

# Survey Emission Detection and Quantification Final Report



Performer: Xplorobot  
Report Generated: October 11, 2023

# 1 Experiment Summary

Testing included a total of 36 experiments performed between 2023/09/24 23:59 and 2023/09/27 23:59. A total of 105 controlled releases were performed during these experiments. Individual experiments included between 1 and 6 controlled releases, with an average of 2.92 controlled releases per experiment. Figure 1 shows the distribution of number of controlled releases per experiment. Figure 2 shows the distribution of emission rate of controlled releases during experiments. Emission rates ranged from 0.0 and 2090.0 gCH<sub>4</sub>/h. Figure 3 summarizes the location of controlled releases by equipment unit.

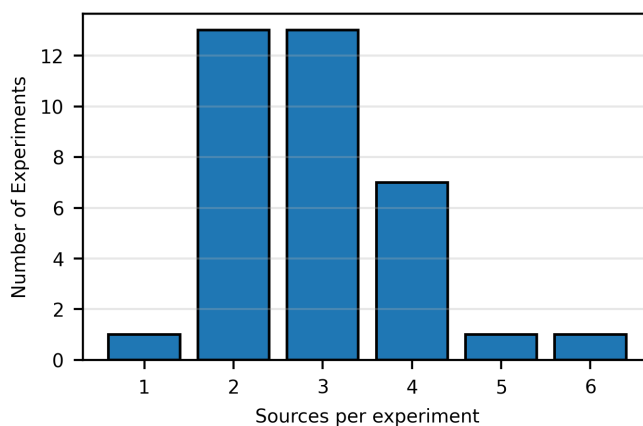


Figure 1: Histogram of number of controlled releases included in each experiment

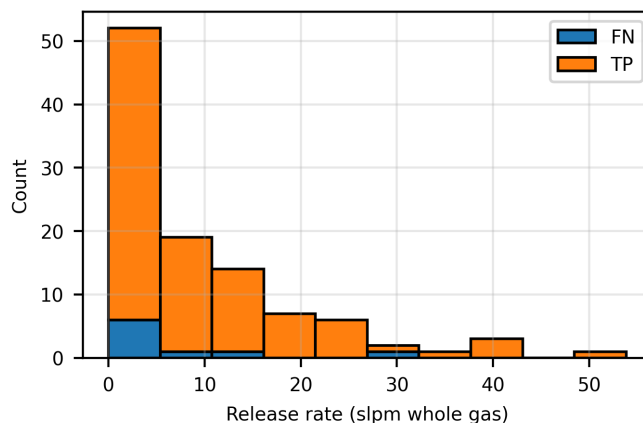


Figure 2: Histogram of metered emission rate (slpm whole gas) for all controlled releases performed during experiments

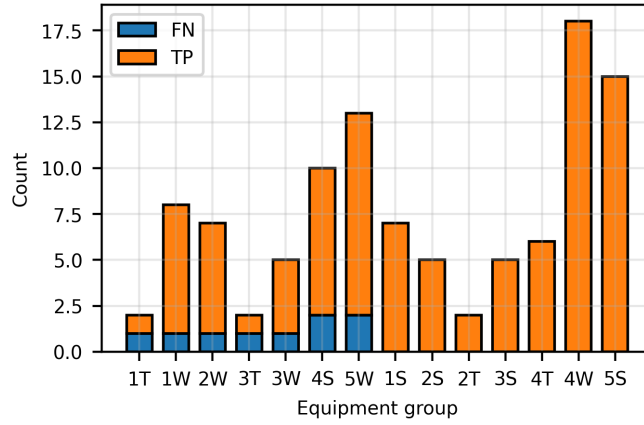


Figure 3: Distribution of controlled releases across equipment groups

Figure 4 shows the average ambient temperature during each experiment. Temperature ranged from 18.3 °C to 27.7 °C, with a mean of 24.2 °C.

