PROJECT CANARY

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Request for Alternative Test Method for Periodic Screening

Alternative Test Method
December 23, 2024

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Project Canary Alternative Test Method Application

Contents

1 SCOPE AND APPLICATION 3

1.1 APPLICABILITY 3
1.2 ANALYTES 3
1.3 METHOD SENSITIVITY 3
1.4 DATA QUALITY OBJECTIVES (DQO) 4

2 SUMMARY OF METHOD 4

3 DEFINITIONS OF METHOD 4

4 INTERFERENCES 5

4.1 WIND DIRECTION 5
4.2 WIND SPEED 6
4.3 METHANE BUOYANCY AND RELEASE HEIGHT 6
4.4 AMBIENT TEMPERATURE 6

5 SAFETY 7

6 EQUIPMENT AND SUPPLIES 7

6.1 METHANE DETECTION SENSOR 8
6.2 METHANE MICROCONTROLLER PRINTED CIRCUIT BOARD (PCB) 8
6.3 MODEM PCB 8
6.4 PUMP 8
6.5 FILTER 8
6.6 METEOROLOGICAL SENSORS 8
6.7 POWER SYSTEM 9

7 REAGENTS AND STANDARDS 9

8 SAMPLE COLLECTION, PRESERVATION AND STORAGE 9

9 QUALITY ASSURANCE AND QUALITY CONTROL 9

9.1 INITIAL MEASUREMENT SYSTEM PERFORMANCE TESTS 11

10 CALIBRATION AND STANDARDIZATION 11

10.1 CALIBRATION 11

11 PROCEDURE 12

11.1 FACILITY APPLICABILITY DETERMINATION 12
11.2 SAMPLING LOCATION AND INSTALLATION 12
11.3 DATA ACQUISITION 13

12 DATA ANALYSIS AND CALCULATIONS 13

12.1 PREPROCESSING 13

12.2 FORWARD MODEL 13
12.3 INVERTER 14
13 METHOD PERFORMANCE 14
14 POLLUTION PREVENTION [RESERVED] 14
15 WASTE MANAGEMENT [RESERVED] 14
16 REFERENCES 14
17 TABLES, DIAGRAMS, FLOWCHARTS AND VALIDATION DATA [RESERVED] 15

1 Scope and Application

The Alternative Test Method (ATM) in this application is for periodic screening of methane emissions, utilizing a continuous monitoring system to be implemented at oil and natural gas production facilities within the United States. This document provides the necessary information and procedures for implementation, operation, and utilization of the Canary X Methane Monitoring System as a periodic screening tool as provided in §60.5398b(b) and §60.5398b(d).

1.1 Applicability

This alternative test method is intended to meet approval standards under 40 CFR §60.5398b(d) for alternative standards for fugitive emission components affected facilities and continuous inspection and monitoring requirements for covers and closed vent systems under §60.5398b. This method is intended for facility-wide detection of methane emissions across a seven-day screening period during each required periodic survey cycle, above the Minimum Detection Threshold of less than or equal to 5 kg/hr. Emission rates will be averaged over the first seven days of each required survey cycle. This evaluation will be performed monthly at eligible well sites and centralized production facilities subject to quarterly OGI or EPA Method 21 monitoring or quarterly at eligible well sites and centralized production facilities subject to semiannual OGI or EPA Method 21 monitoring, as described in Table 1 and Table 2 of the OOOOb regulations, respectively. Use of this method will demonstrate compliance with EPA's New Source Performance Standards (NSPS OOOOb) and Emissions Guidelines (EG) OOOOc Leak Detection and Repair program as specified in §60.5398b(b) and §60.5398b(d).

1.2 Analytes

This method measures the concentration of methane (CH_4) using a Tunable Diode Laser Absorption Spectroscopy (TDLAS) methane sensor.

Analyte List

ANALYTE	CAS NO.	SENSITIVITY
Methane (CH_4)	74-82-8	≤5 kg/hr

1.3 Method Sensitivity

The sensitivity of the Canary X Methane Monitoring System under this method meets a minimum detection threshold of less than or equal to 5 kg/hr, with a 90% probability of detection. A detailed description of method sensitivity can be found in Section 1 of the Quantification Validation document provided in the Supporting Documentation of Project Canary's Canary X Continuous Methane Monitoring System method application, ALTTECH-46.

