Canary X Methane Monitoring System: 5, 10, 15 kg/hr Fugitive Methane Emission Monitoring

1. Scope and Application

1.1 Scope

This method is applicable for demonstrating compliance with the procedures in 40 CFR §60.5398b for fugitive emissions components affected facilities and compliance with periodic inspection and monitoring requirements for covers and closed vent systems, specifically demonstrating compliance through periodic screening in 40 CFR §60.5398b(b), as approved, per §60.5398b(d). Affected facilities could include but are not limited to single wellhead-only sites, small well sites, multi-wellhead sites, well sites with major production and processing equipment, and centralized production facilities.

1.2 Application

1.2.1 The application of this technology is per the Environmental Protection Agency's 40 CFR part 60 New Source Performance Standards (NSPS): Subparts OOOO, OOOOa, and OOOOb, and Emissions Guidelines (EG): OOOOc, for well sites and centralized production facilities in the Oil and Natural Gas Source Category. This test method is broadly applicable across the sector.

1.2.2 The test method is applicable to methane (CH_4, CAS No. 74-82-9) emissions from oil and gas facilities. This method can be used, as approved by the Administrator, in lieu of the applicable fugitive monitoring requirements in either §60.5397a or §60.5397b and inspection and monitoring of covers and closed vent systems in either §60.5416a or §60.5416b. This test method may be used for fugitive monitoring requirements in §60.5397c and monitoring of covers and closed vent systems under §60.5416c when a state, local, or tribal authority incorporates the model rule (i.e. OOOOc) for the emission guidelines as part of their State Implementation Plan (SIP) or elsewhere approved as applicable.

1.2.3 The test method is a performance-based, stationary in-situ sensor method used to determine whether facility-wide emissions remain below prescribed thresholds.

1.3 Method Sensitivity

1.3.1 The Canary X Methane Monitoring System under this method is a facility-level Alternative Test Method (ATM) per 40 CFR §60.5398b(b)(5)(ii) with applicable detection thresholds for emission reporting of 5 kg/hr, 10 kg/hr, and 15 kg/hr with a 90% probability of detection (POD).

1.3.2 The Canary X Methane Monitoring System has a minimum detection threshold of 0.5 kg/hr with a 90% POD, as calculated per release level without considering facility-aggregated quantification. In essence, the calculations performed by the Methane Emissions Technology Evaluation Center (METEC) regarding this 90% POD represent the ability of the system to both detect that emissions were occurring and count the correct number of active emission points. If the system was merely evaluated for its ability to detect emissions, then every single experiment run by METEC was detected by the Canary X Methane Monitoring System. There were overlapping detection reports associated with all the 347 experiments. As such, the 90% POD, computed at a facility level, is below the tested range. For reference, the minimum facility-level release experiment from the Advancing Development of Emissions Detection (ADED) 2024 campaign was 0.154 kg/hr.

1.4 Data Quality Objectives (DQO)

Adherence to the requirements of this method will ensure that the data supporting the Canary X Methane Monitoring System's facility-wide quantification determinations are accurate and of quality. The Canary X Methane Monitoring System's objective is to perform facility-wide methane screening, across a 7-day screening period, and provide alerting on fugitive emissions at or exceeding the applicable detection threshold of 5 kg/hr, 10 kg/hr, or 15 kg/hr on oil and gas well sites and centralized production facilities. The frequency of this screening is dependent on facility type and applicable detection threshold, as summarized in Table 1 and Table 2, below. Alerting through this method will trigger operator response, including leak detection through follow-up OGI screenings, and leak repair.

Table 1: Applicable Detection Threshold and Screening Frequency Requirements - Oil and gas multi-wellhead sites, well sites with major production and processing equipment, and centralized production facilities

APPLICABLE DETECTION THRESHOLD	SCREENING FREQUENCY
5 kg/hr	Monthly
10 kg/hr	Bimonthly + Annual OGI
15 kg/hr	Monthly + Annual OGI

Table 2: Applicable Detection Thresholds and Screening Frequency Requirements - Oil and gas single wellhead sites and small well sites

APPLICABLE DETECTION THRESHOLD	SCREENING FREQUENCY
5 kg/hr	Quarterly
10 kg/hr	Triannual + Annual OGI
15 kg/hr	Quarterly + Annual OGI Bimonthly

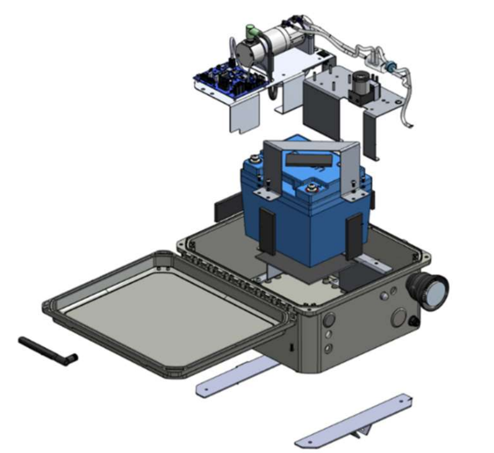
2. Summary of Method

2.1 Description of Technology

2.1.1 The Canary X Methane Monitoring System is composed of several individual, fixed Canary X devices triangulated on the facility being monitored. The number of devices and their locations on a facility are determined through a proprietary Siting Tool, which optimizes device count and placement. The Siting Tool is further detailed in Appendix A.

2.1.2 A Canary X device is a stationary, autonomous methane sensing Internet of Things (IoT) device, containing a Tunable Diode Laser Absorption Spectroscopy (TDLAS) methane sensor. TDLAS operates based on the principle of absorption spectroscopy, where a laser beam at a specific wavelength is directed through a gas sample. Methane gas molecules absorb specific wavelengths of light, specifically at 1650 nm, that correspond to unique molecular vibrational and rotational transitions. By measuring the amount of absorption, the methane concentration of the gas can be determined. A Canary X device is depicted in Figure 1.

Figure 1: The Canary X Device



2.1.3 Detection and quantification of methane by the Canary X Methane Monitoring System is supported by several components, including meteorological sensors, a solar panel and battery, cellular data upload capabilities, backend quantification algorithms, and a customer dashboard with alerting and near real-time data display. These individual components function together as a complete system to gather facility-specific concentration and wind data, upload the information to a secure cloud network, and process the data for facility-level methane quantification determinations. Figure 2 shows the installation of a Canary X device, with an anemometer and solar panels mounted externally.

Figure 2: Canary X Device, Anemometer, and Solar Panel Mount

2.2 Data Collection and Screening

2.2.1 The Canary X Methane Monitoring System continuously measures methane concentration, wind speed, and wind direction, preparing and sending a minute-averaged measurement data packet for processing and quantification determination every 15 minutes.

2.2.2 Under this method, the Canary X Methane Monitoring System performs facility-wide methane screening across the first consecutive 7-day screening period of each survey cycle, defined by the screening frequency in Table 1 and Table 2. The Canary X Methane Monitoring System determines a daily average methane mass emission rate for each day within the screening period, by averaging the 15-min facility level quantification values. When the screening period is complete, a 7-day average mass emission rate for the facility will be determined and compared to the applicable method detection threshold of 5 kg/hr, 10 kg/hr, or 15 kg/hr. Screening results are immediately available to the owner or operator through Project Canary's SENSE™ dashboard.