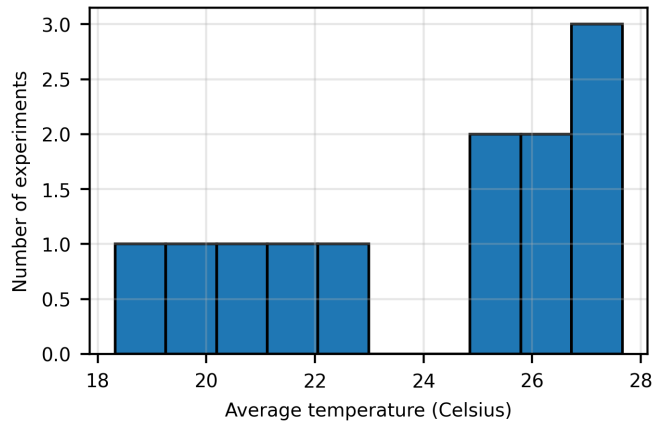


Figure 4: Histogram of average temperature (°C) during each experiment

Figure 5 shows the average wind speed of each experiment. Wind speed ranged from 1.27 m/s to 2.78 m/s, with a mean of 2.02 m/s.

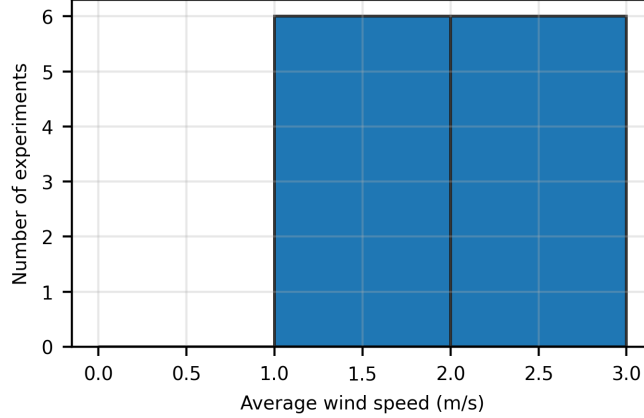


Figure 5: Histogram of average wind speed (m/s) during each experiment

## 2 Performance Metrics

Metrics as described in section 6 in the protocol are reported in this section. Primary metrics are reported for all performers. Secondary metrics are reported only if the performer detection reports included the required data for their calculation.

### 2.1 Classification of Detections

Xplorobot reported a total of 98 detection reports. Detection reports were matched to controlled releases following the method outlined in the test protocol to identify true positives, false positives, and false negatives. The classification of controlled releases and detections is shown in Table 1. The classification of individual detections and controlled releases can be found in the accompanying data files.

Table 1: Classification of controlled releases and detection reports.

Level	True Positive	False Negative	False Positive	Excluded from Analysis	Total
Controlled Releases	96	9	-	0	105
Detection Reports	96	-	2	0	98

### 2.2 Probability of Detection

The probability of detection (POD) curves derived from the classified detection and controlled release records are illustrated in figures 6 through 10. Figures 6 and 7 shows the POD calculated using a variable width bin. In this approach the number of data points within each bin, and therefore the statistical significance of each bin, is approximately equal.

