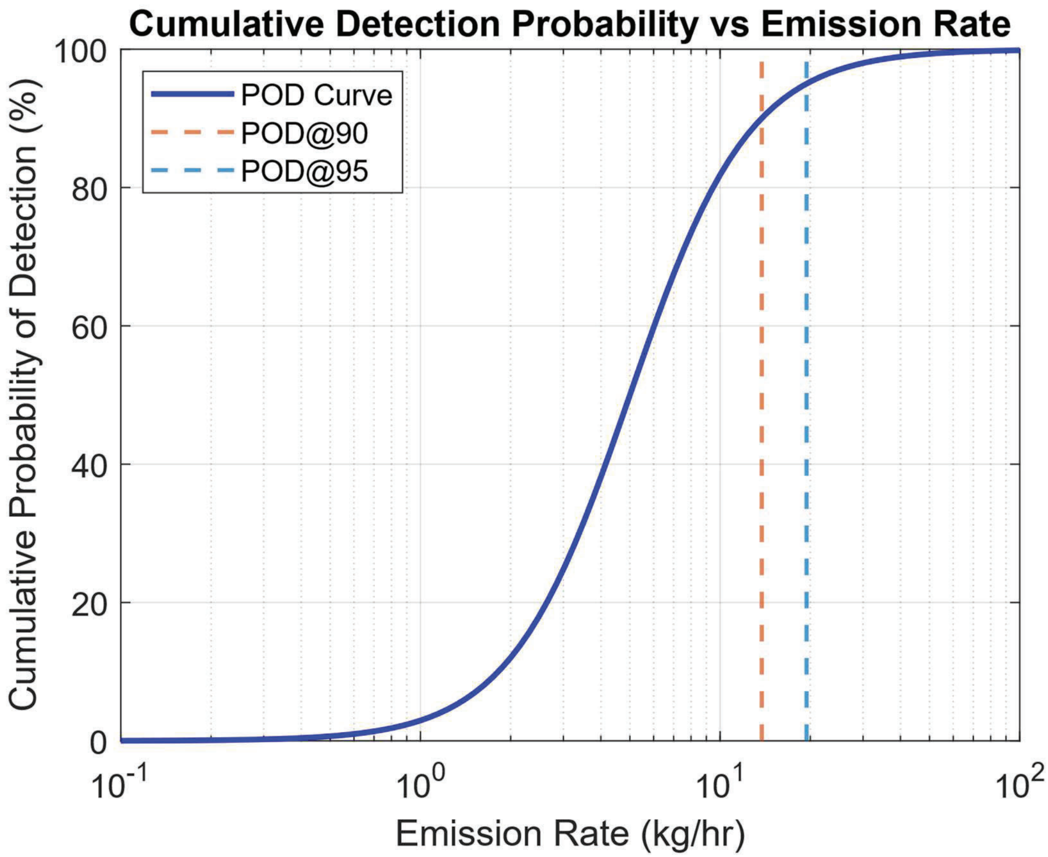

Figure 3: Cumulative Probability of Detection (POD) as a function of emission rate (kg/hr) on a logarithmic scale. The S-shaped curve represents increasing detection probability as emission rates rise, consistent with controlled release test (CRT) results. Vertical dashed lines indicate the emission rates at which the Technology achieves 90% and 95% detection probability (POD@90 and POD@95), two common performance benchmarks used in Technology evaluation.

6.1.3.3 Time-to-Detection (TTD)

Time-to-Detection (TTD) evaluates how quickly a Technology identifies the start of an emission event. This metric specifically measures the delay between the onset of a CR and the Technology's detection, providing insight into response efficiency. TTD excludes any data transmission delays, focusing solely on the system's detection capabilities.

To evaluate TTD, the Test Facility analyzes overlapping time intervals between its releases and the Technology's detection reports. The delay is determined by measuring the time difference between the start of the CR and the first detection event recorded by the Technology. If the Technology fails to detect a Test Facility emission, it is categorized as a "no detect." Conversely, if the Technology reports a detection when no Controlled Release occurred, it is classified as a "false detect." By systematically analyzing these cases, the TTD metric provides a clear measure of detection responsiveness under controlled conditions.

6.1.3.4 Time-to-Alert (TTA)

Time-to-Alert (TTA) extends the analysis of detection performance by including the delay in transmitting detection information to the Test Facility. It measures the total time elapsed between the start of an emission event and when the Test Facility receives the Technology's first valid detection report. This metric combines the TTD with any reporting delay, offering a more comprehensive view of how quickly Technology can identify and communicate the presence of emissions.

TTA provides a more comprehensive measure of real-world response time, evaluating not only how quickly a Technology detects an emission but also how efficiently it communicates detection data. In operational settings, timely alerts are critical for determining whether detections should be flagged for follow-up investigation, immediate mitigation actions, or routine monitoring.

6.2 Localization-Based Testing

Localization-based testing assesses a Technology's ability to identify the precise source of emissions. This can occur at various levels, including site-level, equipment-level, or component-level source identification, ensuring accurate pinpointing of methane releases.

6.2.1 Localization Test Design

The localization test design aims to rigorously evaluate the ability of detection technologies to accurately identify the spatial coordinates of methane emissions. To achieve this, tests must be structured to ensure that the location of the CR is blind to the Performers. Refer to Table 7 *Test Scenarios* which are designed to prevent bias and ensure that the results truly reflect the capabilities of the Technology under realistic operating conditions.

To thoroughly assess localization performance, multiple release points should be incorporated into the test design. These release points must include both equipment-level and component-level locations to evaluate the granularity and precision of the Technology. Release points should be strategically distributed across the testing facility to represent diverse and challenging scenarios that the Technology may encounter in real-world operations. For example, oilfield equipment groupings present an aerodynamically complex and confounding effect on plume dispersion. A Test Facility may be of sufficient complexity to be able to simulate this. Refer to Table 2 which outlines the various levels of facility complexity.

Localization test design should ensure a comprehensive evaluation of the Technology's ability to pinpoint methane emission sources with accuracy and reliability.