2.2.3 To ensure data quality, Project Canary employs thorough data validation and maintains extensive quality control (QC) criteria, detailed in Section 9. Periods of time when data is deemed invalid and filtered or when equipment is faulty or failing, contribute to invalid data. The Canary X Methane Monitoring System provides reliable quantification values as long as 50% of the system measurements are deemed valid, evaluated every 12 hours. Therefore, downtime occurs when the system has less than 50% valid data in any 12-hr period, deeming the entire 12-hr period as downtime. If downtime exceeds 24 hours and data cannot be backfilled within the applicable screening period, the 7-day screening period will restart when the system returns to normal operation.

2.3 Emissions Detection and Alerting

A facility-wide 7-day average mass emission rate, determined during an applicable screening period, at or above the applicable detection threshold of 5 kg/hr, 10 kg/hr, or 15 kg/hr is a detection and will trigger alerting through Project Canary's SENSE™ dashboard and notification directly to the owner or operator. Detections, causing an alert, must be investigated through a facility-level monitoring survey of all fugitive emissions components and covers and closed vent systems, as described under 40 CFR 60.5398b(b)(5)(ii). All sources of fugitive emissions must be repaired according to CFR 60.5397b(h). All emissions or defects of covers and closed vent systems must be repaired according to 40 CFR 60.5416b(b)(5).

3. Definitions of Method

3.1 Definitions

Blind time: A term specific to Project Canary's Siting Tool and analyses. A 12-hr period during which the network of devices on a given facility detected fewer than ten methane concentration readings greater than 1 ppm per emission source.

Canary X Device: A single methane monitoring unit which includes all necessary equipment to detect methane, store and transmit data, generate and store power for operation, and in some cases, include an anemometer to determine local wind direction and speed.

Canary X Methane Monitoring System: All Canary X devices on a given facility, supporting hardware, backend software, and customer-facing dashboard, used to identify methane leaks, quantify facility-level emissions, and alert owners or operators of action level exceedances.

Downtime: Occurs when less than 50% of the system data is deemed valid in any 12-hr period. If downtime exceeds 24 hours and data backfilling is not available, the screening period will be adjusted when the system returns to normal operation.

Equipment Group: An area within an oil or natural gas facility which includes a common set of major equipment from which methane emissions may be anticipated.

Facility: For purposes of this application, a distinct area of ground disturbance on which equipment associated with the extraction and production of oil or natural gas is placed and operated.

Screening Period: The 7-day period during which the Canary X Methane Monitoring System monitors emissions during each survey cycle.

Source: A point or area on an oil or natural gas facility from which methane emissions could be expected or are detected.

Survey Cycle: The recurring period during which a periodic survey must be conducted, prescribed by Tables 1 and 2 of 40 CFR Part 60, Subpart OOOOb.

3.2 Abbreviations

ADED – Advancing Development of Emissions Detections

ATM – Alternative Test Method

HSA – Hardware Support Application

JSA – Job Site Analysis

kg/hr – kilograms per hour

LDAR – Leak Detection and Repair

mb - millibars

m/s – meters per second

METEC – Methane Emissions Technology Evaluation Center

nm - nanometers

PPE – Personal Protective Equipment

ppm – Parts Per Million

POD – Probability of Detection

PCB – Printed Circuit Board

TDLAS – Tunable Diode Laser Absorption Spectroscopy

4. Method Interferences and Envelope of Operation

Interferences associated with this method are summarized in Table 3 and inclusive of limitations of the hardware and envelop of operation, sampling interferences, and constraints on the system's capacity to accurately quantify emissions.

Table 3: A summary of the method interferences and envelopes of operation.

CONDITION	SUMMARY	MITIGATION
Sensor Sensitivity and Precision	The TDLAS sensor envelope of sensitivity ranges from 0 ppm – 40,000 ppm.	During periods of time when a sensor reports concentration outside of this envelope of operation, data is filtered during quantification pre-processing.
Temperature	The TDLAS sensor has a temperature operating envelope between -10 °C and 50 °C, as prescribed by the manufacturer. The Canary X device has been internally tested up to 40 °C.	During extreme temperatures outside of this envelope of operation, -10 °C – 40 °C, data is filtered during quantification pre-processing.

CONDITION	SUMMARY	MITIGATION
Relative Humidity	The TDLAS sensor has an envelope of operation of 0% – 99% humidity.	The likelihood of condensation on the mirrors in the sampling cell is very low, and in most cases recoverable when the droplets re-vaporize. If unlikely environmental conditions and lasting condensation occur, the effects of condensation will manifest as contamination in the sampling cell and will result in a failure and engineering alarm for investigation.
Pressure	The TLDAS sensor has a pressure operating envelope between 600 mb and 1200 mb.	During time periods of pressures outside of this envelope of operation, data is filtered during quantification pre-processing.
Power	Solar power is required to recharge the internal battery that powers each Canary X device.	Solar availability is considered during installation to determine the number of solar panels required. Battery voltage is continuously tracked and reported on every data packet and hourly health check with alarms in place.
Cellular Connectivity	The Canary X Methane Monitoring System requires cellular connectivity to transmit data packets for quantification.	The Canary X Methane Monitoring System can store and backfill valid data after short interruptions of cellular connectivity. Connectivity is monitored and alarms are in place if connectivity is lost.
Anemometer Functionality	Quantification requires continuous and reliable wind speed and direction measurements.	Anemometer functionality is continuously tracked and reported on every data packet and hourly health check with associated alarm functionality in place.
Wind Speed	Low wind speeds, less than 0.5 m/s, are indicative of variable wind directions and atmospheric instability, making emissions hard to predict, impacting quantification capabilities.	During time periods of low wind speed, data is filtered during quantification pre-processing.

CONDITION	SUMMARY	MITIGATION
Wind Speed	The anemometer is rated for operation within 0 m/s – 70 m/s, as prescribed by manufacturer specifications. The Canary X device and quantification capabilities have been tested up to 15 m/s.	During periods of time where wind speed is outside of this envelope of operation, 0 m/s – 15 m/s, data is filtered during quantification pre-processing.
Wind Direction	Quantification capabilities are dependent on wind direction transporting methane releases to a sensor in a predictable manner. There are, however, periods of time where wind direction blows unfavorably.	Siting Tool optimizes device count and placement based on predominant wind conditions. Still, the recursive algorithm is designed to handle periods of unfavorable wind direction.
Methane Buoyancy and Release Height	Methane buoyancy and emission source height can affect the ability of the stationary devices to detect methane concentrations.	Vertical turbulent mixing and source heights are accounted for in dispersion modeling.
Facility Complexity and Topography	Quantification and attribution are affected by large obstructive infrastructure and prominent surrounding terrain.	Facilities will be evaluated for complexity and surrounding topography before determining applicability for use of this method. This method is applicable to facilities with a fractional area obstructed of up to 2%.
Tree Coverage	The quantification model cannot properly account for the effects of significant tree coverage on turbulent dispersion.	Facilities will be evaluated for tree coverage before determining applicability for use of this method. If nearby tree cover exceeds 75% canopy density, there must be at least 100-ft distance from Canary X devices for applicability of this method.
Exterior Obstructions	The quantification model does not account for impacts on the dispersion of gas from large obstructions on the perimeter of a facility, like walls.	Facilities will be evaluated for exterior obstructions before determining applicability for use of this method. Facilities with walls exceeding two meters in height covering more than 20% of the perimeter of the facility will be considered ineligible for compliance under this ATM.