1.4 Data Quality Objectives (DQO)

Project Canary will generate facility-level continuous quantification data throughout each periodic screening period that is of sufficient quality to be used to meet the inspection and monitoring requirements of fugitive emissions components affected facilities and closed vent systems in section §60.5398b. Main objectives include:

- Determining and recording a valid, average methane mass emission rate over the first seven-day period of each survey cycle; and
- Maintaining a system-wide detection threshold of ≤5 kg/hr.

2 Summary of Method

The Canary X Methane Monitoring system is composed of several individual, fixed Canary X devices. The number of devices and their locations on a facility are determined through a proprietary siting tool, described in detail in Section 2.2 of the Description of Technology document. A Canary X Methane Detection system consists of several main components, including: a Tunable Diode Laser Absorption Spectroscopy (TDLAS) methane sensor, 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.

3 Definitions of Method

Blind time: A term specific to Project Canary's Siting Tool and analyses. A twelve-hour 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.

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 period during which the Canary X System will monitor for 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 reoccurring period during which a periodic survey must be conducted, prescribed by Tables 1 and 2 of 40 CFR Part 60, Subpart OOOOb.

4 Interferences

Interferences associated with this method are classified as sampling interferences related to limitations of methane reaching one of the Canary X device sensors.

4.1 Wind Direction

Sensors are placed strategically around the subject oil and natural gas production facility utilizing Project Canary's device siting tool, further described in Section 2.2 of the Description of Technology. 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 sensor.

During these uncommon periods of time where the wind blows in an unfavorable direction as it relates to sensor placement, data gaps are intrinsically handled by the nature of recursive Bayesian estimation. The Description of Technology provides a detailed discussion of continuous state estimation in Section 2.6.

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 within a 12-hour period. A detailed blind time analysis is provided in Section 3 of the Quantification Validation document found in Supporting Documentation.

4.2 Wind Speed

The Canary X Methane Monitoring system provides excellent methane detection capabilities across a broad range of wind speeds; however, wind speeds that are very low can impact methane detection. Periods of low wind speed, less than 0.5 meters per second (m/s), correspond to high variability in wind direction, during which methane tends to pool and transport in a less predictable manner. In some cases, this can result in reduced accuracy of emissions source allocation due to the unpredictability of wind behavior. Methane pooling can produce biased, high methane readings and mass emission rates due to higher concentrations in the pooled area.

The quantification algorithms account for low wind speeds in the preprocessing, prior to running data through the localization and quantification algorithm. Preprocessing steps are covered in Section 2.6.1 of the Quantification section in the Description of Technology.

4.3 Methane Buoyancy and Release Height

Methane buoyancy can impact the ability of stationary methane sensors to detect methane concentrations. Methane is not only lighter than air, but in some circumstances, can be released through an elevated release point, at a temperature higher than ambient temperature, or with a high vertical velocity, or any combination of these factors. Canary X monitors are typically placed at a height of approximately six feet above ground level which, when combined with the aforementioned factors, could result in monitors not detecting the center of a methane plume, or any of the plume.

In order to address these factors, vertical turbulent mixing and source heights are all explicitly accounted for in the dispersion modeling employed for source rate inference. Section 2.6.2 in the Description of Technology document addresses these factors in more detail.

4.4 Ambient Temperature

The sensor in the Canary X Methane Monitoring system has temperature limitations which, when operating outside such limitations, can reduce accuracy in measured methane concentrations. The normal operating temperature range of the sensor is between -10°C and +50°C.

Additional limitations listed below are covered in more detail in Section 1.4 of the Description of Technology:

- Sensor sensitivity and precision
- Power requirements
- Cellular connectivity
- Anemometer functionality
- Facility complexity
- Tree cover and other obstructions
- Sensor placement availability

5 Safety

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

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 outlined in Project Canary's Field Operations Employee Safety Manual, available in the Supporting Documentation.

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 Field Technicians meet any client or facility-specific safety requirement, prior to field work.

Before performing field work, field technicians are expected to fill out a Job Site Analysis (JSA), identifying hazards that may be present while onsite. Training requirements, specific to hazards typically associated with work on oil and gas facilities, are outlined in more detail in the Field Operations Employee Safety Manual, submitted with Supporting Documentation.

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 described below.

