Methane Emissions from Gathering and Boosting Compressor Stations in the U.S.
Supporting Volume 1:
Multi-Day Measurements of Pneumatic Controller Emissions

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S1-1 Host Study

This study was part of a larger study (the Gathering Emission Factor, or "GEF") study [1] to develop activity and methane emission factors for EPA's Greenhouse Gas Inventory (EPA GHGI) using direct emission measurements at the device level on all classes of equipment found on gathering compressor stations. To accomplish this, Colorado State University (CSU) partnered with the engineering firm AECOM to assist with planning, logistics, field work and analysis. Nine midstream natural gas companies – Anadarko Petroleum, Equinor, DCP Midstream, Kinder Morgan, MarkWest Energy Partners, Pioneer Natural Resources, Southwestern Energy, Williams Companies Inc., and XTO Energy Inc. – acted as partners in the study, provided site access for measurements, and provided representatives to advisory committees. At all times, and with the encouragement of industry partners, CSU maintained control the sampling plan, analysis and reporting. This study documents one part of the larger study - emissions from pneumatic actuated valve controllers (PC).

S1-2 Site & Device Selection

The following sections outline how stations and specific devices were selected for measurement.

S1-2.1 Preliminary Site Selection

Initial sampling for this study was part of the GEF study national field campaign. The GEF study developed a nationally representative sample of sites from partner company assets using a randomized, clustered sampling strategy, as outlined in the main report (Section 3.1). First, basins were selected to be representative of a national sample, with two constraints: (1) at least 2 partner companies had operating gathering station assets in the basin (to provide anonymity for the study partners), and (2) at least one basin was selected for each production type (wet/dry gas). Basins were arranged in order to minimize travel time for the team using a mobile measurement unit.

After basin selection, measurement weeks were allocated to each basin. For each week, one company was selected to host measurements, except for two weeks where basin size and station count necessitated measurements on two companies' assets during one week. Once the company-weeks were confirmed, site selection proceeded as described below. Each company was assigned at least two weeks of measurement, and two companies hosted three full weeks each. In all, after data validation and quality assurance, 44 devices at eight stations were measured over eight weeks between June and November 2017.

S1-2.2 Secondary Site Selection

In order to increase measurement counts and sample diversity, partner companies agreed to support and participate in additional pneumatic controller measurements after the conclusion of the initial field campaign (June- November 2017). A sample of pneumatic controllers were measured at eleven additional gathering stations in four basins. To select these stations, the following aspects were considered:

1. The study team identified basins where meters *were not* installed during the field campaign.
2. An effort was made to place meters with partners who had not previously hosted meters. Ultimately, all but one partner hosted measurements; that partner had converted all stations to operate PCs on instrument air.

3. The partner had field staff capable of assisting with the installation and moving measurement systems between sites without CSU personnel present.

These additional samples were selected by guided, not random, selection. The following process was utilized for each of these additional stations selected for measurement:

1. The meters were shipped, or were transported by CSU personnel, to the basin.
2. An operator for the partner and CSU personnel selected PCs on the first station and installed the meters. During this installation, the CSU personnel trained the operator on how use the measurement system.
3. CSU and operator travelled to other stations in the basin and identified PCs to measure. Partners agreed to not change the PC operation in any way between selection and measurement.
4. After approximately three days of installation at the first station, the partner operator, acting without CSU involvement:
   (a) De-installed the measurement system.
   (b) Uploaded data to CSU
   (c) Recharged the measurement system battery (typically overnight).
   (d) Moved the six measurement systems to the next station selected for measurement.
   (e) Installed and verified installation.
5. Depending upon the basin and number of stations selected for measurement, the partner operator may have repeated this process more than once.