4.1 Cellular Connectivity

Canary X devices are equipped with cellular model technology, capable of sending and receiving data on the following networks:

- AT&T
- Verizon
- T-Mobile

If cellular connectivity is not available or reliable on the facility being evaluated, the Canary X Methane Monitoring System will not be able to transmit the required data to determine a quantified emission rate. During short interruptions of cellular connectivity, the Canary X system has the capability to backfill valid data once connection is restored. If cellular connectivity is not available for more than 24 hours during a 7-day screening period of facility monitoring, a new 7-day period will be established after cellular service is restored.

4.2 Wind Direction

4.2.1 Devices are placed strategically around the subject oil and natural gas production facility utilizing Project Canary's device Siting Tool, detailed in Appendix A. While the Siting Tool optimizes device placement based on predominant meteorological conditions, there will still be times where wind direction will not favorably transport a methane release to a device. During these uncommon periods of time where the wind blows in an unfavorable direction as it relates to device placement, data gaps are intrinsically handled by the nature of recursive Bayesian estimation.

4.2.2 To better understand the prevalence of blind time in the field, Project Canary analyzed meteorological data measured by hundreds of Project Canary anemometers installed across the US on representative production facilities. By simulating release rates from emission sources across facility specific wind data, Project Canary determined how frequently the continuous monitoring systems fail to 'observe' every emission source (blind time) on the facility at least 10 times within a 12-hr period. This study found that with near-optimal placement, three sensor networks achieved an average blind time of less than 10% and a mean time-to-detection of 82 minutes.

4.3 Exterior Obstructions

Devices are placed specifically to avoid the influence of large obstructions that may cause significant errors in the forward modeling, which does not account for recirculation or downwash effects that may be prevalent in the vicinity of such obstructions. In some cases, however, exterior obstructions may be constructed after the devices have been placed at a given facility or a device may be erroneously placed too close to such an obstruction. As a part of automated QA/QC efforts, the residual is computed (i.e., the forward model direction error using the best-fit rate estimates), and cases where the residual is high will be flagged as the model, which does not account for the effects from large nearby obstructions, will fail to accurately predict concentration measurements that are affected by these obstructions. These cases of high residuals will trigger further investigation and potential re-siting of the facility.

5. Safety

5.1 This method may not address all potential safety scenarios associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

5.2 This method generally doesn't require personnel on site, except during times of system installation, preventative maintenance (including calibration), troubleshooting and repair, operator leak investigation, and operator LDAR.

5.3 Emissions detected by this method may contain compounds that are irritating or corrosive to tissues (e.g., heptane) or may be toxic (e.g., benzene, methyl alcohol). Nearly all are fire hazards. Compounds in emissions must be determined through familiarity with the source. Operation of the Canary X Methane Monitoring System on an oil and gas facility requires compliance with Hot Work Permit and other safety standards as defined by the facility operator.

5.4 All Project Canary field technician personnel are onboarded with a thorough safety training program and are required to follow safety protocols provided by customers and internal to Project Canary.

5.5 Field training includes Onsite Preparation Training, Installation Training, Maintenance Training, and Removal Training to support the installation, maintenance, and removal of Canary X devices. Onsite Preparation training outlines safety equipment and personal protective equipment (PPE) required to be maintained and worn by Project Canary field technicians while on a facility. In addition, a record of customer specific equipment and training requirements is maintained to ensure our field technicians meet any client or facility-specific safety requirement, prior to field work.

5.6 Before performing field work, field technicians are expected to fill out a Job Site Analysis (JSA), identifying hazards that may be present while onsite.

5.7 As required under 29 CFR Part 1910, Occupational Safety and Health Standards, Project Canary's siting placement ensures that Canary X devices are placed a minimum of 50 ft from any processing equipment in accordance with OSHA 1910.307 Subpart S requirements for electrical systems.

6. Equipment and Supplies

Use of this method requires various equipment and supplies. All monitoring system equipment is included as part of the Canary X Methane Monitoring System and provided by Project Canary. Critical equipment and supplies are summarized in Table 4.

Table 4: Summary of Canary X Equipment and Supplies

EQUIPMENT AND SUPPLIES	DESCRIPTION
Methane Sensor	Performs the methane sensing through TDLAS
Methane Microcontroller PCB	Converts methane sensor output into ppm values
Modem PCB	Establishes communication to the cloud database for data transmission, reading data from the sensors, formatting sensor data, transmitting the data packet, monitoring data transmission completion, storing the data packet if needed, monitoring the health of the internal components, and controlling battery charge
Pump	Controls the air flow into and out of the methane sensor
Filter	Ensures contamination does not enter the methane sensor
Battery	Provides power to the system
Solar Panel	Charges internal battery
Anemometer	Determines wind direction and speed
RHTP Sensor	Monitors internal relative humidity, temperature, and pressure of the device
GPS Device	Determines location of device
Software	Processes data and health packets for quantification and QC, respectively; primarily functions to collect data and prepare, validate, and transmit data packets

EQUIPMENT AND SUPPLIES	DESCRIPTION
Firmware	Processes data and health packets for quantification and QC, respectively; primarily supports data processing, additional data validation, storage, and quantification determination
Storage	Provides device and cloud storage capabilities for data processing and recordkeeping; data is stored locally on each device when a cellular network is unavailable. Under normal operation, multiple databases are used for data access, storage, and backup

7. Reagents and Standards

Calibration gases for the Canary X Methane Monitoring System consist of known concentrations of methane, typically mixed with nitrogen. Table 5 summarizes the gas mixture specifications. Documentation of each NIST traceable calibration gas cylinder is maintained. Gas cylinders must be used prior to the listed expiration date or returned to the supplier. Calibration of the Canary X monitors is performed using three known gas concentrations (direct calibration procedures are further discussed in Section 10):

- Zero Calibration Gas: This calibration gas contains 0 ppm methane and is used to determine the sensor offset and span.
- Low-level Calibration Gas: This calibration gas is 25 ppm methane ± 2% and used to verify the span.
- High-level Calibration Gas: This calibration gas is 100 ppm methane ± 2% and used to determine the span.

Table 5: Calibration Gas Mixture Specifications

COMPONENTS	SPECIFICATION, 0 PPM CALIBRATION GAS	SPECIFICATION, 25 PPM CALIBRATION GAS	SPECIFICATION, 100 PPM CALIBRATION GAS
Methane	0	25 ppm ± 2%	100 ppm ± 2%
Nitrogen	> 99%	Balance	Balance

8. Data Collection and Method Input Sourcing

8.1 Data Collection

8.1.1 Each Canary X device samples the ambient air through an active sample collection pathway. The ambient air is routed through a filter to remove possible contamination, through a pump and into the laser sensor for determination of methane concentration, after which the sampled air is exhausted from the monitor. Devices do not otherwise collect, store or preserve the sample.