6.1 Methane Detection Sensor

The Canary X Methane Monitoring system uses a TDLAS methane sensor with exceptional sensitivity, as low as 0.4 parts per million (ppm). The sensor operates in the near-infrared spectrum range, measuring target gas in a contactless flow-through cell. Project Canary has incorporated this sensor for more than 2 years, gathering billions of pieces of data, validating the efficacy of the sensor. The sensor and supporting components have undergone extensive testing, including environmental chamber testing at extreme operating conditions and robust sensitivity testing at Colorado State University's (CSU) Methane Emissions Technology Evaluation Center (METEC), and other locations with various academic institutions. Much of this data is provided in Section 1 of the Quantification Validation document in the Supporting Documentation of this application.

6.2 Methane Microcontroller Printed Circuit Board (PCB)

The methane microcontroller converts the detected methane concentration into parts per million (ppm) values for processing. The methane microcontroller PCB contains values that are specific to a single methane sensor.

6.3 Modem PCB

The modem PCB is responsible for establishing communication to the cloud database, 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.

6.4 Pump

Each Canary X monitor is equipped with an air pump, which controls air flow into and out of the methane sensor to ensure adequate air sampling volume.

6.5 Filter

The filter is installed in line with sampling air flow and prevents contaminants from entering the methane sensor.

6.6 Meteorological Sensors

The Canary X Methane Monitoring system will include at least one anemometer, measuring wind direction and speed, on every facility. This facility-specific wind data is critically important in methane mass emissions quantification and source allocation.

The system also includes a relative humidity, temperature and barometric pressure (RTP) sensor, internal to each monitor, used primarily for data validation and system health by determining if the system is operating within range.

6.7 Power System

Each monitor is equipped with one or more solar panels, depending on geographical area and average solar radiation, sufficient to charge a 12-volt battery to maintain all monitor functions for extended periods of time, up to five days without significant solar radiation.

7 Reagents and Standards

Calibration gases for the Canary X methane monitoring system consist of known concentrations of methane, typically mixed with nitrogen. Documentation of each calibration gas cylinder is maintained for traceability. 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:

- Zero Calibration Gas: This calibration gas contains less than 0.1 parts per million (ppm) methane and is used to determine the sensor offset and span.
- Low-level Calibration Gas: This calibration gas is typically at 25 ppm methane and used to verify the span.
- High-level Calibration Gas: This calibration gas is typically 100 ppm methane and used to determine the span.

Calibration procedures are further discussed in Section 10.

8 Sample Collection, Preservation and Storage

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.

9 Quality Assurance and Quality Control

Table 1 summarizes Quality Control performance criteria for components and data as part of the Canary X Methane Monitoring system. Additional quality control criteria related to quantification and localization are included in the Device Health Table in the Supporting Documentation section.

Table 1: Quality Control Performance Criteria

PROCESS	QA/QC SPECIFICATION	ACCEPTANCE CRITERIA	FREQUENCY CHECKED
TDLAS sensor	Analyzer sensitivity	Accuracy within 2 ppm CH_4 up to 100 ppm test gas; Precision: 2σ ≤0.25ppm	Manufacturer
Anemometer	Wind speed Wind direction	+/- 2% +/- 2°	Manufacturer
Power system	Battery state of charge	<20% state of charge	Every data packet (1-minute)
Wind speed	Data validity	>0.5 m/s	Every data packet (1-minute)
Wind direction	Data validity	Non-null values, and readings not "stuck" at 0° or 180°	Every data packet (1-minute)
Temperature	Data validity	> -10C and < 50°C	Every data packet (1-minute)
Calibration gas	Zero-level calibration gas	+/- 5% of requested concentration	Each calibration, at a minimum, annually
Calibration gas	Low-level calibration gas	+/- 5% of requested concentration	Each calibration, at a minimum, annually
Calibration gas	High-level calibration gas	+/- 5% of requested concentration	Each calibration, at a minimum, annually
Data transmission	Sensor data transmission	Sensor data uploaded to cloud database	Once every 24-hour period
Sensor operation	System health check	System confirmed for power and function	Twice every 6-hour block
Methane mass emission rate determination	Methane mass emissions rate	Valid methane mass emissions rate determined	Once every 12-hour block

Average methane mass emission rate determination across the 7-day screening period	Average methane mass emission rate 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
Concentration readings	Monitor outside of range	<0 ppm, >40,000 ppm	Every data packet (1-minute)

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-hour 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 site is "published" to 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.