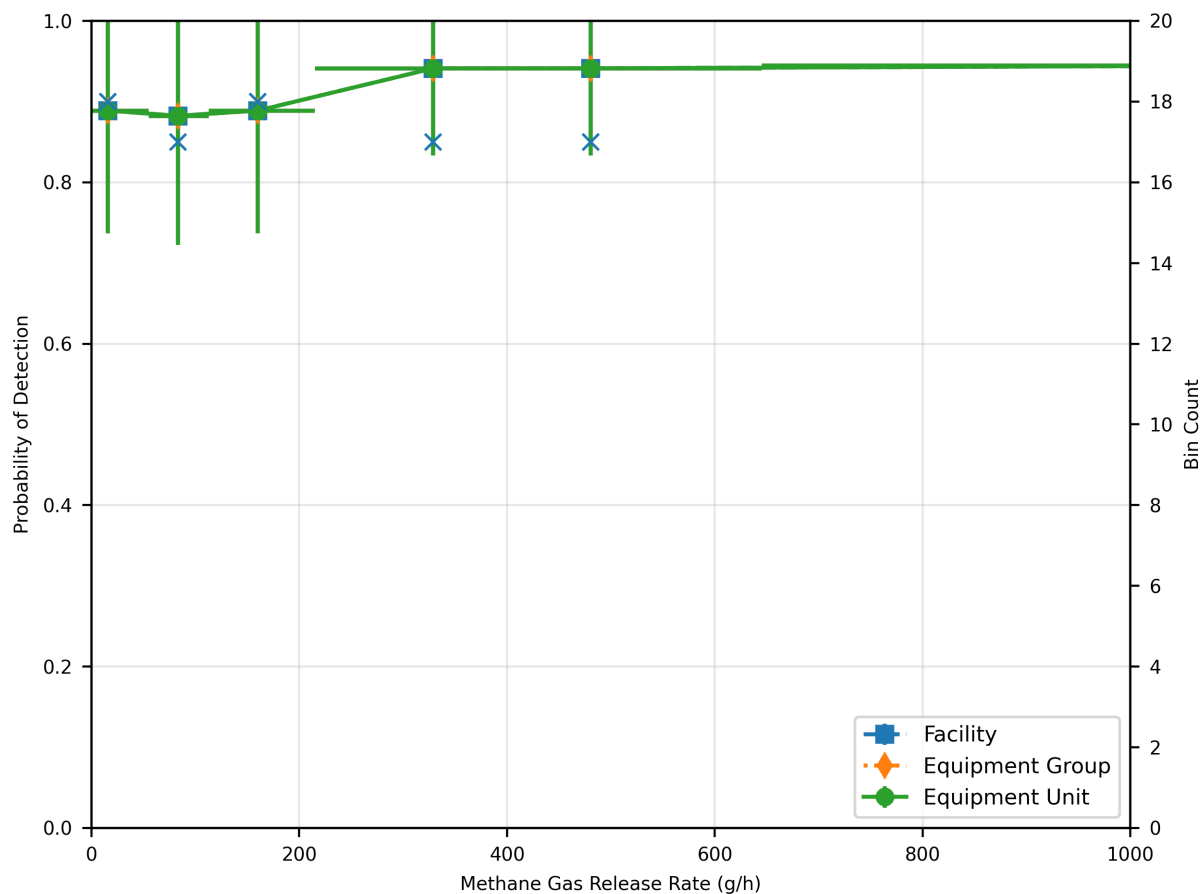


Figure 6: Probability of detection vs emission rate ( $\text{g CH}_4/\text{hr}$ ) with even data count per bin. POD includes all true positives at equipment unit, equipment group, and facility levels. Markers represent mean emission rate and observed POD. X whiskers indicate maximum and minimum emission rate in bin. Y whiskers indicate maximum and minimum POD when empirical data is bootstrapped. Number of data points within each bin is plotted on right hand axis.