8.1.2 Canary X devices measure methane every second, preparing minute averaged data packets every minute, for quantification determinations every 15 minutes. Additionally, each Canary X Methane Monitoring System is equipped with at least one anemometer, which records wind direction and speed every second, which is imperative to inform the quantification determination through each minute-by-minute data packet.

8.1.3 Additional data is collected by RHTP sensors, internal to each device. This internal device data is used to analyze device health and whether the device is operating within the prescribed operating envelope.

8.1.4 Table 6 summarizes the data collected by each instrument/source within the Canary X Methane Monitoring System, summarizing the raw data inputs used to quantify a facility-wide methane mass emission rate or the information used to validate these inputs and determine device health.

Table 6: A summary of data collected by each instrument.

INSTRUMENT/SOURCE	VARIABLES	USE
TDLAS Sensor	Methane concentration, ppm	Measures the concentration of methane, in ppm, of the air sample for quantification determination
Anemometer	Wind speed (m/s), Wind direction (degrees)	Measures wind speed and direction for quantification determination; Nearby Project Canary anemometer data used to determine predominant wind direction in Siting Tool

INSTRUMENT/SOURCE	VARIABLES	USE
HRRR Model	Temperature, Pressure, and Dew Point Wind speed (m/s) and wind direction (degrees)	Temperature, pressure and dew point are estimated by the HRRR model to inform the quantification forward model; Wind speed and direction data from the HRRR model may be utilized in place of internal anemometer data in the Siting Tool when nearby anemometer data is not available
RHTP Sensor	Relative humidity (%), temperature (°C), and Pressure (mb), internal to the device	Records internal device RHTP, primarily for data validation and system health determination
GPS	Device location	Records device location for quality assurance of device location

8.2 Facility Applicability Determination

The Canary X Methane Monitoring system provides reliable and accurate facility-level methane mass emissions rates; however, there are current limitations on certain types of facilities that impact the system's ability to collect data and provide reliable methane quantification using Project Canary's internally developed forward dispersion model. Some of the key variables which limit the system's ability to accurately quantify emissions include facility building and obstruction complexity, facility physical area, and surrounding terrain. Further, each potential facility evaluated for Periodic Screening under this ATM will be assessed against a set of eligibility criteria, described in Section 4.

8.3 Sampling Location and Installation

8.3.1 Each Canary X device at a facility will be placed according to results from Project Canary's proprietary Siting Tool, described in more detail in Appendix A. The Siting Tool uses the most representative, facility-specific meteorological data, obtained from the nearest Canary X device, if available. With facility-specific parameters, emission events are modeled to optimize device placement, while ensuring there is adequate separation between monitors for the best possible coverage of the facility.

8.3.2 Once the device locations are determined, the operator will install permanent poles at the agreed upon locations. Project Canary field staff will then install each device and associated anemometers, as appropriate, and calibrate each device to ensure the unit is operating within specified limitations, outlined in Section 10. Once successful calibration is complete, the devices will begin collecting and transmitting data and the cellular connectivity is monitored for a 24-hr period to verify a stable cellular connection for data transmission. Subsequently, the device data will be published on the Project Canary SENSE™ dashboard for operator visibility.

8.4 Data Acquisition

Data collected by the Canary X Methane Monitoring System is initially collected on each device, including methane concentration data, meteorological data (if equipped), and other relevant data to monitor the health and operation of the unit. A data packet is sent to a cloud server every minute, where the data is checked for quality and eventually processed to determine methane mass emissions rates.

9. Quality Control

9.1 Initial Measurement System Performance Tests

After installation at the facility, Canary X devices are booted up and run through a series of internal checks. Each device is calibrated and monitored for stability and connectivity over a 24-hr period. The devices are also checked for accurate and timely reporting, and device coordinates are validated to ensure placement matches the siting plan. Once all checks are passed, the facility is "published" on the Canary SENSE™ dashboard and made available to the owner or operator. Devices that do not pass any of the checks must be fixed prior to publishing.

9.2 Quality Control Performance Criteria

Table 7 summarizes the QC performance criteria for Canary X devices and instruments that make up a Canary X Methane Monitoring System. These criteria are monitored at various frequencies, also described in Table 7, with intentional overlap between hourly cron job health packet alarms and engineering alarms to promote redundancy and quality data.

Table 7: Quality Control (QC) Performance Criteria

INSTRUMENT	QC MEASUREMENT	ACCEPTANCE CRITERIA	FREQUENCY OF QC PROCEDURE	CORRECTIVE ACTION
TDLAS Sensor	Analyzer sensitivity	Accuracy within 2 ppm CH_4 up to 100 ppm test gas; Precision: 2σ ≤ 0.25 ppm	Manufacturer	Do not deploy
TDLAS Sensor	Concentration measurement precision and accuracy	0 ppm methane: ± 0.8 ppm 25 ppm methane: ± 2 ppm 100 ppm methane: ± 8 ppm	Annual 3-point field calibration	If the first calibration fails, reinspect and recalibrate. If the second calibration fails, replace and repair the device.
TDLAS Sensor	Instrument initialization	Sensor initializes and is connected	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
TDLAS Sensor	Instrument component failure	No internal diagnostic error	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
TDLAS Sensor	Instrument power on photodiode value with respect to critical threshold	Sensor value above critical threshold, indicating no contamination issue	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
TDLAS Sensor	Instrument data validation	Sensor data is valid	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
TDLAS Sensor	Instrument failure	Sensor is recording and reporting data	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
TDLAS Sensor	Instrument functionality	No fault reported	Hourly health check	Alarm to PC Operations for troubleshooting and repair

INSTRUMENT	QC MEASUREMENT	ACCEPTANCE CRITERIA	FREQUENCY OF QC PROCEDURE	CORRECTIVE ACTION
TDLAS Sensor	Data validity	Non-null values	Every data packet (1-min)	Filter invalid data
TDLAS Sensor	Concentration data within acceptable range	> 0 ppm, < 40,000 ppm	Every data packet (1-min)	Filter invalid data
Anemometer	Wind speed Wind direction	± 2% ± 2°	Manufacturer	Do not deploy
Anemometer	Instrument initialization and connection	Anemometer is initialized and is connected	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
Anemometer	Data load capability	Adequate controller processing resources	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
Anemometer	Instrument data validity	Anemometer data is valid	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
Anemometer	Instrument functionality	No fault reported	Hourly health check	Alarm to PC Operations team for instrument repair
Anemometer	Wind speed data validity	Non-null values	Every data packet (1-min)	Filter invalid data
Anemometer	Wind speed data validity	> 0.5 m/s	Every data packet (1-min)	Filter invalid data
Anemometer	Data within acceptable wind speed range	0 m/s – 15 m/s	Every data packet (1-min)	Filter invalid data
Anemometer	Wind direction data validity	Non-null values, and readings not “stuck” at 0° or 180°	Every data packet (1-min)	Filter invalid data
Anemometer	Data within acceptable wind direction range	0° – 360°	Every data packet (1-min)	Filter invalid data