6.2.2 Localization Performance Metrics

This metric evaluates how accurately a Technology can pinpoint the source of emissions within defined spatial areas, known as Analysis Spatial Extents (ASEs). It reflects the precision with which emission points are identified within these predefined zones—particularly important for source-specific detection technologies. ASEs are established through a spatial filtering process to ensure that only relevant data within set boundaries are analyzed.

Additional ASEs may be established prior to testing or refined afterward to better align with the evaluation objectives. These customized ASEs allow for focused analysis on particular facility zones or categories of equipment types, enhancing the understanding of how well a Technology can localize emissions under different spatial conditions.

Furthermore, aggregating localization metrics across ASEs of similar characteristics can offer valuable insights into how performance varies across distinct operational environments. A comparison within and between categories of equipment types ensures a thorough and adaptable evaluation of a Technology's localization capabilities within well-defined scenarios.

Note — localization metrics are calculated only for detections that occur (i.e., they are conditional on a true- or false-positive report and do not include false negatives).

6.2.2.1 Localization Precision

The granularity – here referred to as precision – of localization for methane emissions is assessed using the emission source from detection reports. For true positive detections, localization precision is evaluated by comparing the Performer's reported location with the actual emission source. Each detection is classified into one of three nested precision levels (each level can itself be treated as an ASE), ranked in order of decreasing granularity: [3],[4]

1. Correct Equipment: Performer-identified equipment matches the equipment where the CR occurred.

2. Correct Equipment Group: Performer-identified equipment belongs to the equipment group (or process block) within which the CR occurred.

3. Correct Facility: Performer- identified equipment is within the facility boundaries where the release occurred.

6.2.2.2 Localization Accuracy

Localization accuracy for equipment is calculated as the fraction of reported detections at each precision level. The formulas for each level of precision are as follows:

Equipment:

$$\boldsymbol{LA_{Equipment}} \frac{\boldsymbol{N_{TPEquipment}}}{\boldsymbol{N_{RD}}} = \frac{\boldsymbol{N_{TPEquipment}}}{\boldsymbol{N_{TP} + N_{FP}}} \qquad \text{(Eq. 2)}$$

Equipment Group:

$$\boldsymbol{LA_{Equipment\ group}} = \frac{\boldsymbol{N_{TPGroup} + N_{TPEquipment}}}{\boldsymbol{N_{RD}}} = \frac{\boldsymbol{N_{TPGroup} + N_{TPEquipment}}}{\boldsymbol{N_{TP} + N_{FP}}} \qquad \text{(Eq. 3)}$$

Facility:

$$\boldsymbol{LA_{Facility}} = \frac{\boldsymbol{N_{TPFacility} + N_{TPGroup} + N_{TPEquipment}}}{\boldsymbol{N_{RD}}} = \frac{\boldsymbol{N_{TP}}}{\boldsymbol{N_{TP} + N_{FP}}} \qquad \text{(Eq. 4)}$$

where N_{TP} represents true positives, N_{FP} false positives, and N_{RD} total reported detections.

Because these metrics are conditional on reported detections, they should be interpreted together with overall POD to understand both detection likelihood and localization quality. Additional metrics evaluate localization using other approaches as listed in Table 8.

Table 8: Additional accuracy metrics

Single Coordinate Localization Accuracy	Measured as the absolute distance (in meters) between the reported coordinate and the actual release location
Bounding Box Localization Accuracy	Determined by the absolute distance between the center of the bounding box and the release location. A bounding box is accurate if the controlled release lies within it.
Localization Stability	Assesses the consistency of reported locations for the same emission source across sequential detection reports.

Stability is calculated:

$$LS = \begin{cases} 1, & n_{reports} = 1 \\ 1 - \dfrac{n_{changes}}{n_{reports} - 1}, & n_{reports} > 1 \end{cases} \qquad \text{(Eq. 5)}$$

where $n_{changes}$ is the number of times the equipment changes between consecutive reports, and $n_{reports}$ is the total number of detection reports for the same emission source.

6.3 Quantification-Based Testing

Methane emissions quantification refers to converting measured concentrations into volumetric or mass flow rates. Quantification-based testing evaluates the Technology's ability to accurately quantify methane emissions, ensuring the reported values align with the actual release rates under controlled conditions.

6.3.1 Quantification Test Design

Quantification test design is structured to evaluate the accuracy and reliability of methane emission rate estimates across a diverse range of conditions. CRs must span a spectrum of flow rates, from very low to high, to capture the Technology's performance limits and ensure comprehensive assessment. Tests are conducted under varied environmental conditions, including fluctuations in wind speed, temperature, and humidity, to simulate realistic operational scenarios. The timing of releases should also account for different times of the day to evaluate the Technology's sensitivity to diurnal variations, such as changes in atmospheric stability and light conditions. This approach ensures a robust evaluation of quantification technologies and provides insight into their effectiveness in real-world settings.

6.3.2 Data Processing for Quantification

6.3.2.1 Quantification Uncertainty

Incorporating uncertainty metrics is crucial for accurately evaluating a system's quantification capabilities and ensuring confidence in emission estimates. These metrics provide a comprehensive assessment of a Technology's accuracy and reliability by characterizing the range and confidence of reported values and identifying potential sources of error. The following uncertainty performance metrics are recommended to support quantification evaluation.[15],[16]

- Quantification Uncertainty (Absolute): This metric measures the potential error in the reported emission rate, expressed in grams per second (g/s) or kilograms per hour (kg/h). It accounts for uncertainties from measurement instrument precision, environmental conditions, and data processing methods. A lower absolute uncertainty reflects greater confidence in the reported emission rate. For each true positive detection, absolute uncertainty represents how much the estimated emission rate may deviate from the actual value., the absolute uncertainty can be calculated as:

$$\boldsymbol{U_{abs} = \frac{U_{high} - U_{low}}{2}} \quad \text{(Eq. 6)}$$

where U_{high} and U_{low} represent the upper and lower bounds of the estimated emission rate confidence interval. Reporting this metric provides a direct measure of uncertainty magnitude for individual detections.