The locations of all field measurements are shown in Figure S1-1

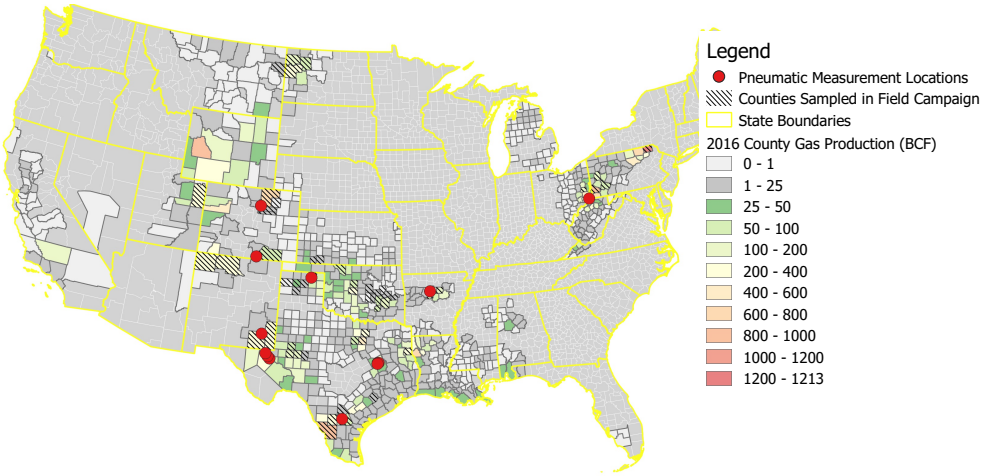

Figure S1-1: Basin locations of pneumatic controller measurements during the field campaign.

To identify the installation method in the data, the following code is used for each measurement:

- "Class I" – measurement system was installed and de-installed during the GEF field campaign by a partner operator working directly with on site CSU personnel. CSU personnel uploaded data, recharged the measurement system and transported the measurement system to the next station to be measured.
- "Class II" – measurement system was installed after the GEF field campaign by a partner operator working directly with on site CSU personnel. The measurement system was de-installed, and data was uploaded, by a partner operator without on site CSU involvement.
- "Class III" – measurement system was installed and de-installed after the GEF field campaign by a partner operator without on site CSU personnel present.

S1-3 Measurement Protocol

S1-3.1 Measurement Strategy

Prior studies [2, 3, 4, 5, 6] have relied on short duration measurements of PCs. To better understand longer-term temporal variation in PC emissions, this study aimed to perform long-duration measurements of PCs, with minimal disturbance to station operations.

Measurement durations of more than 24 hours were expected to capture common variations in emissions behavior, and the study team, in cooperation with partners, settled on the following objectives for the measurement system:

1. Measurement duration capability of more than three days (72 hours). Given the overall sampling plan for the study, this requirement practically constrained measurements to one installation per week during the field campaign.
2. Design the measurement system to allow unattended operation.
3. Since many gathering stations have not electricity service, measurement system must be independently powered.

S1-3.2 Data Collection

Six Sierra 780i thermal mass flow meters (TMFMs) were used in this study. The meters were calibrated on ambient air at a pressure of 51 psia. This measurement system was powered by an external battery pack that provided adequate power for 3-4 days of continuous emissions monitoring. Each meter was fitted with a custom datalogger mounted on the meters electronics inside their explosion proof housing to record flow, temperature and pressure data for the duration of deployment. A real time clock was integrated with the data logger so each recorded data point written to the SD card was time and date stamped.

Meta-data was collected on each PC measured during this study, in addition to data pertaining to the operation of the site where the the PC was located. Collected meta-data included: PC make and model, the major equipment type where the PC was operating (compressor, glycol dehydrator, separator, or yard piping), the operation of the PC's valve (throttling or snap acting), the vent behavior of the controller (intermittent vent, high bleed or low bleed) and the PC's control variable (liquid level, pressure or temperature). Each PC's vent behavior and the operation of the PC's end device was recorded as it was reported by the site operator or escort.

S1-3.3 Meter Installation

Each station visit began with a site safety briefing and a hands on introduction to the measurement system with station operators. After the site safety briefing, operations staff performed a walk through of the site with the CSU measurement team to identify PCs for measurement. If operations staff decided there were no acceptable options for isolating devices of a certain process and installing the meters on supply gas lines, the meters were connected via threaded exhaust ports. When devices were identified for measurement, the measurement team and operations staff coordinated on the meter installation. If a meter was installed on a PC supply gas line (Figure S1-2), the protocol was as follows.

- Measurement team connected flow meter to independent power supply and configured data collection. Location of independent power supply was be determined by site operator to minimize footprint and impact of measurement device at each location.
- Site operator or technician isolated valve/controller
- Site operator or technician parted supply line and installed and secured meter
- Measurement team turned on the device and begin data collection
- If possible, site operator manually actuated device and measurement team ensured meter was operating correctly and data was being recorded
- Site operator performed final safety assessment and leak check of installed meters and independent power supply boxes
- Measurement team performed leak scan of entire pressurized control loop with FLIR camera to ensure the installation did not result in leaks in the control loop.