INSTRUMENT	QC MEASUREMENT	ACCEPTANCE CRITERIA	FREQUENCY OF QC PROCEDURE	CORRECTIVE ACTION
RHTP Sensor	Instrument initialization	Sensor initializes	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
RHTP Sensor	Instrument functionality	RHTP sensor data is stable and within standard deviation limits	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
RHTP Sensor	Instrument data validity	RHTP Sensor is valid	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
RHTP Sensor	Instrument functionality	No fault reported	Hourly health check	Alarm to PC Operations team for instrument repair
RHTP Sensor	Temperature data validity	Non-null values	Every data packet (1-min)	Filter invalid data
RHTP Sensor	Data within acceptable temperature range	> -10 °C and < 40 °C	Every data packet (1-min)	Filter invalid data
RHTP Sensor	Humidity data validity	Non-null values	Every data packet (1-min)	Filter invalid data
RHTP Sensor	Data within acceptable humidity range	> 0% and < 99%	Every data packet (1-min)	Filter invalid data
RHTP Sensor	Pressure measurement functionality	No fault reported	Hourly health check	Alarm to PC Operations team for instrument repair
RHTP Sensor	Pressure data validity	Non-null values	Every data packet (1-min)	Filter invalid data
RHTP Sensor	Data within acceptable pressure range	> 600 mb and < 1200 mb	Every data packet (1-min)	Filter invalid data
Modem	Instrument functionality	No fault reported	Hourly health check	Alarm to PC Operations team for instrument repair

INSTRUMENT	QC MEASUREMENT	ACCEPTANCE CRITERIA	FREQUENCY OF QC PROCEDURE	CORRECTIVE ACTION
Power System	Battery functionality	No fault reported	Hourly health check	Alarm to PC Operations team for instrument repair
SD Card	Instrument initialization	Instrument initializes	Every data packet (1-min)	Alarm to PC Engineering team for instrument repair or replacement
SD Card	Instrument functionality	No fault reported	Hourly health check	Alarm to PC Operations team for instrument repair
Canary X Device	Overall device functionality and ability to report collective data	Data being reported, no fault reported	Hourly health check	Alarm to PC Operations team for instrument repair
GPS	Location of device	Device < 10 m from sited location	Hourly health check	Alarm to PC Operations team for instrument repair
Coin cell battery	Instrument initialization	Real Time Clock being read	Every data packet (1-min)	Alarm to PC Engineering for troubleshooting and repair
Calibration Gas	Zero-level calibration gas, NIST Traceable	± 2% of requested concentration	Each calibration, at a minimum, annually	Do not use
Calibration Gas	Low-level calibration gas, NIST Traceable	± 2% of requested concentration	Each calibration, at a minimum, annually	Do not use
Calibration Gas	High-level calibration gas, NIST Traceable	± 2% of requested concentration	Each calibration, at a minimum, annually	Do not use
Canary X Device	Sensor data transmission	Sensor data uploaded to cloud database	Once every 24-hr period	Alarm to PC Operations team for device repair
Canary X Device	System health check	System confirmed for power and function	Twice every 6-hr block	Alarm to PC Operations team for device repair

INSTRUMENT	QC MEASUREMENT	ACCEPTANCE CRITERIA	FREQUENCY OF QC PROCEDURE	CORRECTIVE ACTION
Canary X Methane Monitoring System	Methane mass emissions rate	Valid methane mass emissions rate determined	Once every 12-hr block	Alarm to PC Operations team
Canary X Methane Monitoring System	Average methane mass emission rate determination across the 7-day screening period	Valid average methane mass emission rate determined for the 7-day screening period	At the beginning of each survey cycle	Alarm to PC Operations team

10. Calibration and Standardization

10.1 Calibration Procedures

10.1.1 To guarantee sensor data quality, each methane sensor is factory calibrated, prior to shipment to the assembly manufacturer. After the Canary X device is assembled and before it is shipped to the field, the unit is bump tested and passed by the assembly manufacturer. Upon field installation, Project Canary field personnel are required to perform an initial field calibration, as detailed in Section 10.1.3.

10.1.2 Sonic anemometers are factory calibrated for wind speed. Upon installation, field technicians follow manufacturer procedures for orientation and adjustment for declination.

10.1.3 After device installation and prior to measuring emissions as directed under this ATM, a three-point field calibration is performed on an annual basis. The following procedures must be performed by Project Canary field personnel:

1. Verify the calibration gas by obtaining appropriate certificates from the calibration gas manufacturer, verifying specifications of the methane concentrations, and ensuring the certifications haven't expired.
2. Connect to Canary X using the Project Canary developed Hardware Support Application (HSA), turn on Canary X and allow the methane sensor to initialize.
3. Enter the methane gas concentration in the HSA.
4. Attach the known methane gas.
5. Wait for readings to stabilize. Once stabilized, the system will capture sample readings and average the values to determine the sensor reading.
6. The offset is determined by sampling zero ppm methane gas, and span is determined with zero and 100 ppm* methane concentration gases in the same manner as described

above. Verification points of the curve will be determined using zero, 25, and 100 ppm gases.

7. Passing criteria is determined by the following values:
    a. Zero ppm methane: ± 0.8 ppm
    b. 25 ppm methane: ± 2 ppm
    c. 100 ppm methane: ± 8 ppm
8. If the calibration does not meet the passing criteria listed above, the system will be reinspected for potential leaks from loose connections and the calibration will be repeated.
9. If the calibration fails again, the sensor will be replaced with a properly functioning sensor.

*The TDLAS sensor has two measurement ranges; a precision measuring range identified with a full scale between 0-100 ppm, and high relative percentage range with a full scale of 0-40,000 ppm. There is hysteresis built into the range switching, which occurs anywhere from 600-2000 ppm depending on the measured relative change in methane concentration. The precision and accuracy of the measurement is dependent on which scale the sensor is measuring in, i.e., 0.8 ppm or 0.25 ppm with 10-s averaging and ± 2 ppm accuracy in the lower or high precision scale, and 250 ppm or 100 ppm with 10-s averaging and ± 800 ppm accuracy in the higher percentage or larger scale. The manufacturer suggests annual sensor calibration at zero, 25, or 100 ppm to ensure the sensor is calibrated appropriately for the lower range concentrations or high precision scale, which are more prevalent in field operations. Project Canary follows the sensor manufacturer recommendations for calibration for low range operation.

11. Analytical Procedure

[Reserved]

12. Detection and Alerting

As described in Section 2, the Canary X Methane Monitoring System will continuously collect methane concentration, wind speed, and wind direction data across the 7-day screening period, and apply the relevant algorithms to estimate a facility-wide methane mass emission rate every 15 minutes. The following subsections provide a high-level overview of the quantification algorithm that is applied every 15 minutes, and how these estimates are aggregated to provide “detections” and “alerts” of OOOOb thresholds.

12.1 Preprocessing

The first step in localization and quantification is preprocessing the measurement data. This step gathers relevant device data, including meteorological data, on minute-averaged values. Data is then preprocessed to enable quantification. These steps include methane background subtraction, computation of atmospheric conditions such as stability class, and data trimming to remove invalid or missing data. Because ambient atmospheric methane concentrations can slowly vary about 1.9 ppm and can also geographically vary, each sensor estimates this atmospheric background statistically and subtracts it from the measurements to obtain the “methane enhancement” signal that represents excess concentration above the ambient background that originate from emissions on the facility.