- Quantification Uncertainty (Relative): This metric expresses uncertainty as a percentage of the reported emission rate, providing insight into the proportional accuracy of measurements across different emission levels. It is calculated by dividing the absolute uncertainty by the true emission rate, R_{true}, and multiplying by 100, offering a scale-independent measure of accuracy. The formula is:

$$\boldsymbol{U_{rel} = \frac{U_{abs}}{R_{true}}} \quad \text{(Eq. 7)}$$

Relative uncertainty is particularly useful for comparing measurement accuracy across a wide range of emission rates, as it reflects how significant the uncertainty is relative to the size of the emission.

- Uncertainty Coverage Probability (UCP): UCP evaluates the fraction of true emission rates that fall within the reported confidence intervals of the quantification estimates, R_{true}, CI. A well-calibrated system should aim for a UCP close to the intended confidence level (e.g., 90%). It can be calculated as:

$$\boldsymbol{UCP} = \frac{N_{R_{true},CI}}{N_{TP}} \quad \text{(Eq. 8)}$$

This metric assesses the reliability of reported uncertainty intervals.

- Confidence Interval Width: The average width of confidence intervals across all true positive detections provides a measure of the precision of the quantification estimates:

$$\boldsymbol{WCI} = \frac{\sum_{i=1}^{N}(\boldsymbol{U_{high,i} - U_{low,i}})}{N_{TP}} \quad \text{(Eq. 9)}$$

where N_{TP} is the total number of true positive detections. Narrower confidence intervals indicate higher precision, though they must still adequately capture the true values.

- Bias-Adjusted Uncertainty (BAU): To evaluate whether uncertainties are systematically over- or under-estimated, the BAU metric considers the difference between the midpoint of confidence intervals and the true value:

$$\boldsymbol{BAU} = \frac{\sum_{i=1}^{N} \left| \frac{\boldsymbol{U_{high,i}} - \boldsymbol{U_{low,i}}}{\boldsymbol{2}} - \boldsymbol{R_{true,i}} \right|}{N_{TP}} \quad \text{(Eq. 10)}$$

This metric highlights potential systematic errors in how uncertainty is reported.

- Uncertainty Sensitivity Analysis: To understand the dependency of uncertainty on key variables (e.g., wind speed, emission duration, or source location), sensitivity analysis can be conducted by correlating reported uncertainties with these factors. For instance:

$$\boldsymbol{S_{wind}} = \frac{\Delta \boldsymbol{U_{abs}}}{\Delta \boldsymbol{V_{wind}}} \quad \text{(Eq. 11)}$$

where ΔU_{abs} represents the change in absolute uncertainty and ΔV_{wind} the change in wind speed. This analysis can identify conditions under which uncertainties increase significantly, guiding future methodological improvements.

- Aggregate Uncertainty Assessment: For cumulative quantification (e.g., over days or months), the aggregate uncertainty U_{agg} can be reported to account for compounded errors over multiple detections:

$$\boldsymbol{U_{agg}} = \sqrt{\sum_{i=1}^{N} (\boldsymbol{U_{abs,i}})^2} \quad \text{(Eq. 12)}$$

This metric provides an overview of the uncertainty for total emission quantification over a specified period.

Some studies [16] have suggested that increasing the number of repetitive measurements from a single plume during an individual release event can directly reduce uncertainty in the results. While this is an approach that test facilities could consider when designing protocols, the optimal balance between measurement frequency and other test constraints remains an evolving area of study. Integrating these uncertainty metrics into quantification evaluations ensures a robust, multi-dimensional understanding of performance. Such metrics not only enhance the reliability of reported quantification estimates but also build confidence in the system's ability to deliver actionable data in diverse operational conditions.

6.3.3 Quantification Performance Metrics

Quantification accuracy assesses how closely a Technology’s estimated emission rates align with actual emissions measured by the Test Facility. This evaluation is based on systematically pairing the Technology’s observation reports with corresponding Test Facility measurements. Pairing is determined by overlapping time intervals, ensuring that emission rates from all active CRs are aggregated for accurate comparison. These paired values are further aggregated over defined ASEs to provide a comprehensive assessment of the Technology's performance.

To effectively visualize quantification performance, the Test Facility employs several key methods. One primary visualization is a 1:1 scatter plot, where Test Facility measurements are plotted on the X-axis (independent variable) and the Technology’s emission rate estimates on the Y-axis (dependent variable). This plot includes a least-squares regression line constrained to pass through the origin (no Y-intercept), accompanied by relevant goodness-of-fit statistics. This visualization helps to identify whether the Technology systematically overestimates or underestimates emission rates.

In addition to scatter plots, relative error plots are used to illustrate how estimation errors vary across different emission rates. In these plots, the independent variable—typically the Test Facility’s measured emission rate—is on the X-axis, while the relative error is plotted on the Y-axis. The relative error for each paired observation is calculated using the formula:

$$\boldsymbol{\epsilon_i = \frac{s_i - c_i}{c_i}} \qquad \text{(Eq. 13)}$$

where s_i represents the Technology's emission rate estimate, c_i the Test Facility’s emission rate measurement for pair i, and ϵ_i the relative error. While the Test Facility emission rate is the suggested independent variable, other parameters, such as wind-normalized emission rates, may be used depending on the specifics of the Test Program or Technology.

To enhance interpretation, box-and-whisker plots may also be used to group relative error data into distinct bins based on ranges of the independent variable. This visualization method provides a clearer understanding of how quantification performance changes across different emission rates or environmental conditions.

Additionally, alternative parameters—such as wind-normalized emission rates—may be used as the independent variable, depending on the specific objectives of the Test Program or Technology being evaluated.

By combining these quantitative metrics and visual tools, the Test Facility ensures a rigorous and comprehensive evaluation of a Technology’s ability to accurately quantify methane emissions across varying operational scenarios.

When sufficient data is available, quantification uncertainty will be analyzed as a function of emission rate, duration, wind speed, and other variables. Parity charts, regression analyses, and error distributions will provide a comprehensive evaluation of the Performer's capabilities under varying conditions. These analyses will help quantify both accuracy and precision, offering insights into the Performer's performance across different scenarios.

