PROJECT CANARY

Project Canary

Request for Alternative Test Method for Periodic Screening

Description of Technology
April 3, 2025

Project Canary Technology Description and Workflow

1 Description of Technology

This document describes the Canary X Methane Monitoring System's functional capabilities to demonstrate its qualification for the Alternative Test Method and requirements specified in §60.5398b(d).

The process of converting raw methane concentration values into reliable methane mass emissions rates is a complex challenge that requires robust modeling techniques, reliable input data, and well-defined assumptions where necessary. This section describes the scientific theory behind the Tunable Diode Laser Absorption Spectroscopy (TDLAS) sensing principle, Canary X device physical instrumentation, and method limitations.

1.1 Scientific Theory

The fundamental sensing principle is Tunable Diode Laser Absorption Spectrometry (TDLAS), which is widely used and provides a solution to many gas detection challenges in emission monitoring and process control. TDLAS is an established measurement method used to detect methane and other hydrocarbons due to several key advantages including rapid response time, high selectivity, high sensitivity at low concentrations, and a dynamic measurement range, showing effective detection of sub-ppm concentration levels and high percentage concentration levels.

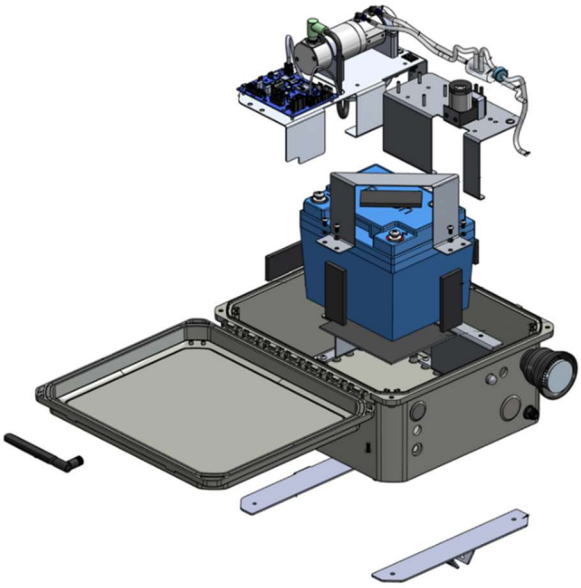
TDLAS (Tunable Diode Laser Absorption Spectroscopy) operates based on the principle of absorption spectroscopy, where a laser beam at a specific wavelength is directed through a gas sample. The gas molecules (like methane) absorb specific wavelengths of light that correspond to their unique molecular vibrational and rotational transitions. By measuring the amount of absorption, the concentration of the gas can be determined. Methane gas molecules absorb specific wavelengths of light, specifically at 1650 nm.

The Canary X device sensor laser is line locked and is specifically tuned by the manufacturer to selectively absorb methane. There is no measurable interference with other gases, however condensation and other large contaminants could cause harm to the sensor which is why a two-stage filtration system is employed. The sensor has a multi-pass cell which makes the effective distance the laser travels much longer than the sensor itself, about one meter.

1.2 Description of Physical Instrumentation

The Canary X Methane Monitoring System is composed of several individual Canary X devices triangulated on the facility being monitored. A Canary X device is an autonomous methane sensing Internet of Things (IoT) device, containing a state-of-the-art TDLAS methane sensor, components required to support the sensor operation, and meteorological sensors, providing meteorological data for Project Canary's mass quantification calculations.

Figure 1: The Canary X Device



Each Canary X device is secured on a pre-installed metal pole, approximately 6 feet above the ground, with metal clamps and bracket hooks to ensure a stable installation. One or more solar panels are mounted on each pole, externally to each device, depending on geographical area and average solar radiation. A Canary X device installation is shown in Figure 2.

Figure 2: Canary X Device Field Installation

Each Canary X Methane Monitoring System configuration will include at least one anemometer per facility, mounted externally to a Canary X device, on the top of the pole mount, as shown in Figure 3.

Figure 3: Canary X Device and Anemometer Mount

Project Canary's Siting Tool, detailed in Section 2.2, optimizes sensor placement for the most effective leak detection and determines where mounting poles must be placed. Operators are required to properly install and place poles prior to the arrival of Project Canary field personnel for Canary X device installation.

A single Canary X device contains a methane sensor, microcontroller Printed Circuit Board (PCB), modem PCB, pump, filters, and a battery. The system also includes a relative humidity, temperature and barometric pressure (RHTP) sensor, internal to each device. Canary X Methane Monitoring System hardware components are summarized below in Table 1.