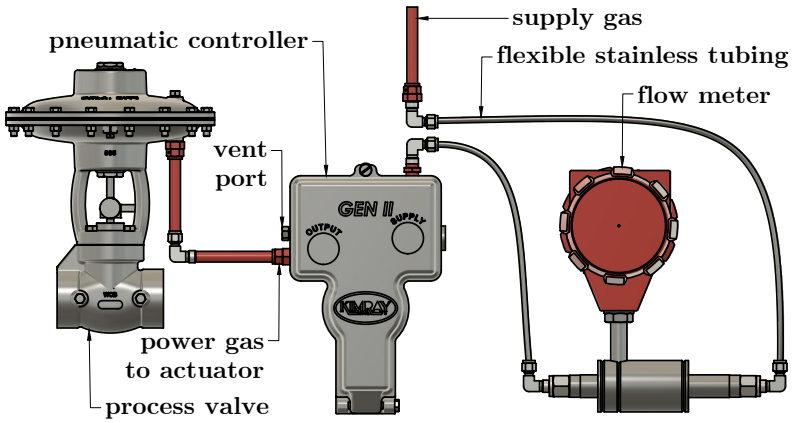

Figure S1-2: Configuration of a thermal mass flow meter used to measure PC emissions on the supply gas lines to the PC. Meters inserted in-line with supply gas lines as shown capture all emissions in the control loop occurring at or downstream of the meter.

If the meter being installed on an PC exhaust port (Figure S1-3), the protocol is as follows.

- Measurement team connected flow meter to independent power supply and configure data collection. Location of independent power supply was determined by site operator to minimize footprint and impact of measurement device at each location.

- Site operator or technician connected flow meter inlet to controller exhaust port
- Measurement team turned on the device and began data collection
- If possible, site operator manually actuated device and measurement team ensured meter was operating correctly and data was being recorded
- Site operator will perform final safety assessment and leak check of installed meters and independent power supply boxes.

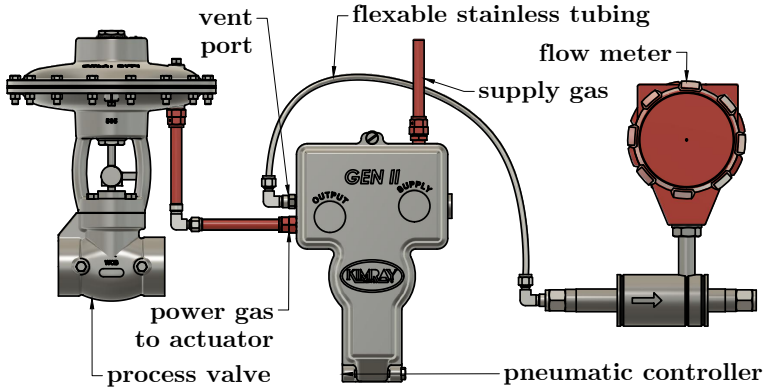

Figure S1-3: Configuration of a thermal mass flow meter used to measure PC emissions at a PC's exhaust port. Most PCs have a dedicated, threaded exhaust port that can be used to route exhaust gases out of buildings or away from ignition sources. Meters connected to PC exhaust ports only capture emissions venting from the port.

After installation the measurement systems were left in place unattended for a minimum of three days. The CSU measurement team would return to retrieve the meters after four to five days, which typically exceeded the battery life of the measurement system and maximized the amount of data collected.

To anonymize data sets, a randomly generated letter was assigned to each station where pneumatic controller emissions were measured. The number of the flow meter that was used to measure each PC (meter 1-6) was used to identify specific PCs on each site. For example, dataset G-6 refers to measurements made at station "G" using flow meter #6.

S1-4 Data Preparation

S1-4.1 Gas Composition Corrections

The TMFMs used in this study were calibrated using ambient air, so flow measurements were corrected to account for specific gas compositions at each station. Fuel gas compositions were provided for each station where PC measurements were made. Film coefficient correction factors were generated using software provided by meter the manufacturer (user interface shown in Figure S1-4). This software computes a correction coefficient between a reference gas (air) and a known gas composition based on the density, thermal conductivity, heat capacity, and viscosity of the known gas composition at a given temperature and pressure. The average supply gas temperature and pressure readings for each recording were used to generate these correction factors. Raw data

was scaled by factors between 0.775 and 0.81 to correct for station specific gas compositions. The error introduced by performing these gas composition corrections are included in validation tests performed on the measurement system to estimate absolute meter error (discussed in Section S1-4.5).