6.3.3.1 Quantification Metrics for Screening Technologies

When conducting aerial detection and quantification, it is important to select a test location that is at least 1 km away from any background methane emissions or environmental obstructions. For instance, standing water can interfere with hyperspectral methane imaging technologies. Additional environmental factors that may affect detection and quantification capabilities include the reflectivity of the ground surface, the type of ground cover, and regional meteorological conditions such as humidity, typical wind speeds, and cloud cover.

6.3.3.2 Total Quantification over Time

Total quantification over time evaluates how well a Technology tracks cumulative emissions over specific periods, such as daily, weekly, or monthly intervals. For each period, the total emissions measured by the Test Facility are compared with the emissions estimated by Technology. This comparison is supported by statistical analyses and visualizations that highlight how closely the Technology’s estimates align with actual emissions. This metric is particularly useful for assessing the long-term performance of Technology in capturing emission trends.

6.4 Cross Cutting and Additional Metrics

6.4.1 Operational Metrics

Operational metrics assess the reliability and usability of a detection Technology. Key metrics include:

- Time Offline: The proportion of time a Technology is non-operational compared to the Test Facility’s operational time. A higher offline percentage could indicate issues with system reliability or maintenance requirements. This is calculated by comparing the Technology’s total online time to the Test Facility’s operational period. This metric can also be further analyzed to understand how environmental conditions, system malfunctions, or other factors contribute to downtime.
- Reporting Delay: The lag between when a detection event occurs and when the Test Facility receives the report. This affects the timeliness of mitigation actions. Reporting delays are often visualized with histograms to illustrate the distribution and frequency of delays across all detection events.
- Survey Time: For survey-based technologies, this measures the duration between the Test Facility's start signal and the Technology's stop signal, providing insight into the efficiency of the Technology in covering the target area.

6.4.2 Other Metrics

The Test Facility may develop supplementary performance metrics to provide deeper insights into a Technology’s capabilities. For example, Receiver Operating Characteristic (ROC) curves may be used to evaluate how detection performance changes with varying detection thresholds. These curves help balance the trade-offs between sensitivity (true positive rate) and specificity (false positive rate), offering a nuanced view of detection accuracy.

Other metrics could include analyzing false positive and false negative rates in greater detail, helping to identify systematic biases or operational limitations in the Technology.

7 Initiatives & Policy Direction

Various jurisdictions are in the process of updating existing methane abatement regulations. Internationally, there are policy shifts toward measurement technologies to quantify emissions instead of traditional emission factor-based calculations or engineering-based calculations to more effectively target source emissions and implement LDAR programs in an efficient and cost-effective manner.

Test facilities that provide controlled release information can play a critical role in advancing methane regulations by enabling the adoption of more stringent standards. They help fulfill the increasing complexity required by regulatory frameworks, including the widely adopted OGMP 2.0 standard (refer to OGMP 2.0 levels 4 and 5 outlined in Appendix III). By providing empirical data and validating measurement technologies, test facilities support transition from estimation-based method to direct measurement approaches, strengthening regulatory enforcement.

At the global level, regulatory shifts are increasingly driven by international climate commitments. Initiatives such as the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) and The Global Methane Pledge are shaping policy directions by emphasizing methane mitigation as a critical climate action. These global efforts to methane emission abatement are summarized in Appendix IV.

7.1 International

A summary of the regulatory developments in select jurisdictions is provided.

7.1.1 United States

7.1.1.1 United States Environmental Protection Agency

The Environmental Protection Agency (EPA) established the Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector published March 2024.

The standards, commonly referred to as New Source Performance Standards (NSPS) establish the following:

- standards regulating GHGs for the Crude Oil and Natural Gas source category for onshore oil and natural gas facilities
    - precursor standards from 2015 known as 40 CFR 60 Subpart OOOOa (sometimes referred to as “Quad O”) first established OGI as the ‘best system of emission reduction’ (BSER); covers existing facilities from 2015 up to December 2022

- 40 CFR 60 Subpart OOOOb requires higher levels of methane emissions monitoring and control for new construction and modified facilities after December 2022
- Emission guidelines and procedures that States must follow in developing, submitting and implementing at least as stringent as federal emission guidelines by March 2026.
    - States that already have a methane rule in place such as California, Colorado and New Mexico will need to revise their plans by deadline March 2029.
- A protocol for use of optical gas imaging (OGI) Technology for LDAR inspections – Appendix K to 40 Code of Federal Regulations (CFR) part 60 of the NSPS details 'senior' operator procedures, training, use cases and Technology specifications for onshore oil and natural gas processing plants, but may be expanded to other sectors in future.
    - Method 21 standard dates back to 2008 and focuses on the detection of VOC emissions from specific equipment types using a portable instrument; Appendix K which only applies to natural gas processing plants, provides simplified guidance on using OGI cameras in the field.

In the context of innovation, the NSPS encourages operators to employ a range of advanced monitoring technologies to identify emissions. It also creates a streamlined process by which new technologies can demonstrate adherence to performance requirements.

7.1.1.2 United States Methane Emissions Reduction Program

In the Inflation Reduction Act (IRA) of 2022, the EPA in partnership with the Department of Energy (DOE) created the Methane Emissions Reduction Program —Section 136 of the *Clean Air Act*. It provides $1.36 billion in funding as well as technical assistance to promote the adoption of available and innovative technologies to support monitoring and measurement programs. As a result of a shift in federal administration, the funding has been put on hold, and other aspects may be repealed.

From this program, the following Rules for Petroleum and Natural Gas Systems were enacted as part of the IRA.

- The Waste Emissions Charge Rule was intended to levy and financial penalty on large emitters who exceed 25,000 metric tones of CO2 equivalent per annum. It was to begin January 2025 with a waste emissions charge of $900 per ton of emissions, increasing to $1,200 and $1,500 in 2025-2026 respectively. Congress is in the process of attempting to nullify this.
- Subpart W of EPA's Greenhouse Gas Reporting Rule was amended in May 2024 which requires large emitters to report empirical data, amend calculation methods to enable greater accuracy and verification of methane emissions, effective January 2025. Stringent reporting remains in play, but if the Waste Emissions Charge is nullified the financial penalty will disappear.