12.2 Forward Model

The forward model is the physical description of gas transport from methane emissions sources to sensors under specified atmospheric conditions. The forward model must take many factors into account including wind speed and direction, the amount of turbulence in the atmosphere, and the relative positioning and heights of potential sources and sensors. Project Canary applies a dispersion model to generate a system of equations relating release rates from every potential source on the facility to estimated concentration measurements at the locations and times of sensor measurements.

12.3 Inverter

Using the system inferred from measurement data in a given 15-minute time window, the Canary X Methane Monitoring System applies a recursive Bayesian estimator to combine the last known state and associated uncertainties with the new incoming information to compute an updated rate estimate for every potential source on the facility.

12.4 Detection

By applying the calculations outlined in Sections 12.1 - 12.3 to the data collected during the 7-day periodic screening period, the Canary X Methane Monitoring System generates a facility-wide rate estimate every 15 minutes over the entire screening period. Throughout the screening period, a daily facility average methane mass emission rate is determined by averaging the 15-minute quantification values. When the screening period is complete, the average rate is computed over the seven days and reported as the estimate of the facility’s emissions during this screening period. If this quantity exceeds the pre-defined applicable threshold of 5 kg/hr, 10 kg/hr, or 15 kg/hr then this is considered a “detection” of fugitive emissions.

12.5 Alerting

An alert is generated for every detection of fugitive emissions, none are filtered out. This approach is being taken to ensure that no false negatives are incurred by erroneously filtering out a positive detection. This further motivates the longer (7-day) integration window, as these long-timescale estimates are more reliable (i.e., lower uncertainty) than shorter instantaneous flux estimates, as highly uncertain instantaneous rate estimates average out due to the low bias of the system. If an alert occurs, the operator will be notified through the Project Canary SENSE™ dashboard or directly to an owner or operator by SMS text or email. Alerts require performance of a facility-wide survey, leak identification, and leak repair.

13. Method Performance

The Canary X Methane Monitoring system has been thoroughly tested at METEC under their ADED protocol in 2022 (Bell, 2023), 2023 (Ilonze, 2024), and 2024 (Cheptonui, 2024), and through other ad-hoc testing standards in collaboration with METEC personnel. Project Canary also participated in testing at METEC in the summer of 2024, termed ADED 2.0, which more closely represents emissions from real oil and natural gas production facilities. Project Canary's 2024 ADED and ADED 2.0 results are provided in the Supporting Documentation. The Canary X Methane Monitoring System results provided through this testing demonstrate the system's ability to quantify emissions within a 90% POD well below the applicable detection level of this alternative test method. The following two subsections detail some of the key metrics demonstrated via single blind controlled release experiments at METEC.

13.1 ADED 2024 Summary

Project Canary participated openly (as opposed to anonymously) in the ADED 2024 study ("CMReport_ProjectCanary" 2024). Some of the key metrics that can be found in METEC's official report are summarized here. The Canary X Methane Monitoring System detected 713 out of 772 individual release sources, corresponding to a False Negative fraction of 8%. The False Positive fraction was somewhat higher, at 14%, indicating that the system has the tendency to overreport the number of active sources for a given set of releases. The 90% POD computed via both the standard power-law and sigmoid fitting methods was 0.5 kg/hr. The mean absolute quantification error was -0.0641 kg/hr, indicating near-zero bias, but the slight tendency to underestimate emissions. The percentage of emissions estimates within a factor of three of the actual rates (an often-used proxy for quantification precision) was reported at 92%. For reference, the next-best performer from ADED 2024 with respect to this metric was reported to be 74%. All the above statistics and metrics can be found directly in the official METEC report. In addition to the officially reported metrics, Project Canary also computed the cumulative emissions error over the 90-day period. During this testing, Project Canary blindly reported that 2,208 kg of methane was released by the facility. METEC released 2,278 kg, corresponding to an underestimation of 2.8%, another analysis demonstrating the low bias of the system.

13.2 ADED 2.0 Trial Period

In late August and early September of 2024, Project Canary participated in a 4-week blind study at METEC designed to more accurately mimic emissions patterns from an operational facility. METEC did not provide analysis or metrics associated with each technology's performance as a part of this study, however Project Canary analyzed the blindly reported rates and compared them to the ground-truth rates that METEC provided at the conclusion of the study. During this 4-week study, Project Canary blindly estimated that the facility emitted 674 kg of methane, when METEC released 701 kg, an underestimation by 3.86%, which is a measurement of the system's bias that is consistent with previous simpler tests from the original ADED protocol.

14. Pollution Prevention

[Reserved]

15. Data Management and Recordkeeping

The Canary X Methane Monitoring System collects device-level data, performs in-depth data processing for device health monitoring, compliance with data quality objectives, and accurate facility level methane quantification values, and stores critical data across the quantification process.

15.1 Firmware Data Management

15.1.1 The firmware on each Canary X device performs three main functions: data collection, data packet preparation, and data packet transmission. Data from the methane sensor, the temperature/humidity sensor, the pressure sensor, the HRRR model, and the anemometer are collected every second and averaged to inform the data packet, which is prepared every minute. The data collection task reads the data values from the sensors, creates an array of the data values for the measurement minute and then performs a simple average.

15.1.2 During data packet transmission, if the network is available, the data packet is sent to the modem for transmission. If the network is not available or if the transmission fails, the data packet is written on the SD memory card. When the network becomes available, the data packet is read from the memory card and sent to the modem for transmission.

15.1.3 The Canary X device firmware does not limit or truncate any reported valid data before sending the data to the backend quantification model. All data filtering occurs on the backend by the system. Data is reported valid by the device if the device is returning data and not indicating an error in the measurement. When an error condition is identified, a fault is sent to the server with the data payload. The device that failed will be reported as "null" with the error code sent in the health packet. Each device is time-synced to an NTP server once an hour to ensure that timestamps associated with measured quantities are accurate and do not drift.

15.2 Software Data Management

15.2.1 Once the firmware has deemed the measurement data valid, the data packet is sent by the firmware on the Canary X device to the cloud in Java Script Object Notation (JSON) format to an MQ Telemetry Transport (MQTT) Broker. The MQTT Broker transforms the raw JSON from the device into a different format for data ingestion. The transformed data is published to a Publish/Subscribe (pub/sub) broker where a data processing subscriber can process and save the new format.

15.2.2 The data processor is responsible for validating the data, parsing the data to match the data schema, and storing the measurement and metadata. For the measurement to be valid, the timestamp must be defined, not in the future, and not more than a month old. Any data that is over a month old and backfilling from the device must be processed manually. The device ID must also be defined. If the data is deemed invalid for any reason, it is not saved to the relational database but rather stored in a cloud-based object store. If the device ID is not one that our system has seen before, a new device is created in the database and all subsequent measurements will be associated with that device. If the device ID has been seen before, the system updates the "last reported" timestamp.

15.2.3 Once the measurement packet is deemed valid, it is parsed to match the data schema. Here, individual values are set to null if they are not sent by the device or if they are deemed to be outside the operating envelope defined in Section 4. All the raw unparsed data is still kept as a part of the measurement in its own column.

15.3 Storage

The final step of the data processor is to store the measurement data. The data is stored in three places: a high-performance relational database, long-term storage columnar database, and cold storage cloud-based object store.