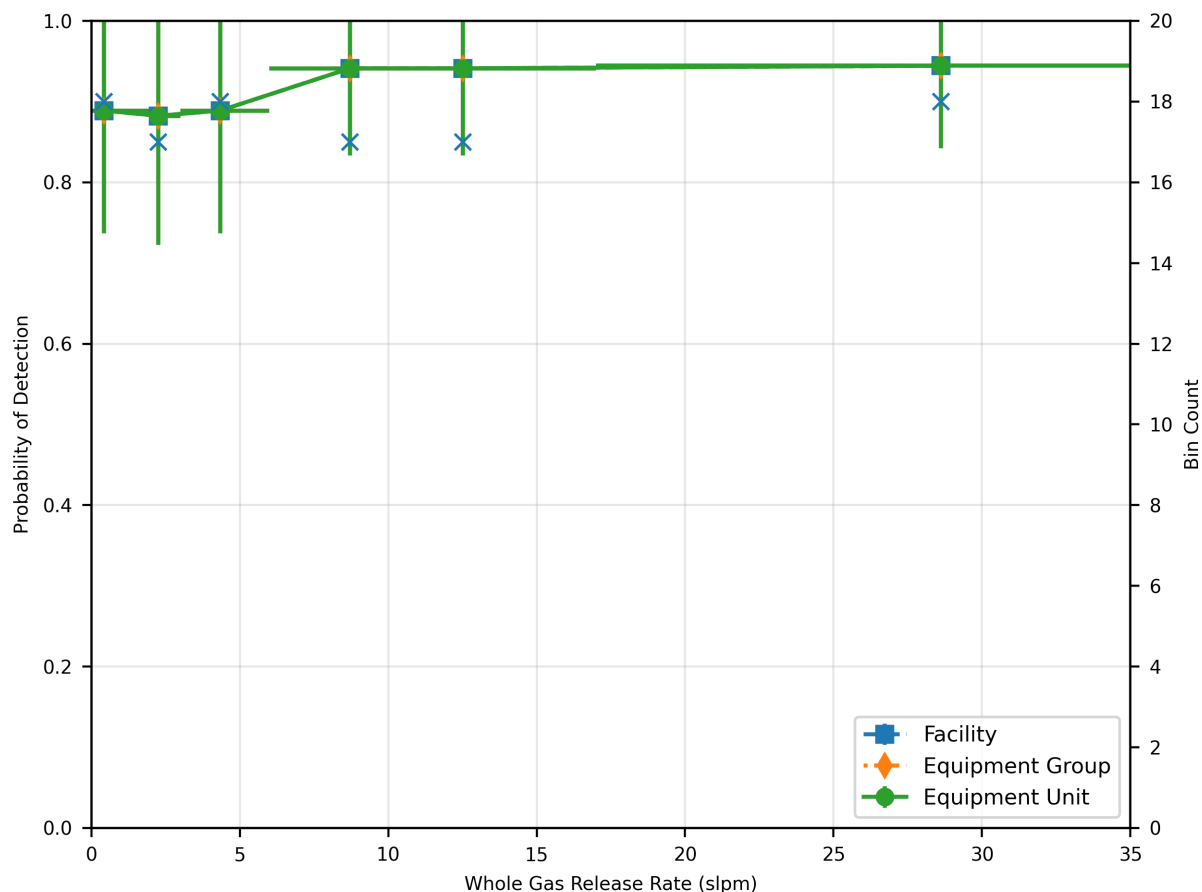


Figure 7: Probability of detection vs emission rate (slpm whole gas) with even data count per bin. POD includes all true positives at equipment unit, equipment group, and facility levels. Markers represent mean emission rate and observed POD. X whiskers indicate maximum and minimum emission rate in bin. Y whiskers indicate maximum and minimum POD when empirical data is bootstrapped. Number of data points within each bin is plotted on right hand axis.

Figures 8 and 9 shows the POD calculated using a fixed bin width. In this approach the number of data points within each bin, and therefore the statistical significance of each bin, varies according to the distribution of controlled releases included during the testing. Beware using this form of the curve, as the statistical significance of some bins may be very low.