These regulations apply to upstream and midstream oil and gas entities, as defined within the Petroleum and Natural Gas Systems category in the North American Industry Classification System (NAICS).

7.1.2 European Union

The energy, climate change and environment division of the European Commission recently amended EU2019/942 in May 2024. It is a regulation whereby the Agency for the Cooperation of Energy Regulators

(ACER) obliges the fossil gas, oil and coal industry in Europe to measure, monitor, report and verify their methane emissions, and to take action to reduce them. Some aspects of the regulations, as reported from a May 2024 announcement from the Directorate-General for Energy are summarized below.

- The regulation was designed around OGMP 2.0 (refer to Appendix III), requiring operators to submit both source- and site-level measurements.
- Europe imports a large part of the fossil fuel-derived energy it consumes; therefore the methane reduction requirements apply to the imported commodity — notable in that it creates a potential market access issue for those looking to export to the EU.
- Consistent with the bullet point above, ACER will develop a monitoring tool on global methane emitters to provide satellite-based data on large methane-emitting sources and will include independent verification requirements, such as the International Methane Emissions Observatory (IMEO).
- Set up a rapid alert mechanism for 'super-emitting' events to enable remedial action.

Industry observers comment that the requirement to verify the emission footprint of imported fossil fuel is the first of its kind.

7.2 Domestic

7.2.1 Federal

Canada's methane regulation, SOR/2018-66 *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds*, is enabled under the *Canadian Environment Protection Act* (CEPA). The regulation came into effect January 2020.

A draft amendment to the methane regulation was released November 2024 and proposes updates with intent to expand the coverage and stringency levels of GHG pollution limits from oil and gas production. This is in support of Canada's recent commitment to the Global Methane Pledge announcement to achieve at least a 75% reduction in oil and gas sector methane emissions by 2030, relative to 2012 levels. Methane reductions in the waste sector are also covered in the proposal.

The proposed changes at the time of this report were developed after a consultation process with stakeholders. They are expected to be released sometime in 2025 to be put into effect January 2027. The proposed changes include the following aspects:

- Onshore oil and gas facilities engaged in upstream, midstream and transmission activities.
- Performance-based compliance option as opposed to a purely prescriptive, rules-based approach; meaning that companies can focus on achieving a certain emission target overall, rather than prescribing specific approaches to individual equipment level emission sources that are subcomponents of complex oil and gas operations.
    - An allowance for operators to install continuous monitoring systems at facilities; this deployment method accounts for large but intermittent emission events that likely are not captured by traditional measurement approaches.

- Prohibits intentional, routine venting and flaring (blowdowns) of natural gas into atmosphere by 2027; instead, facilities must capture gas to be either conserved or destroyed.
    - Venting during equipment maintenance is an exception to the prohibition for health and safety reasons to protect the public.
    - Other 'one-off' circumstances are acceptable with support from an engineering study demonstrating that usefulness of natural gas is not feasible.
- Unintentional, fugitive emissions would be subjected to a risk-based approach whereby inspection schedules vary by facility type.
    - High-risk Type 1 facilities maintain a quarterly inspection schedule whereas lower-risk Type 2 only require an annual inspection; OGI screenings are still required.
    - Inspections are to be conducted with detection and quantification instruments that have a standard minimum detection limit (MDL) of 500 ppm.
    - Remedial action, as part of an LDAR program, are required within stated timeframes dependent on emission rate.
- Offset credits are permissible to meet obligations under the proposed amendments.

Increasing measurement frequency and accuracy will allow for robust and reliable measurement-based data for the National Inventory, allowing for mitigation tracking against stated methane-reduction commitments.

7.2.2 Provincial

The provinces of Alberta, BC and Saskatchewan have implemented methane abatement regulations that the federal government has recognized as meeting equivalent emissions-reduction outcomes.

7.2.2.1 Alberta

The Alberta government states that it achieved a 52% methane reduction from conventional oil and gas sector from 2014 levels, thereby exceeding the 2025 target two years in advance.

Provincial-federal equivalency was established through Directives under the Alberta *Methane Emission Reduction Regulation* (MERR):

Directive 060 – *Upstream Petroleum Industry Flaring, Incinerating, Venting*
Directive 017 – *Measurement Requirements for Oil and Gas Operations*

The equivalency agreement expires October 2025, but Alberta Energy Regulator introduced an update to Directive 060 which enhances accuracy and transparency in emissions measurement, reporting and verification (MRV). It may meet or exceed the federal requirements and be granted equivalency.

The general intent is to shift towards performance-based approach where emitters must figure out how to hit targets versus the current prescriptive, rules-based approach. In addition, methane emission volumes will increasingly shift to be 'measurement-informed' as opposed to desktop analysis using emission factors and other engineering calculations. Therefore, the implementation of technologies to support measurement-informed inventory is of paramount importance. OGMP 2.0 will inform reporting aspects of the amendments but may not necessarily be adopted as it has in other jurisdictions such the European Union recent regulation EU2019/942.

Two protocols are published by Alberta Environment and Parks:

1) Quantification protocol for greenhouse gas emission reductions from pneumatic devices, effective 2023, and
2) Quantification protocol for vent gas reduction, introduced 2021.

Additionally, the province has instituted programs in the past regarding implementation of methane technologies that are commercially available and a baselining support program for small- and medium-sized oil and gas operators with action items to become compliant with Directive 060. These programs ended in fall 2022.

Currently the Alberta Methane Emissions Program (AMEP) supports the alt-FEMP. This is a $17.6 million initiative that evaluates and grants equivalency to existing methods for those technologies that are not approved in Directive 060. The results of some of the controlled release tests funded by AMEP will also be included in the data hub, ensuring continuity and leveraging prior work to enhance the repository's value. This hub will serve as a critical resource for industry, government, and public stakeholders, providing access to transparent, high-quality data that fosters best practices in methane emissions management and reductions. The program is ongoing and is administered by a joint collaboration between Carbon Management Canada and Sundre Petroleum Operators Group.