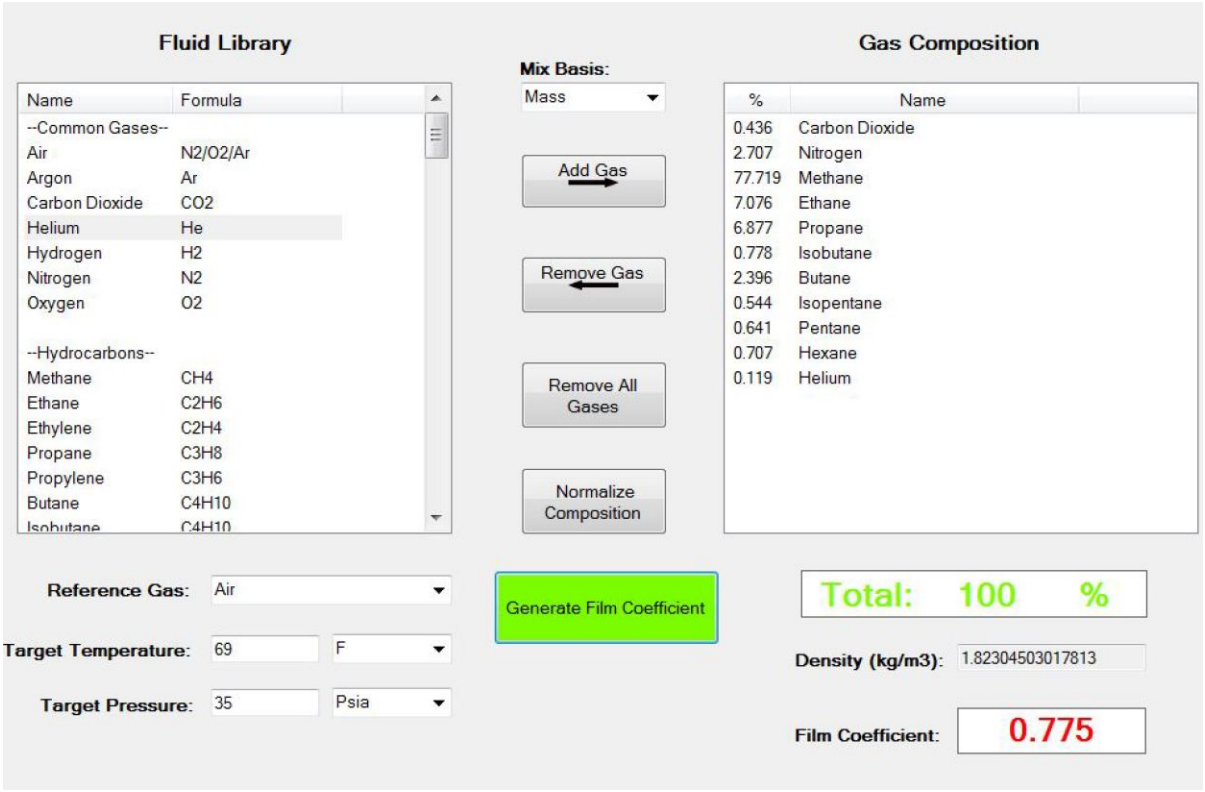

Figure S1-4: User interface for software provided by Sierra instruments to calculate correction factors for flow meter readings between flow meter calibration gas (air) and site specific natural gas compositions. Gas composition shown is from site N.

S1-4.2 Non-Zero Flow Readings

The TMFMs that were utilized for the study exhibit a behavior where they indicate a non-zero flow through the meter when the meter is pressurized and no flow is occurring. In lab tests, the magnitude of this non-zero value increased at higher supply gas pressure and decreased at lower supply gas values, eventually falling to zero below a supply pressure of 30-35 psia. This suggested measurements made on the supply gas lines of PCs at pressures above this threshold value were prone to showing a non-zero baseline. Emissions data collected by meters connected to controller exhaust ports were not prone to this error because measurements were made at atmospheric pressure, below this pressure threshold. Henceforth this error is referred to as *NZ flow*: "NZ" indicates times when no gas is flowing through the meter, but the meter indicates non-zero flow.