Table 1: Summary of Hardware Components

HARDWARE COMPONENT	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
Pump	Controls the air flow into and out of the methane sensor
Filter	Ensures contaminates do not enter the methane sensor
Battery	Provides power to the system
Solar Panel	Charges to internal battery
Anemometer	Determines wind direction and speed
RHTP Sensor	Monitors internal relative humidity, temperature, and pressure of the device

1.3 Type of Measurement and Application

The Canary X Methane Monitoring System is a fixed, in-situ continuous monitoring solution. The desired applicability of the system under this Alternative Test Method is for periodic screening with an Applicable Detection Threshold of 5 kg/hr, 10 kg/hr, or 15 kg/hr, and broadly applicable across the sector with an understanding of the interferences and the limitations outlined below in Section 1.4.

1.4 Technology Limitations

1.4.1 Hardware Limitations

This section provides a list of limitations within the hardware of the Canary X Methane Monitoring System.

1.4.1.1 Sensor Sensitivity and Precision

The sensitivity of the TDLAS sensor ranges from less than 0.4 parts per million (ppm) methane to 40,000 ppm methane. Internally, the sensor has two measurement ranges: the “Low Range,” which spans from 0 ppm to 2,000 ppm, and the “High Range,” which spans from 2,000 ppm to 40,000 ppm. There is hysteresis built into the range switching functionality. When switching

from the low range to the high range, the switch occurs at 2,000 ppm. When switching from the high range to the low range, the switch occurs at 1,000 ppm.

The precision is impacted by which range the sensor is measuring within. While the low range precision is +/-0.8 ppm, the high range precision is +/-250 ppm. All other sensor characteristics are unaffected by the range switch.

1.4.1.2 Temperature

The TDLAS sensor has an operating range between -10°C and 40°C. Outside of this operating range, the Canary X device does not reliably measure methane concentration. Methane concentrations, when measured outside of this temperature range, will be removed during data preprocessing.

1.4.1.3 Power Requirements

Solar power is required to recharge the internal 12-volt battery that powers the Canary X Methane Monitoring System. The internal battery can last up to five days without solar radiation but must be recharged thereafter.

1.4.1.4 Cellular Hardware

The Canary X device is dependent on the cellular network for communications, including LTE-M bands, providing extensive coverage across multiple regions. If the cellular network is not available, the measurement data is stored locally in a circular buffer, with nearly four years of storage capacity. The cellular network is required to communicate the stored or measured data to the quantification model.

1.4.1.5 Anemometer Functionality

The Canary X Methane Monitoring System requires a minimum of one anemometer per facility to inform the quantification models with wind speed and direction data. Without wind speed and direction, the quantification model cannot determine the methane emission rate.

1.4.2 Software Limitations

1.4.2.1 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 required data to determine a

quantified emission rate. During short interruptions of cellular connectivity, the Canary X Methane Monitoring 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 seven-day period of facility monitoring, a new seven-day period will be established after cellular service is restored.

1.4.2.2 Low Wind Speed

Wind speed is necessary to perform accurate methane emissions quantification calculations. Periods of very low wind speeds, less than 0.5 meters per second (m/s), are indicative of highly variable wind directions and atmospheric instability. When wind speeds are less than 0.5 m/s, the Canary X Methane Monitoring System considers it a "no data" period and the device data is discarded. It is important to note that periods of "no data" do not necessarily result in downtime of the system. A detailed description of downtime is provided in Section 3.

1.4.2.3 Facility Complexity and Topography

Large obstructive infrastructure, and surrounding terrain affect the ability of the forward model to make accurate predictions of methane mass emissions rates and source localization. Project Canary evaluates every facility for complexity and surrounding topography before determining applicability of the system for NSPS OOOOb compliance. Facilities that don't meet the requirements will be deemed not applicable for use under this Alternative Test Method.

More details regarding facility complexity and limitations to the quantification forward model are outlined in Section 2.1.

3 System Downtime [Reserved for CBI]

3.1 Downtime Calculations [Reserved for CBI]

3.1.1 Monitor Power Interruptions [Reserved for CBI]

3.1.2 Anemometer System Downtime [Reserved for CBI]

3.1.3 Relative Humidity, Temperature and Pressure Sensor Downtime [Reserved for CBI]

3.1.4 Cellular Connectivity Downtime [Reserved for CBI]

4 Determining a Mass Emission Rate, Alerting, and End User Data through the Canary SENSE™ Dashboard

4.1 7-Day Average Quantification Determination

As described in detail in Section 2, the Canary X Methane Monitoring System calculates facility-level methane mass emissions rates approximately once every 15 minutes. Throughout the screening period, Project Canary will calculate a daily facility average methane mass emission rate by taking the average of the 15-minute facility-level quantification values.