Earning emission offset credits is incentivized through the Technology Innovation and Emissions Reduction (TIER) Regulation. Through industrial pricing mechanisms, buying and selling of carbon offset credits is a tool available to reach compliance.

7.2.2.2 British Columbia

The British Columbia (BC) government set an emission reduction target of 75% by 2030 relative to 2014 levels with near elimination of all industrial methane emissions by 2035. Provincial-federal equivalency was established through BC's *Drilling and Production Regulation* (DPR) 282/2010 (last amended March 2024) under the *Energy Resources Activities Act*. The equivalency agreement was established in 2019 and expires in March 2025. With stricter amendments to the DPR, a draft order is underway which would renew equivalency with the *Canadian Environmental Protection Act* (CEPA) until 2029.

The BC Measurement Guideline v2.4 (2023) provides guidance to measurement obligations under Section 53 of DPR. The Guideline is roughly equivalent to Alberta's Directive 017 with detailed guidance on oil and gas volumes to be measured and reported, as well as acceptable methods of measurement. As with Alberta and Saskatchewan, reporting on the Petrinex platform allows for transparency and tracking of produced volumes (including intentionally vented gas) from oil and gas operators.

Similar to Alberta, BC's approach to regulation is prescriptive in nature, meaning requirements and procedures are laid out in detail for operators to follow.

A collaborative effort between BC's energy regulator, the BC Ministry of Environment and Climate Change Strategy and various other research organizations and industry associations form the BC Oil and Gas

Methane Emissions Research Collaborative (MERC). The purpose of MERC is scientific research and sharing of information to improve research and implementation of detection and measurement methods for emission reduction and control.

One of MERC's funded projects was a top-down aerial survey campaign conducted by the Energy and Emissions Research Laboratory (EERL) at Carleton University using Bridger Photonics' aerial LiDAR-based GML Technology. The 2021 campaign resulted in a measurement-based inventory of 508 oil and gas production sites in B.C. Of note, the analysis indicated that emissions were approximately three times higher than that which was reported for the 2021 emissions reported in the National Inventory Report. Compressors, tanks and unlit flares were the main sources for underreported emissions.[17]

7.2.2.3 Saskatchewan

In 2019 the Saskatchewan government introduced the *Oil and Gas Emission Management Regulation* (OGEMR) under Section 53.61 of *The Oil and Gas Conservation Act*. The stated goal was to reduce methane emissions by 4.5 million tonnes from 2015 levels by 2025. It was significantly revised in early 2024 to include a reduction for venting limits for facilities and an increased frequency of leak detection surveys. The new requirements take effect in 2025.

Provincial-federal equivalency was established through Directives PNG036 and PNG017 and was recently renewed December 2024 with a termination date in 2029.

Directive PNG036 *Venting and Flaring Requirements* was revised in March 2024. The Directive requires LDAR surveys for facilities of a certain size. Directive PNG017 *Measurement Requirements for Oil and Gas Operations* of August 2022 covers measurement data collection and reporting obligations.

Flaring is covered by the province's Output-Based Performance Standards (OBPS) Program. For all emissions-intensive sectors such as potash mining, fertilizer manufacturing, pulp mills and upstream oil and gas and pertains to facilities that emit more than 10,000 tonnes of CO2 equivalent per year. Under OBPS, emitters can either earn or purchase offset credits in order to stay in compliance.

Saskatchewan's regulatory design was always performance-based, whereas Alberta's newly-updated Directive 060 has moved in this direction. Performance-based schemes enable operators to plan targeted emissions reduction strategies across their entire operation ('fleet-level'), as opposed to site- and equipment-level assets. Similar to the Alberta TIER program, penalties for exceeding permitted levels go into the Saskatchewan Technology Fund to be fed into emissions management projects and technologies.

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9 Appendices

I	Abbreviations
II	Case Studies
III	Existing Protocols: OGMP & Method 21 Summary
IV	Global Methane Abatement Initiatives

I. Abbreviations

Abbreviation	Description
AER	Alberta Energy Regulator
AMEP	Alberta Methane Emissions Program
ASE	Analysis Spatial Extents
CMC	Carbon Management Canada
CNG	Compressed Natural Gas
CR	Controlled Release
CRT	Controlled Release Test
FN	False Negative
FP	False Positive
LA	Localization Accuracy
LDAR	Leak Detection and Repair
LP	Localization Precision
LDAQ	Leak Detection and Quantification
MDL	Minimum Detection Limit
OGI	Optical Gas Imaging
QA	Quantification Accuracy
QP	Quantification Precision
POD	Probability of Detection
TN	True Negative
TP	True Positive

II. Case Studies

Case Study — PoMELO

The University of Calgary (UofC) collected data using their Portable Methane Leak Observatory (PoMELO), a passive methane measurement technology that detects emissions from sites adjacent to roads. A series of CR experiments for fugitive emissions were conducted at the AFE Test Facility, in collaboration with the AMEP, in the fall of 2024.

Description of Technology

PoMELO Passive is a frequently used, made in Alberta, vehicle-based methane monitoring system developed at the University of Calgary, as part of its pan-Canadian methane monitoring program. The PoMELO system utilizes the Li-Cor 7700 open path methane sensor, RM Young 86000 sonic anemometer, and the Hemisphere V123 GNSS/Orientation sensor for data collection. Passive is a software that uses raw PoMELO data from public roads. The deployment mode involves off-site measurements from public roads at highway speed to detect, localize and quantify emissions from upwind oil and gas sites without any operator interventions.

Objective

The objective of the CRT was to gather additional data to further enhance the quantification, localization, and uncertainty models of the PoMELO Passive software. Furthermore, the tests were conducted to evaluate the accuracy, precision, and uncertainty of the software's emission detection and the inferred emission rate.