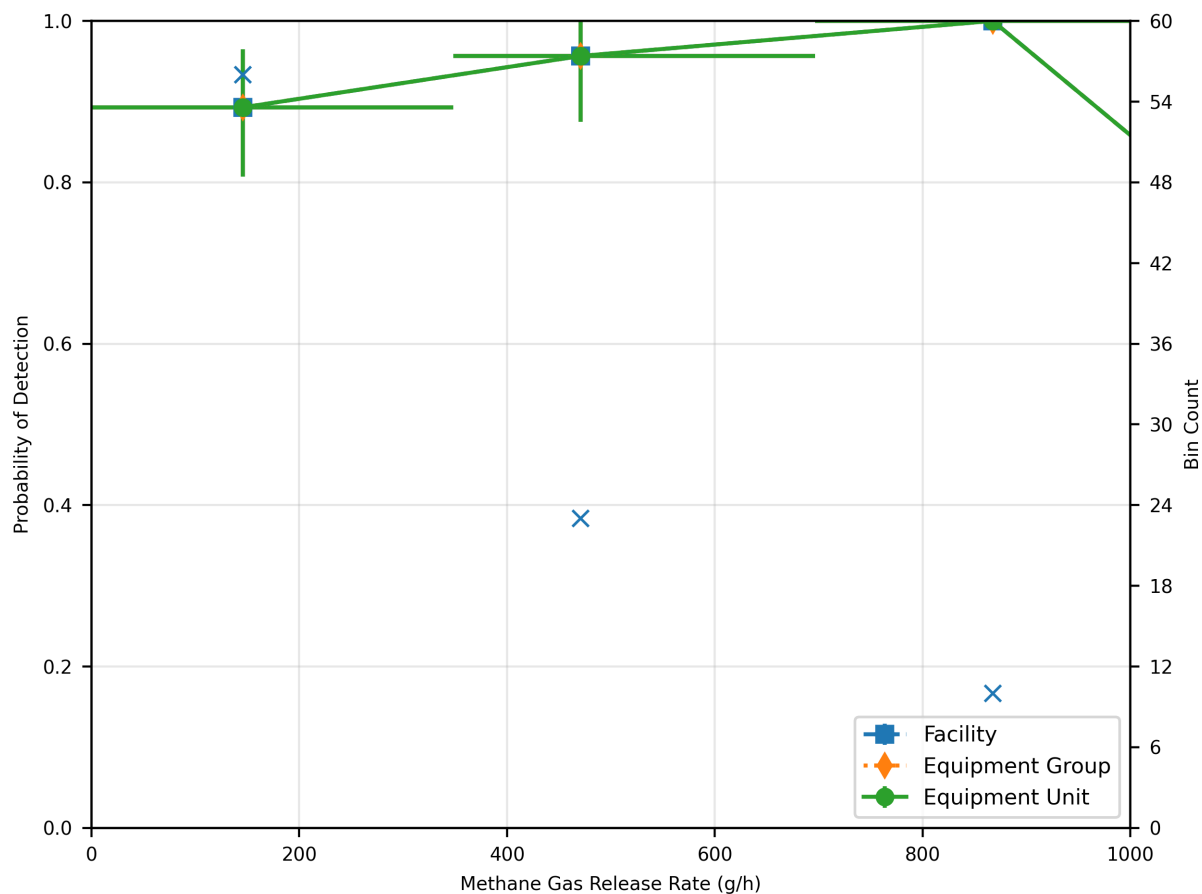


Figure 8: Probability of detection vs emission rate ( $\text{g CH}_4/\text{hr}$ ) with even bin widths. POD includes all true positives at equipment unit, equipment group, and facility levels. Markers represent mean emission rate and observed POD. X whiskers indicate maximum and minimum emission rate in bin. Y whiskers indicate maximum and minimum POD when empirical data is bootstrapped. Number of data points within each bin is plotted on right hand axis.