At such time that the screening period is complete and daily methane mass emission rates are available for seven consecutive calendar days, the Canary X Methane Monitoring System will calculate the seven (7)-day average mass emissions rate. The resultant data are stored in the database ensuring a complete history of the quantification data for OOOOb facilities is maintained. This table is immutable after 24 hours.

This choice of averaging time is motivated by a few factors. First, controlled release testing of fixed-point monitors has generally shown that there can be significant uncertainty associated with individual short-duration emissions estimates. When computing cumulative (or time-averaged) quantification error metrics, however, these systems have been shown to have very low bias. Because of this, the longer the integration time window is, the smaller the expected variance in the error distribution, resulting in more reliable rate estimates when computed over long averaging times. Second, by using a larger time window, the system is more likely to observe any intermittent operational or fugitive event. This is in stark contrast to "snapshot" type measurements which only observe whatever the emissions are at a specific moment in time. By considering a large time window, the monitoring system is exposed to all intermittent sources that occur during this time. Finally, if there is any sort of periodicity to maintenance or operations (e.g., on a weekly cadence), then smaller windows (or snapshot observations) at a given day/time may be subject to sampling bias. For example, if a periodic screen is always taken on Mondays but maintenance that results in higher-than-average emissions is scheduled on Tuesdays, the sampling routine of the snapshot measurement will result in a biased-low estimate simply due to the lack of temporal coverage. By computing the average emissions over a week, any sort of weekly or smaller periodicity in the underlying emissions timeseries will be captured by the system.

4.2 Confirmed Detections and Alerting

At the end of each screening period, average methane mass emission rate will be determined and compared to the Applicable Detection Threshold listed in Tables 1 and 2 of 40 CFR Part 60, Subpart OOOOb. If the calculated 7-day average methane mass emission rate exceeds the Applicable Detection Threshold, 5 kg/hr, 10 kg/hr, or 15 kg/hr, the Canary X Methane Monitoring System will notify the owner or operator of the subject facility, following the procedures outlined in their fugitive monitoring plan. Notifications can be provided by SMS

messaging, or email and can be sent to multiple individuals within the owner or operator's organization as desired. Additionally, when a threshold is exceeded, Project Canary's SENSE™ dashboard for the respective owner or operator will display a notification banner or similar identifier that one of the monitored locations has exceeded the Applicable Detection Threshold, which will remain visible until the subject facility's methane mass emissions rate decreases below the respective detection threshold.

The Project Canary Methane Monitoring system also has the capability to customize "soft alerts" which provide similar notifications to the owner or operator as an action level notification, but rather are indications of facility-level emissions approaching a detection threshold prior to exceeding it. Soft alerts can be somewhat customizable by the owner or operator, depending on their specific needs or other operational considerations. Some examples of soft alerts are:

- A given facility is approaching a certain percentage of detection threshold, where the percentage is customizable
- A given facility is experiencing an upward trend in emissions, and at the current rate of increase, will exceed detection threshold in a certain number of days, calculated based on facility emissions information

Soft alerts allow an owner or operator to more quickly respond to a potential fugitive emissions leak prior to emissions reaching the Applicable Detection Threshold, allowing for further methane emissions reductions versus waiting for a threshold to be exceeded.

Regardless of whether the owner or operator is notified of potential fugitive emissions by exceedance of the Applicable Detection Threshold, or triggering a soft alert, the Canary SENSE™ dashboard provides data and information to help the owner or operator localize the most probable area of the source of emissions, expediting the investigative analysis process and emissions mitigation.

4.3 Data Storage and Recordkeeping

The data generated by the Canary X Methane Monitoring System hardware and software is maintained for a minimum of five years from data generation.

The mass emission rate data will be stored in two separate tables. The granular 15-minute emission rates will be stored in a time series database while the daily methane mass emission rates will be stored in a separate database table, maintaining the daily average rate for each individual facility, along with the 7-day averages for each survey period. This daily rate table will be immutable while the 15-minute emission rates are subject to recalculations if data backfills.

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.