Methodology/Test Plan

This was a single-blind test scenario, where the CNG release rates were unknown to the Performer, and wind data was provided by the Test Facility only after the trial was completed. Wind speed was measured with a 3D ultrasonic anemometer and release rates were precisely metered with a mass flow controller using CNG of known composition.

Testing was conducted over a 5-day period over 190 single-release, single pass experiments were conducted over a wide range of testing conditions.

The test conditions and parameters during the campaign were:

- Methane release rate: 0.0 to 8.97 kg/h (0.0 to 2.49 g/s)
- Wind speeds: 2.6 to 48.9 km/h (0.72 to 13.6 m/s)
- Detection Distance: 180.7 to 689.9 m
- Temperature: 10.31 to 31.77 °C.

Key Findings & Value

The single-blind test campaign conducted at the AFE Test Facility in collaboration with AMEP and UofC not only assessed the performance of the PoMELO Passive but also provided valuable insights to further enhance the software's quantification, localization, and uncertainty models, as well as resulting in a high-quality dataset that can be used for a range of analyses.

Detection results indicated that PoMELO Passive effectively detected 60 to 85% of the release rates less than 1 g/s and 88% to 100% of the releases above 1 g/s, demonstrating the software's performance to accurately detect methane emissions across a variety of conditions. Non-detections during periods of controlled releases were found to primarily occur in situations with low wind speeds.

Quantification calculations were possible only with 71% of all detections, predominantly due to wind speeds less than 3 m/s, highlighting the optimal operating conditions of the technology. Multiple-pass quantification significantly improved accuracy through averaging the results. PoMELO Passive's effectiveness for ground-based monitoring was established by outperforming many airborne and satellite technologies. Also, it was concluded that in future, Bayesian modelling methods could further enhance accuracy.

Case Study — LSI (LiDAR Services International Inc.)

LiDAR Services International Inc. (LSI) collected data using their methane detection technology, specifically the Hyper-Cam Airborne Mini Sensor, under a series of CR experiments at AFE test facility in collaboration with the AMEP in fall of 2023.

Description of Technology

LSI's Hyper-Cam Airborne Mini Sensor is an aircraft-mounted passive thermal infrared hyperspectral imaging system that utilizes a Fourier-transform infrared (FTIR) spectrometer. The system produces orthorectified, geo-referenced infrared gas detection images to identify and quantify emissions.

Objective

The objective of the CRT was to provide a comprehensive assessment of several key aspects of the Hyper-Cam Airborne Mini sensor's detection performance. Key objectives included determining the system's MDL, evaluating the system's detection error as a function of distance from the target, seasonal effectiveness, along with the accuracy and associated errors in emission location detection. Additionally, the tests were conducted to address the system's ability to detect and quantify emission rates, including potential errors in measurements, and the effect of varying gas compositions on detection capabilities.

Methodology/ Test Plan

This was a single-blind test scenario, where the CNG release rates were unknown to the Performer, and wind data was provided by the Test Facility only after the trial was completed. Wind speed was measured with a 3D ultrasonic anemometer and release rates were achieved with a flow controller using CNG of known composition.

Testing was conducted over a 5-day period during which 605 flyovers were performed using a helicopter-mounted sensor. The testing yielded 16,883 measurements acquired over a wide range of testing conditions.

The test conditions and parameters during the campaign were:

- Methane release rate: 0.2 to 80 kg/h (0.07 to 22.2 g/s), including Null (0 kg/h) releases.
- Wind speeds: 6.1 to 14.8 km/h (1.7 to 4.1 m/s)
- Flight speeds: 46 to 90 knots
- Flight height (AGL): 250 to 410 m (820 to 1345 ft)
- Thermal contrasts: 0 to 15° C.

Key Findings & Value

The single-blind test campaign conducted in collaboration with the AMEP and LSI not only evaluated the performance of the Hyper-Cam Airborne Mini but also resulted in a high-quality dataset that was subsequently utilized for various analyses. Test cases covered a broad range of release rates under varying atmospheric conditions. Detection limits were calculated for each measured scene, ensuring a high degree of confidence in the inspection results. The POD was found to be 93% for release rates at or above the calculated detection limit. Furthermore, the POD increased to 98% for release rates larger than 18 kg/h, demonstrating the system's capability to reliably detect methane emissions across diverse conditions.

Quantification analysis allows LSI to properly communicate the measurement uncertainty of methane emission estimates (i.e., an estimated range of release rates within a certain confidence interval). Because quantification errors increase with increasing rate, the test plan encompassed release rates ranging from 0 to 80 kg/h to simulate real-world emissions.

Increased repetition of measurements leads to reduced measurement uncertainty; therefore, this was an important element of the test plan. In addition, incorporating a variety of rates and source locations, both impeded and unimpeded, while experiencing extreme meteorological conditions, broadens the range of conditions for analyzing a technology's accuracy in detection and quantification analysis.

III. Existing Protocols

Oil and Gas Methane Partnership (OGMP):

OGMP was launched in 2015 as a joint initiative between the United Nations Environmental Programme (UNEP) and the Climate and Clean Air Coalition (CCAC) Secretariat as a voluntary initiative for methane emissions reduction in the oil and gas sector. The focus is on measurement-based frameworks to enable reporting of methane emissions (see Table 9).

The reporting framework applies to all sources of methane emissions including intentional emissions from process venting, fugitive (unintentional) emissions and emissions due to incomplete combustion.

The List of OGMP 2.0 Member Companies, as of December 2024, includes 61 oil and gas production ('upstream') companies and 81 mid- and downstream companies which include natural gas transmission and distribution pipeline operators, gas storage facilities and LNG terminals. Member companies comply with framework requirements in annual reporting of methane emission sources. Adoption of new measurement techniques, tracking of emissions reductions, establishing performance benchmarks and incorporation of informed Leak Detection and Repair (LDAR) programs are the touted benefits of joining the partnership.

Calgary-based Kiwetinohk Energy Corporation is the only Canadian company on the list, though several multinationals listed may have operations in Canada.