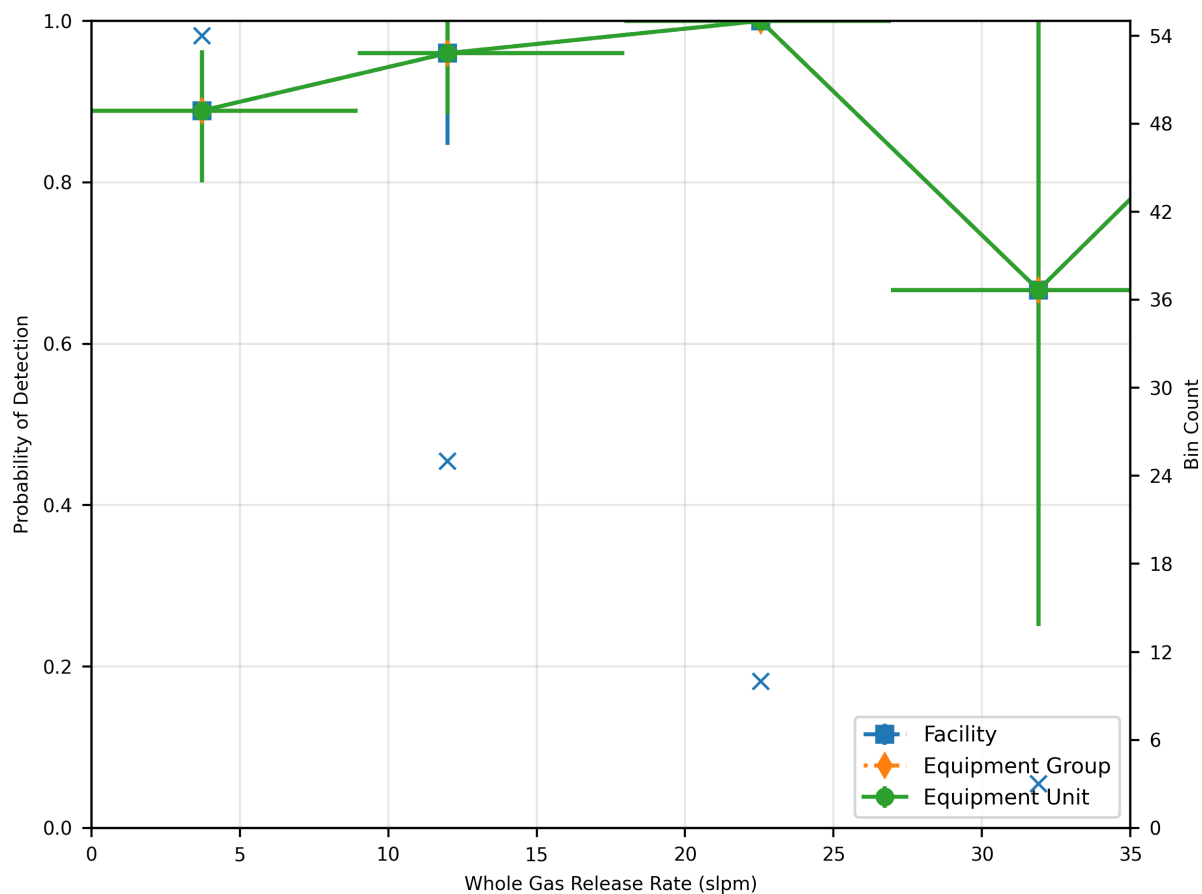


Figure 9: Probability of detection vs emission rate (slpm whole gas) with even bin widths. POD includes all true positives at equipment unit, equipment group, and facility levels. Markers represent mean emission rate and observed POD. X whiskers indicate maximum and minimum emission rate in bin. Y whiskers indicate maximum and minimum POD when empirical data is bootstrapped. Number of data points within each bin is plotted on right hand axis.

Figures 10 shows a logistic regression performed against the true positive and false negative results.