The following records, listed in §60.5424b(b) will be maintained by the Canary X Methane Monitoring System, and available to the owner and operator at all times as requested:

- Date of each periodic screening during the reporting period and date that results of the periodic screening were received, as described in §60.5424b(b)(1)
- Results from each periodic screening during the reporting period, as described in §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, date that instrument inspections of all required covers and closed vent systems was completed, date visual inspection for emissions of all required covers and closed vent systems was conducted, as described in §60.5424b(b)(4)(i) through (iii), entered into the SENSE™ dashboard by the owner or operator
- For each fugitive emission from a fugitive emissions component affected facility and all defects of each cover and closed vent system, number and type of components for which fugitive emissions were detected, each emission or defect identified for each cover and closed vent system, date of each repair, and number and type of fugitive emission components and identification of cover and closed vent system placed on delay of repair, as described in §60.5424b(b)(4)(iv)(A) through (D)
- All continuous monitoring system downtime data, including start date of any exceedance of the 12-month rolling average, 10 percent downtime limit, or the highest value of the 12-month rolling average downtime value if it did not exceed 10 percent, as described in §60.5424b(d)(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, as described in §60.5398b(d)

4.4 Reporting

All relevant NSPS OOOOb data will be able to be exported in the format of the sample spreadsheet provided by the rule. This report can be generated at any time by the end user and included in the owner or operator's annual report for any given reporting period.

4.5 Client Interface and Documentation

4.5.1 Canary SENSE™ Platform

The Canary X Methane Monitoring System is a Software as a Service (SaaS) model, which provides customers with a robust, data-rich, dashboard giving users near real-time visibility of data on facilities where Canary X devices are deployed. Data and information that is available to users implementing the Canary X Methane Monitoring System for NSPS OOOOb and EG OOOOc compliance, includes but is not limited to the following:

- Aerial map of the selected facility showing the location of each Canary X device, and unit(s) equipped with a sonic anemometer
- Current and historic methane sensor concentration data, with ability to customize the time window for viewing and investigation
- Current and historic wind direction and wind speed, aligning with methane sensor data time scales for direct evaluation of concentrations and wind data as well as a wind rose for the selected time scale
- A list of recent alerts triggered and for which the owner or operator was notified
    - Operators have the ability to annotate their alerts and look at trends in their alerts
- Estimated equipment group methane flux rate
- Estimated facility level methane mass emission rate

The information available to the user not only supports the investigation of potential methane emissions events after a confirmed detection, but also provides leading information to evaluate methane emissions increases well before exceeding an Applicable Detection Threshold. The SENSE™ dashboard can be customized for each user to send "soft alerts" which are notifications that emissions may be trending upward, or facility level emissions have reached a certain percentage of the action level, as examples. Such data and information encourage and incentivizes early detection and mitigation to further reduce methane emissions more quickly than otherwise required by regulation. Canary X Methane Monitoring System alerting capabilities are further outlined in Section 4.2 above.

4.6 End User Data

Customers who subscribe to Project Canary's SaaS product to comply with the provisions of this Alternative Test Method under NSPS OOOOb or EG OOOOc, have access to all of the following data provided in the tables below, at a minimum. All sensor 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.

Both raw sensor and derived data streams are real-time and will display the data as it becomes available in the dashboard. Raw sensor data is generated every minute and can be queried on a sensor, facility, or company level. Raw sensor data queries display the following fields in Table 2.

Table 2: Raw Sensor Data Fields

RAW DATA FIELDS	DESCRIPTION
Site ID	Facility name or identifier
Timestamp	Data packet timestamp
Device ID	Unique sensor identifier
Device Latitude	Sensor latitude
Device Longitude	Sensor longitude
CH4 Concentration	CH4 concentration in ppm
Wind Speed	Wind speed in mph
Wind Direction	Wind direction
Internal Temperature	Internal device temperature in ^{o}F
Internal Humidity	Internal device humidity
Pressure	Internal device pressure in mb

The derived equipment-level quantification data and data associated with alerts from action level exceedances is outlined Table 3 and Table 4.

Table 3: Equipment-Level Quantification Data Fields

QUANTIFICATION DATA FIELD	DESCRIPTION
Equipment Group	Associated equipment grouping
Start Date	Quantification data packet timestamp, indicating the start of the 15-minute period
End Date	Quantification data packet timestamp, indicating the end of the 15-minute period
Total Equipment Group Emissions	Total quantified methane emissions, in kg, attributed to the associated equipment group

Table 4: Alerting Data Fields

ALERTING DATA FIELDS	DESCRIPTION
Site ID	Facility name or identifier
Start Date	Date that the alert period started
End Date	Date that the alert period ended
Duration	Duration of the alert period in minutes
Conditions	Minimum Detection Level Exceeded
Source Comments	Operator input field to annotate source details
Action Comments	Operator input field to annotate corrective actions
Alert Type	Always OOOOb for alerts under this ATM
Source Attribution	Associated equipment grouping
Equipment Group	Associated equipment grouping
Equipment Subgroup	Associated equipment grouping
Max Value	The maximum total facility methane emissions for the respective screening period