S1-4.2.1 Pressure to NZ Correlation

Lab tests were performed to analyze the NZ behavior and develop a correction factor to apply to data impacted by this error. The meters were connected to a pressure regulated supply of natural gas at the *Methane Emissions Technology Evaluation Center* (METEC) and tested at a range of pressures. Meters were connected in parallel and lines through the meters were purged. The pressure in the lines was then increased between 13 and 70 psia with the meter outlets closed. After each successive increase in gas pressure, the meter reading was allowed to stabilize and meter parameters were recorded for a period of several minutes. An example of one of these pressure tests

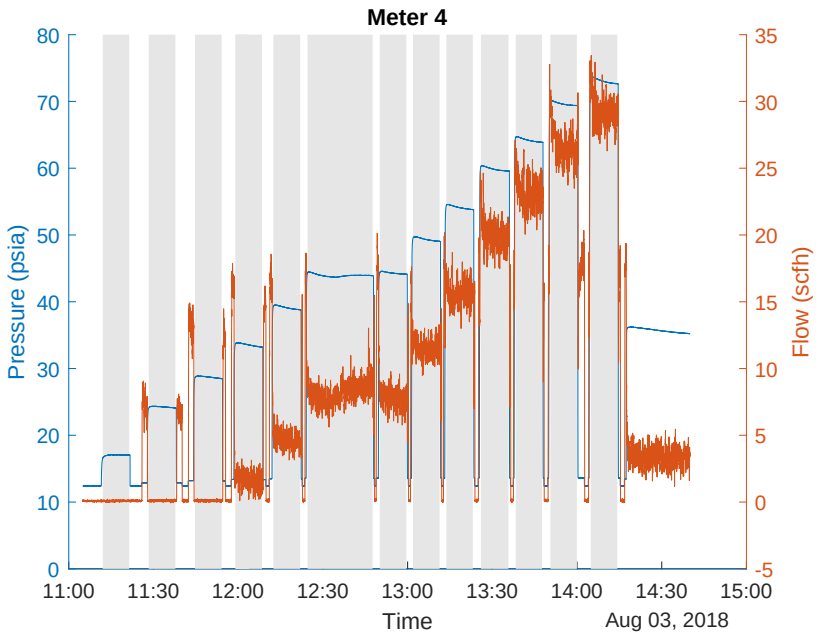

Figure S1-5: Example data recording for flow meter testing and characterization of NZ meter error as a function of operating pressure. Gray shading indicates times when indicated flow had stabilized sufficiently to be utilized for evaluating the indicated flow rates.

is shown in Figure S1-5. All indicated flow measurements are attributed to the NZ effect.

The mean and standard deviation of the indicated flow was extracted for each stable period and a linear or parabolic trend with pressure was fit to the resulting data. Periods with high variability, as represented by standard deviation, were eliminated from the fit. Figure S1-6 provides an example for a meter with a linear fit, while Figure S1-7 illustrates the one meter (meter 6) that utilized a parabolic fit.

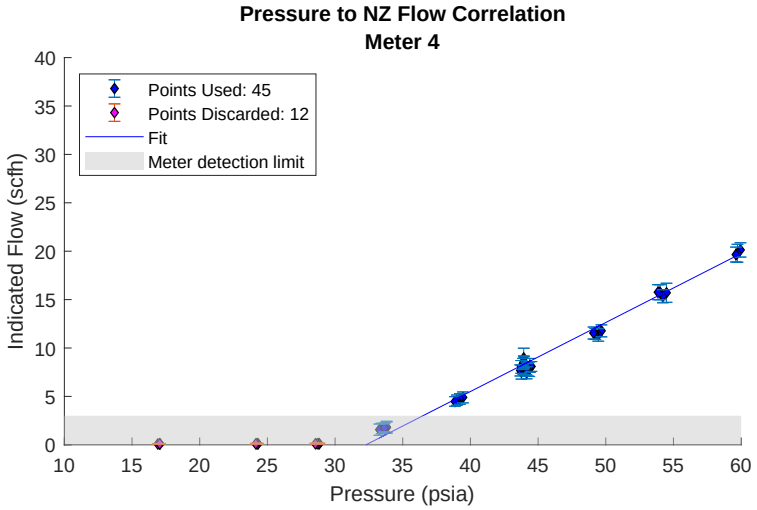

Figure S1-6: Example of a linear fit correlating NZ flow meter readings to operating pressure during measurement. Linear fits were applied to flow meters 1-5.