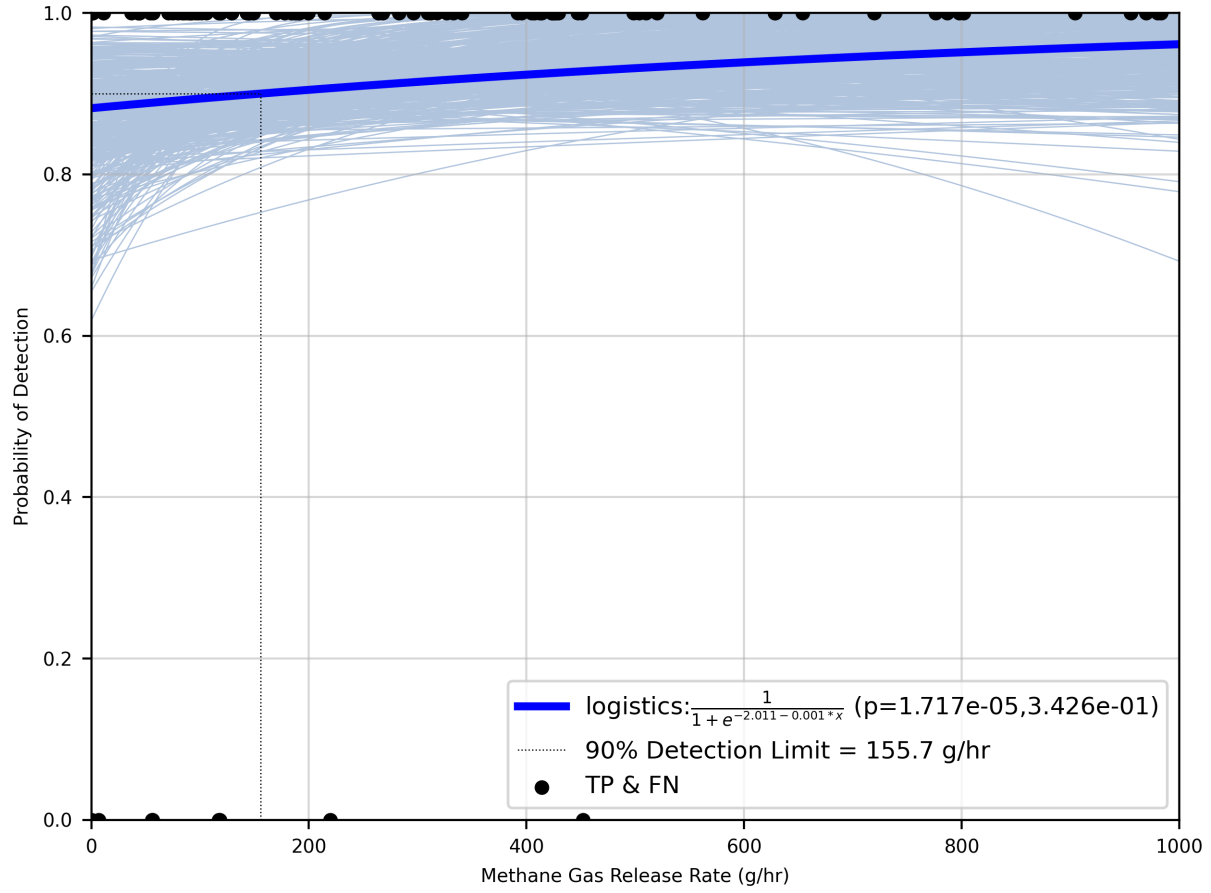


Figure 10: Probability of detection versus emission rate. The probability of detection vs emission rate (g CH<sub>4</sub>/h) assessed with logistic regression including all true positives (equipment unit-, equipment group-, and facility-levels). True positive and false negative detections are shown with markers at  $y = 1$  and  $y = 0$  respectively. The regression is performed on bootstrapped results to show a cloud of curves to illustrate uncertainty in the result.

### 2.3 False Positive Fraction

The false positive fraction ( $N_{FP}/(N_{FP} + N_{TP})$ ) derived from all detections was 0.0204.

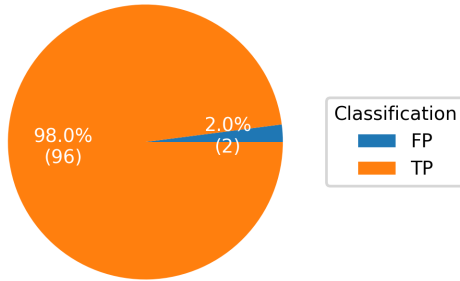


Figure 11: Classification of performer detection alerts. True Positive (TP) alerts were paired with a controlled release at the test center. False Positive (FP) alerts were unpaired.

## 2.4 False Negative Fraction

The false negative fraction ( $N_{FN}/(N_{FN} + N_{TP})$ ) derived from all controlled releases was 0.0857.

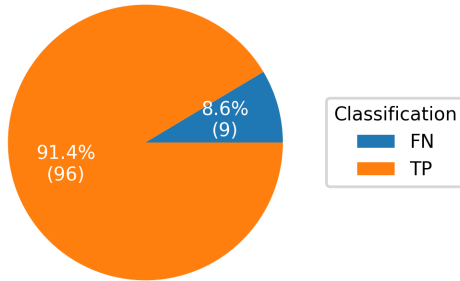


Figure 12: Classification of controlled releases. True Positive (TP) releases were paired with a detection reported by the performer. False Negative (FN) releases were unpaired.

## 2.5 Survey Time

The survey time of individual detections is illustrated in figure 13. The average time on each equipment group normalized by the count of equipment units is shown in figure 14. The minimum survey time was 13.0 minutes. The maximum survey time was 41.0 minutes. The mean survey time was 26.489795918367346 minutes.

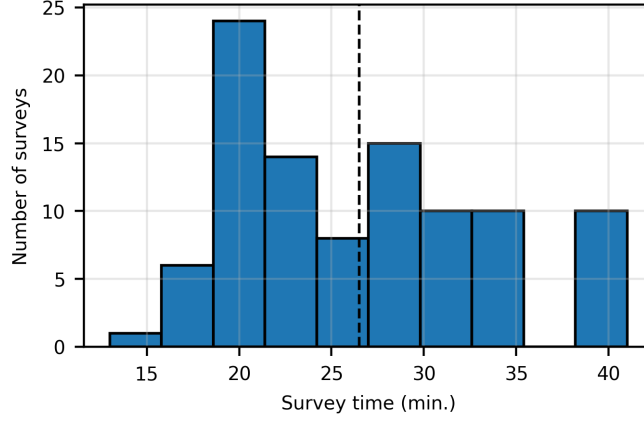


Figure 13: Histogram of survey time per experiment.