There are five distinct reporting levels, representing increasing levels of granularity and accuracy in emissions quantification.

Table 9: OGMP 2.0 reporting levels

Level 1	lowest reporting level at the asset of country level, in circumstances where there is limited information and where high-level standard factors are applied
Level 2	reporting based on five broad categories such as venting, fugitive losses or flaring; calculations are based on generic emission factors
Level 3	reporting at individual source level, common sources are pneumatic controllers and pumps, equipment leakage through reciprocating or centrifugal compressor seals and tanks; calculations are based on generic emission factors
Level 4	highest level of detail for *asset-level* source emissions involving methane sensing and quantification technologies; detailed engineering calculations are based on equipment-specific emissions factors which are derived from direct measurement and sampling — simulation tools can also be employed
Level 5	highest level for *site-level* reporting involving methane sensing and quantification technologies with data that is representative of the entire reporting period – this would involve continuous monitoring techniques

Canada is a leader in emissions reporting with continual progression from Level 3 to Level 4 and 5.

A more detailed explanation of the OGMP 2.0 reporting levels is provided in Section 4.4 on quantification in the document OGMP 2.0 Framework.

The OGMP 2.0 Gold Standard is achieved when all assets with material source emissions are identified and quantified (level 4) and efforts are underway to move to site-level reporting (level 5). The two together, when conducted in tandem, are commonly referred to as ‘top -down, bottom-up’ reconciliation.

In Canada, advancements in detection and quantification technologies enable substantial progress towards achieving level 5, as operators incorporate direct measurement methodologies.

Another initiative of UNEP is the International Methane Emissions Observatory (IMEO). It aims to create a comprehensive database of ‘empirically verified’ methane emissions worldwide. The data reported voluntarily through OGMP 2.0 is a key contributor for the database, however in the absence of reported data, MethaneSAT™, Tanager-1 and TROPOMI satellites, scientific studies and national inventories are sources of data as well.

U.S. EPA’s Method 21 & Quad O Standards

EPA Method 21 is a methodology for identifying VOC leaks on processing equipment such as valves, flanges, pumps, compressors and pressure relief devices, among others. The Method is intended for leak detection, not quantification of emission rate, and is expected to be used for compliance with LDAR regulations.

It necessitates the manual testing of suspected leaks with a portable ‘specialized instrument’ on a regular monitoring schedule. EPA Method 21 defines a leak as 10,000 ppm total hydrocarbons (unless a site-specific lower limit is specified). For methane-specific instruments a lower threshold (e.g., 2,500 ppm CH_4) is typically required.

The detection instrument may be based on catalytic oxidation, flame ionization, infrared absorption and photoionization. An alternative to instrumentation is the manual application of soap solution to conduct a ‘bubble test’ on vulnerable areas.

Method 21 was introduced in 1981, the latest version dating 2017. The Method does not reflect emerging and established Technologies that promise greater accuracy, such as OGI cameras which are becoming less costly for operators. Use of OGI cameras has been allowed in lieu of Method 21 through a series of EPA regulations, the latest of which was published in May 2024. New Quad O Standards have introduced New Source Performance Standards (NSPS) for oil and gas operations. (EPA 40 Code of Federal Regulations, Part 60 – Quad O) recognizes OGI as the “Best System of Emission Reduction” (BSER), and does not require direct measurement of VOCs (cite: Code of Federal Regulations, Part 60)

IV. Global Methane Abatement Initiatives

COP Developments 2021-2024

COP26 Global Methane Pledge, reduce global methane emissions by 30% by 2030; Canada announced support for the Global Methane Pledge to 'reduce global methane emissions by 30% below 2020 levels by 2030. Subsequent to this, Canada committed to further reductions in current proposed amendments, to reduce methane emissions in the upstream oil and gas sector by at least 75% below 2012 levels by 2030.

COP27 Canada proposed the regulatory framework for reducing oil and gas methane emissions to achieve the 75% reduction by 2030 announced during COP26. This was the foundation for proposed regulation that may take effect in early 2025. Canada and the U.S. agreed to continue collaboration to further reduce methane emissions from oil and gas operations.

COP28 The United Nations Environment Program's International Methane Emissions Observatory (IMEO) and Environmental Defense Fund (EDF) announced an initiative to support and report progress made by O&G companies in achieving the emissions reduction targets recently set out in the Oil and Gas Decarbonization Charter (OGDC).

The OGDC initiative was launched at COP28. It is comprised of oil and gas companies with ambition to achieve net zero scope 1 and 2 greenhouse gas (GHG) emission from their operations by 2050, to end routine flaring by 2030 and to achieve near-zero upstream methane emissions by 2030. To date, 50 companies have joined, the majority (~60%) of which are national oil companies.

Canada announced $30 million in funding for the Methane Centre of Excellence.

COP29 Summit on Methane and Non-CO2 GHG: https://unfccc.int/event/cop29-summit-on-methane-and-non-co2-greenhouse-gasesincluded discussions between the U.S. and China

Encouragement of countries to include methane reduction in the waste sector; IMEO will expand detection to major methane emission events from landfills and metallurgical coal mining in 2025. Methane emissions from agriculture, namely livestock, saw a number of announced initiatives as well.

The United States (U.S.) finalized the Rule to collect a Waste Emissions Charge to reduce methane emissions under the Methane Emissions Reduction Program (MERP).

The OGDC published its first Baseline Report, one year after launch at COP28.

Global Methane Pledge

The Global Methane Pledge (GMP) is a promise by 159 countries, many of which are working on or have announced national methane action plans, to cut methane emissions by 30% below 2020 levels by 2030. UNEP provides financial and other types of support to a subset of these countries to develop their methane reduction strategies. Other governments and philanthropic organizations have also provided project investment capital. UNEP's IMEO database has identified 1,200 super emitter events and is working with over 140 companies to reduce emissions. COP28 resulted in increased project financing, namely from European Investment Bank, World Bank, and the African Development Bank. Among other countries, Canada committed $7.5 million over four years to reduce methane emissions in the Caribbean and Pacific Island nations as well as African nations.