10 Calibration and Standardization

10.1 Calibration

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.

After device installation and prior to measuring emissions as directed under this Alternative Test Method, a three-point field calibration is performed. 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:
   - Zero ppm methane: +/- 0.8 ppm
   - 25 ppm methane: +/- 2 ppm
   - 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.

If the calibration fails again, the sensor will be replaced with a properly functioning sensor.

Calibrations are currently performed on an annual basis after initial installation, following the procedures outlined above.

11 Procedure

This section provides the general procedures of the Canary X Methane Monitoring system to determine a facility wide methane mass emissions rate. An average methane mass emission rate will be determined across the first seven-day screening period of each survey cycle.

11.1 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 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. The details of each limitation are described in Section 1.4 of the Description of Technology document. Further, each potential facility evaluated for Continuous Monitoring under this Alternative Test Method will be assessed against a set of eligibility criteria, outlined in Section 2.1.1 of the Description of Technology.

11.2 Sampling Location and Installation

Each of the devices of the Canary X Methane Monitoring system at a production facility will be placed according to results from Project Canary's in-house siting tool, described in more detail in the Description of Technology, Section 2.2. The siting tool uses the most representative, facility-specific meteorological data, obtained from the nearest Canary X monitoring system, if available. With facility-specific parameters, emission events are modeled to optimize sensor placement, while ensuring there is adequate separation between monitors for the best possible coverage of the facility.

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 monitor and associated anemometers, as appropriate, and calibrate each monitor to ensure the unit is operating within specified limitations, outlined in Section 10. Once successful calibration is complete, the monitors will begin collecting and transmitting data and the cellular connectivity is monitored for a 24-hour period to verify a stable cellular connection for data transmission. Subsequently, the monitor data will be published to the Project Canary SENSE™ dashboard for operator visibility.

11.3 Data Acquisition

Data collected by the Canary X Methane Monitoring system is initially collected on each monitor, 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.

There are several detailed steps in these processes, which are discussed in much greater detail in the Description of Technology, Section 2.4.

12 Data Analysis and Calculations

The Canary X Methane Monitoring system performs robust data analysis and calculations to ensure confidence in any mass methane emissions quantification. The analysis includes three main steps, each comprised of multiple calculation and data validation procedures. The three main steps along with a brief description is below and more detailed descriptions and calculations are provided in the Description of Technology, Section 2.6.

12.1 Preprocessing

The first step in localization and quantification is preprocessing. This step gathers relevant sensor data, including meteorological data, on minute-averaged values. Data is then preprocessed for optimal quantification results, including methane background subtraction, computation of atmospheric conditions such as stability class, and data trimming to remove invalid or missing data. A detailed description of the preprocessing steps is included in Section 2.6.1 of the Description of Technology document.

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. Project Canary uses an internally developed forward dispersion model, based on extensive scientific research on the model as well as its processing efficiency for localization and quantification algorithms. Extensive detail on Project Canary's forward model is included in Section 2.6.2 of the Description of Technology document.

12.3 Inverter

Project Canary leverages the forward model, combined with atmospheric conditions measured at the location, to "invert" methane concentration measurements to source rates through recursive Bayesian estimation. There are several detailed calculations in this process, which is detailed in the Description of Technology document, in Section 2.6.3.

13 Method Performance

The Canary X Methane Monitoring system has been thoroughly tested at the Methane Emissions Technology Evaluation Center (METEC) under their Advancing Development of Emissions Detection (ADED) protocol in 2022 (Bell, 2023), 2023 (Ilonze, 2024), and 2024, and through other ad-hoc testing standards in collaboration with METEC personnel. Project Canary also participated in tested 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 system results provided in through this testing, demonstrates the system's ability to quantify emissions within a 90% probability of detection well below the requested Minimum Detection Level of this alterative test method. These results and supporting analyses are further detailed in Section 1 of Quantification Validation document included in the Supporting Documentation section of Project Canary's Canary X Continuous Methane Monitoring System application, ALTTECH-46.

14 Pollution Prevention [Reserved]

15 Waste Management [Reserved]

16 References

1910.307 - hazardous (classified) locations. Occupational Safety and Health Administration. (n.d.). https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.307

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17 Tables, Diagrams, Flowcharts and Validation Data [Reserved]