15.3.1 The high-performance relational database is used by the alerting and downtime systems as well as by operators accessing the data in the SENSE™ dashboard.

15.3.2 The long-term storage is used by any part of the software system that needs to access more than 30 days' worth of measurement data.

15.3.3 Cold storage is used as an additional data backup for emergency data recovery.

15.3.4 Data from all three databases is maintained for a minimum of five years from data generation. For backup and recovery, Project Canary utilizes the tool pgbackrest, which is a database backup tool that ensures the entire database cluster is cloned and saved by taking full and incremental backups to store datafiles and write-ahead logs (WAL) to Amazon Web Services (AWS) S3 storage. Data is subsequently read from AWS S3 to recover full and point-in-time instances of the PostgreSQL cluster. Project Canary also utilizes a full redundant, replicated, and real-time PostgreSQL cluster on separate hardware for disaster recovery.

15.4 Recordkeeping

15.4.1 While some of the recordkeeping and reporting requirements listed in §60.5424b(d), (e) will be the responsibility of the owner or operator, many of the records required will be generated by the monitoring system and provided to the owner or operator.

15.4.2 Table 8 summarizes data records, listed in §60.5424b(b) that will be maintained by the Canary X Methane Monitoring System, and available to the owner and operator at all times as requested.

Table 8: A summary of data maintained by the Canary X Methane Monitoring System to meet recordkeeping requirements

RECORDKEEPING REQUIREMENT	CITATION
Date of each periodic screening during the reporting period and date that results of the periodic screening were received	§60.5424b(b)(1)
Alternative test method and technology used for each screening and the spatial resolution of the technology	§60.5424b(b)(2)
Results from each periodic screening during the reporting period	§60.5424b(b)(4)
If there was a confirmed detection, the date the monitoring survey of the entire fugitive emissions components affected facility was conducted, the date that instrument inspections of all required covers and closed vent systems was completed, and the date visual inspection for emissions of all required covers and closed vent systems was conducted, as entered into the SENSE™ dashboard by the owner or operator	§60.5424b(b)(4)(i), (ii), (iii)

RECORDKEEPING REQUIREMENT	CITATION
For each fugitive emission from a fugitive emissions component affected facility and all defects of each cover and closed vent system, the number and type of components for which fugitive emissions were detected, each emission or defect identified for each cover and closed vent system, the date of each repair, the number and type of fugitive emission components and identification of cover and closed vent system placed on delay of repair, as entered into the SENSE™ dashboard by the owner or operator	§60.5424b(b)(4)(iv)(A), (B), (C), (D)
Date of each periodic screening and date that results of the periodic screening were received.	40 CFR 60.5424b(c)(2)
Name of screening operator.	40 CFR 60.5424b(c)(3)
Alternative test method and technology used for screening, as well as the aggregate detection threshold for the technology and the spatial resolution of the technology	40 CFR 60.5424b(c)(4)
Records of calibrations	40 CFR 60.5424b(c)(5)
Any additional information regarding performance of the Canary X Methane Monitoring System as specified by the Administrator, as part of the Alternative Test Method approval	§60.5398b(d)

15.5 End User Data

15.5.1 Customers who subscribe to Project Canary's SaaS product to comply with the provisions of this ATM under NSPS OOOOb or EG OOOOc, have access to all the data provided below, at a minimum. All device data and derived data are available to the customer through a Representational State Transfer (REST) Application Programming Interface (API) or through downloading a CSV from Project Canary's SENSE™ web-based dashboard.

15.5.2 Both raw device and derived data streams are real-time and will display the data as it becomes available in the dashboard. Raw device data is generated every minute and can be queried on a device, facility, or company level. Raw device data queries display the following fields:

a) Site ID: Facility Name or Identifier
b) Timestamp: Data Packet Timestamp

c) Device ID: Unique Device Identifier
d) Device Latitude: Device Latitude Coordinate
e) Device Longitude: Device Longitude Coordinate
f) CH_4 Concentration: CH_4 Concentration, ppm
g) Wind Speed: Wind Speed, mph
h) Wind Direction: Wind Direction, degrees
i) Internal Temperature: Internal Device Temperature, °F
j) Internal Humidity: Internal Device Humidity, %
k) Pressure: Internal Device Pressure, mb

15.5.3 The derived equipment-level quantification data fields are generated every 15 minutes and are outlined as follows:

a) Equipment Group: Associated equipment grouping
b) Start Date: Quantification data packet timestamp, indicating the start of the 15-min period
c) End Date: Quantification data packet timestamp, indicating the end of the 15-min period
d) Total Equipment Group Emissions: Total quantified methane emissions, in kg, attributed to the associated equipment group

15.5.4 The data associated with alerts from detections is outlined, as follows, once a detection is confirmed:

a) Site ID: Facility name or identifier
b) Start Date: Date that the alert period started
c) End Date: Date that the alert period ended
d) Conditions: Applicable Detection Level Exceeded
e) Source Comments: Operator input field to annotate source details
f) Action Comments: Operator input field to annotate corrective actions
g) Alert Type: Always OOOOb for alerts under this ATM
h) Source Attribution: Associated equipment grouping
i) Equipment Group: Associated equipment grouping
j) Equipment Subgroup: Associated equipment grouping
k) Max Value: The maximum total facility methane emissions for the respective screening period

16. References

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17. Tables, Diagrams, and Flowcharts

[Reserved]

Appendix A

I. Siting Information

Project Canary's Siting Tool optimizes facility-specific device placement by simulating emission source events, maximizing the number of detections by the Canary X Methane Monitoring System, and minimizing time periods during which the system fails to detect these simulated emissions from every source on the site within a given time window.

The optimization process leverages wind data and the location of major emission sources to simulate the spatial and temporal dispersion of plumes and concentrations utilizing a forward model. A continuous leak of 1.6 kg/hr is simulated at each source location across minute-by-minute wind speed and direction data to ensure the tool establishes device locations that allow the system to meet the applicable detection threshold under this ATM.

The siting process optimizes the number of detections by the system while reducing periods of blind time, as defined in Section 3, or periods when the system does not detect emissions from an individual source. For acceptable siting, percent blind time must remain below 25%. In the event that a system is unable to achieve a blind time of less than 25%, Canary X devices will be added until this criterion is met.

II. Sourcing Wind Data and Quality Assurance

The Siting Tool employs two primary sources for historical wind data: internal anemometer measurements from Project Canary's nation-wide device network and National Oceanic and Atmospheric Administration's (NOAA's) High-Resolution Rapid Refresh (HRRR) model.

By leveraging historical wind data from Project Canary's nation-wide device network, the Siting Tool is designed to apply the most representative meteorological data to the simulation. Internal, representative anemometer measurements must meet two criteria to ensure data is characteristic of a particular location. Firstly, the data must be sourced from an anemometer located within a five-kilometer (km) radius of the facility under consideration. Secondly, to account for seasonal variation, the anemometer must have a record of at least 12 months of historical wind data.

The Siting Tool will employ internal anemometer data if the above criteria are met, otherwise, the HRRR model serves as a secondary data source. The HRRR model is a comprehensive atmospheric forecasting model that's updated hourly and provides 3-km resolution data across the nation. Its broad coverage makes it a viable substitute for locations that do not have access to historical anemometer data.