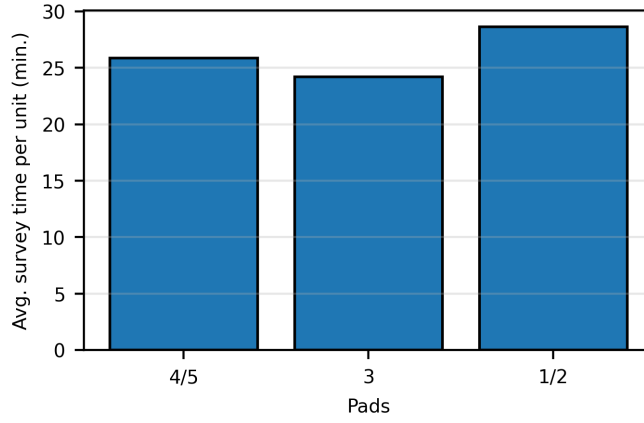


Figure 14: Average survey time per equipment unit by facility.

## 2.6 Localization Precision (Equipment Unit)

Table 2 lists the number of true positives at the equipment unit, equipment group, and facility-level.

Table 2: Localization Precision (Equipment Unit)

Level	True Positive Count
Equipment Unit	96
Equipment Group	0
Facility	0

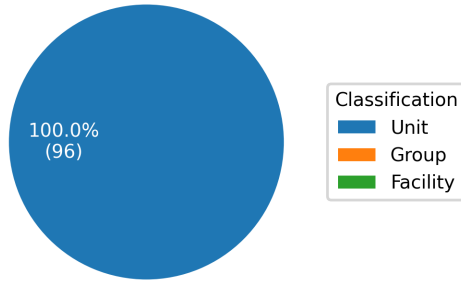


Figure 15: Categorizing True Positive detections by localization precision levels. The localization precision levels include the Equipment unit level, Equipment group level, and the Facility level.

## 2.7 Localization Accuracy (Equipment Unit)

Table 3 lists the localization accuracy (the fraction of reports identified as true positive) at the equipment unit, equipment group, and facility-level . The fraction of reports identified as false positive is also included in the table.

Table 3: Localization Accuracy (Equipment Unit)

Level	Localization Accuracy
Equipment Unit	0.98
Equipment Group	0.98
Facility	0.98
False Positive Fraction	0.0204

## 2.8 Quantification Accuracy (Absolute)

Xplorobot did not report data required to compute this metric.

## 2.9 Quantification Accuracy (Relative)

Xplorobot did not report data required to compute this metric.

## 2.10 Quantification Precision (Absolute)

Xplorobot did not report data required to compute this metric.

## 2.11 Quantification Precision (Relative)

Xplorobot did not report data required to compute this metric.

## 2.12 Localization Accuracy (Single Coordinate)

Xplorobot did not report data required to compute this metric.

## 2.13 Localization Accuracy (Bounding Box)

Xplorobot did not report data required to compute this metric.

## 2.14 Bounding Box Accuracy

Xplorobot did not report data required to compute this metric.

## 2.15 Localization Precision (Bounding Box)

Xplorobot did not report data required to compute this metric.

# 3 Documentation of Test Protocol

A copy of the test protocol is provided in Survey Protocol R0.0.pdf in the zip folder with this report.

# 4 Documentation of System Under Test

Table 4 lists the documentation from Xplorobot while survey testing. Data left empty was reported as N/A.

Table 4: Performer Information

Field	Data
(1) Please provide a detailed description of system configuration and primary components including the sensor and deployment platform. Additionally, the location (latitude, longitude, height) of auxiliary components such as meteorological station or any other equipment installed at or near the Test Center must be recorded.	nan
(2) Please record the model number of each primary component in (1)	nan
(3) Please record the software revision installed on the components in (1), including performer-specific software components, revisions, or customizations	nan
(4) Please record the revision number of any software analytics installed offsite. For example software to convert concentration maps to mass emission quantification estimates during the experiments.	nan
(5) Please provide a detailed description of the methodology used during emission detection/quantification surveys.	nan
(6) Please provide the confidence level at which emission detection data are reported.	nan
(7) Please record the number of personnel participating in the surveys and their roles. Any remote personnel participating in the survey in any fashion should be documented as part of the survey team in this section. Names of individual personnel are not required.	nan

# 5 Controlled Release and Detection Data

Controlled release and classification data are provided in classifiedReports.csv in the zip folder with this report. The raw data reported by the performer is provided in rawPerformerData.xlsx in the zip folder with this report.

## **6 Flow Meter Calibrations**

Meter calibrations are available from the test center by request.