In cases where HRRR model data is utilized to site a facility, Project Canary will perform a QA check by computing the blind time metric with HRRR-informed device placements using in-situ anemometer data after one year of operating. If the blind time exceeds the threshold of 25% with the facility-specific anemometer data, the Siting Tool will be rerun using the in-situ anemometer measurements and the devices will be moved to the appropriate locations.

III. Establishing Emission Sources and Quality Assurance

Once the historical wind data is sourced and loaded, Project Canary personnel will identify major equipment groups, such as tanks, allowing the tool to simulate emission sources in a spatial and temporal manner. Emissions are simulated at 1.6 kg/hr, well under the applicable threshold of this ATM, and representative emission source heights are utilized to most accurately model plume dispersion. A facility boundary is created, and the available area can be adjusted to account for any areas where devices are not permitted, such as entry or exit roads.

If new information becomes available regarding the positioning of sources or the addition or removal of equipment from a facility, these changes will be made to the facility layout in Project Canary's web-based dashboard. The blind time of this site will be recalculated using the new source locations, and if it exceeds the maximum allowable value (25%), then the Siting Tool will be rerun and the locations of devices will be moved, or additional devices will be added to account for these changes.

IV. Method and Installation

This in-house Siting Tool is utilized by Project Canary personnel to assist operators in device placement, prior to deployment. Once device placement is determined by the tool, operators are required to place permanent poles according to designated placements. Following pole installation, Project Canary field personnel will install each device and hook up the system, as prescribed in Section 8.3. Each device has an internal GPS so that device locations can be confirmed and compared to the Siting Tool's output upon installation and tracked throughout the monitoring period to ensure devices are not relocated.

Appendix B

I. Canary X Methane Monitoring System Site Monitoring Plan

Table 9 provides a summary of the information required to be included in a Site Monitoring Plan, as prescribed by 40 CFR 60.5398b(b)(2). It is the responsibility of the operator to develop and maintain the Monitoring Plan while using this ATM.

Importantly, if an OGI survey is required under this ATM or utilized to replace a periodic screening, a Fugitive Emissions Monitoring Plan is required, per 40 CFR 60.5397b(b).

Table 10 and Table 11 summarize the Monitoring Plan requirements applicable to a facility when monitoring surveys are conducted to investigate confirmed detections by this ATM.

Table 9: A summary of Monitoring Plan requirements

REQUIREMENT	DESCRIPTION	CITATION
Facility Name		
Facility Coordinates		40 CFR 60.5398b(b)(2)(i)
Facility Type	(i.e. single wellhead only site, small site, multi-wellhead only site, well site with major production and processing equipment, centralized production facility)	
Alternative Test Method	Canary X Methane Monitoring System	40 CFR 60.5398b(b)(2)(ii)
Spatial Resolution	Facility-level	40 CFR 60.5398b(b)(2)(ii)
Surveyor	Project Canary, Canary X Methane Monitoring System	40 CFR 60.5398b(b)(2)(iii)
Applicable Detection Threshold	5 kg/hr, 10 kg/hr, or 15 kg/hr	
Frequency of Periodic Screenings	(dependent on site type and applicable detection threshold)	40 CFR 60.5398b(b)(2)(iv)
Is an annual OGI survey required as part of this ATM work practice, prescribed by 40 CFR 60.5398b(b)(1)(i) or (ii)?	(i.e., yes or no, dependent on site type and applicable detection threshold)	40 CFR 60.5398b(b)(2)(v)

REQUIREMENT	DESCRIPTION	CITATION
Will an OGI survey be utilized to replace a periodic screening survey with this alternative test method?	(i.e., yes or no)	40 CFR 60.5398b(b)(2)(v)
Procedures and timeframes for identifying and repairing fugitive emissions components, covers, and closed vent systems with confirmed detections		40 CFR 60.5398b(b)(2)(vii)
Procedures and timeframes for verifying repairs for fugitive emissions components, covers, and closed vent systems		40 CFR 60.5398b(b)(2)(viii)
Recordkeeping procedures, a list of records that will be kept and the length of time		40 CFR 60.5398b(b)(2)(ix)

Table 10: A summary of Monitoring Plan information required if confirmed detections are investigated by an OGI monitoring survey

REQUIREMENT	DESCRIPTION	CITATION
Technique for determining fugitive emissions	OGI	40 CFR 60.5397b(c)(2)
Manufacturer of detection equipment		40 CFR 60.5397b(c)(3)
Model number of detection equipment		40 CFR 60.5397b(c)(3)
Verification of OGI specifications, as prescribed by 40 CFR 60.5397b(c)(7)(i)(A) and (B)		40 CFR 60.5397b(c)(7)(i)(A) 40 CFR 60.5397b(c)(7)(i)(B)
Procedure for daily verification check		40 CFR 60.5397b(c)(7)(ii)
Maximum viewing distance		
Procedure for determining maximum viewing distance		40 CFR 60.5397b(c)(7)(iii)

REQUIREMENT	DESCRIPTION	CITATION
Maximum wind speed		
Procedure for determining maximum wind speed		40 CFR 60.5397b(c)(7)(iv)
Procedures for how the operator will ensure adequate thermal background		40 CFR 60.5397b(c)(7)(v)(A)
Procedures for how the operator will deal with adverse monitoring conditions (e.g., wind)		40 CFR 60.5397b(c)(7)(v)(B)
Procedures for how the operator will deal with interferences (e.g., steam)		40 CFR 60.5397b(c)(7)(v)(C)
Required training and experience		40 CFR 60.5397b(c)(7)(vi)
Procedures for calibration and maintenance		40 CFR 60.5397b(c)(7)(vii)
Procedures to ensure all fugitive emissions components are monitored during each survey	(i.e., sitemap with observation path, a written plan of where components are and how they're monitored, fugitive emission component inventory)	40 CFR 60.5397b(d)(1)

Table 11: A summary of Monitoring Plan information required if confirmed detections are investigated by an M21 monitoring survey

REQUIREMENT	DESCRIPTION	CITATION
Technique for determining fugitive emissions	M21	40 CFR 60.5397b(c)(2)
Manufacturer of detection equipment		40 CFR 60.5397b(c)(3)
Model number of detection equipment		40 CFR 60.5397b(c)(3)
Verification of M21 specifications		40 CFR 60.5397b(c)(8)(i)
Procedures for conducting surveys		40 CFR 60.5397b(c)(8)(ii)

REQUIREMENT	DESCRIPTION	CITATION
Procedures for calibration, in alignment with 40 CFR 60.5397b(c)(8)(iii)(A), (B), and (C)		40 CFR 60.5397b(c)(8)(iii)
Procedures for monitoring yard piping		40 CFR 60.5397b(c)(8)(iv)
A list of fugitive emissions components to be monitored and the method for determining the location of fugitive emissions components	(i.e., tagging, identification on a process and instrument diagram, etc.)	40 CFR 60.5397b(d)(2)
Plan for each difficult-to-monitor fugitive emissions component		40 CFR 60.5397b(d)(2)
Plan for each unsafe-to-monitor fugitive emissions component		40 CFR 60.5397b(d)(2)