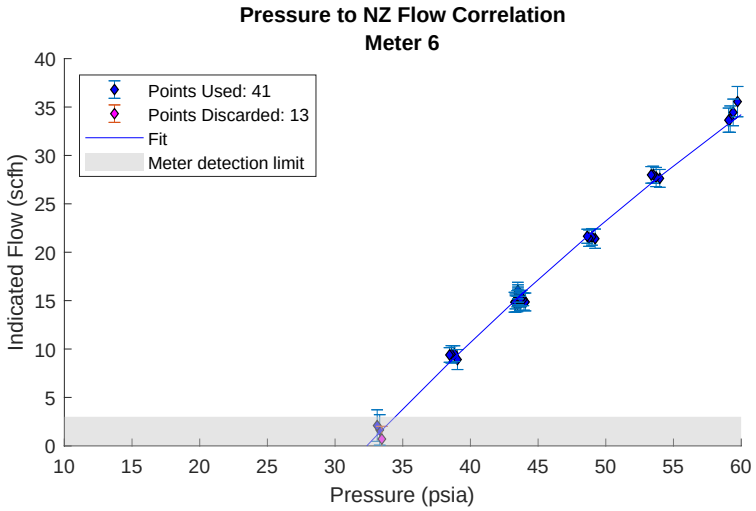

Figure S1-7: Example of parabolic fit correlating NZ flow meter readings to operating pressure during measurement. A parabolic fit was only applied to meter 6.

The gray shaded area in figure indicates the manufacturer's stated detection limit of the meter during normal (i.e. non-zero) flow conditions, based on the meter's 100:1 turn-down ratio and calibrated flow range. The rise of the correlated points above the grey shaded area indicates pressures at which the meter can exhibit non-zero readings. For example, when there is no gas flow, meter 4 begins to indicate a false NZ reading at pressures above ≈35 psia. When supply gas pressures reach 50 psia, any recorded flow at or below ≈10 scfh (whole gas) could represent a false NZ reading.

The resulting fits for all meters are shown in Figure S1-8. These pressure-NZ correlations are used to determine points in each data set where recorded flow rates could have been due to NZ meter error (based on supply gas pressure) and are ultimately applied to set false NZ readings to zero.

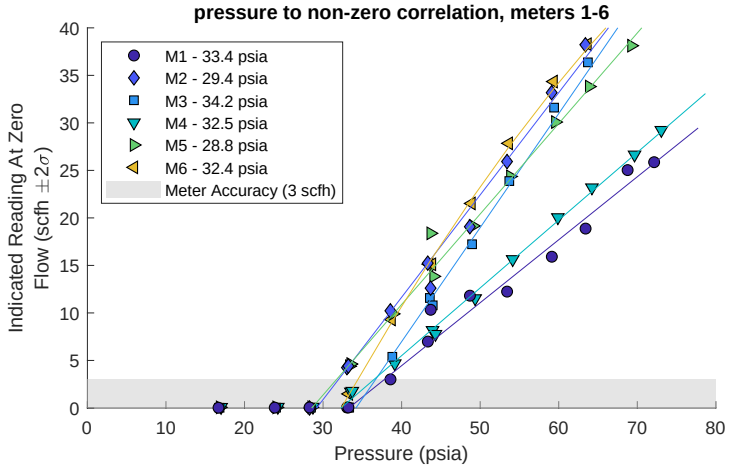

Figure S1-8: Correction curves for all flow meters correlating NZ flow meter readings to operating pressure during measurement. The pressure at which NZ behavior starts is indicated in the legend for each meter.

S1-4.2.2 Long Duration Tests

Two additional long duration tests were performed at CSU's METEC facility [7] to evaluate the stability of the NZ flow baseline over multiple days and quantify uncertainty in the correlations developed in Section S1-4.2.1. For each of these tests, meters were connected in parallel to a regulated, high pressure tank of natural gas. Outlets of all meters were capped and checked for leaks. The meters were then pressurized with natural gas and left to record indicated flow (i.e. the NZ baseline), gas temperature and pressure data over a 3 day period. Testing was performed outside to provide diurnal variation in ambient temperatures the meters similar to what was experienced in the field. The motivation behind these tests was to determine the degree to which the NZ baseline would drift over a multi day test period.

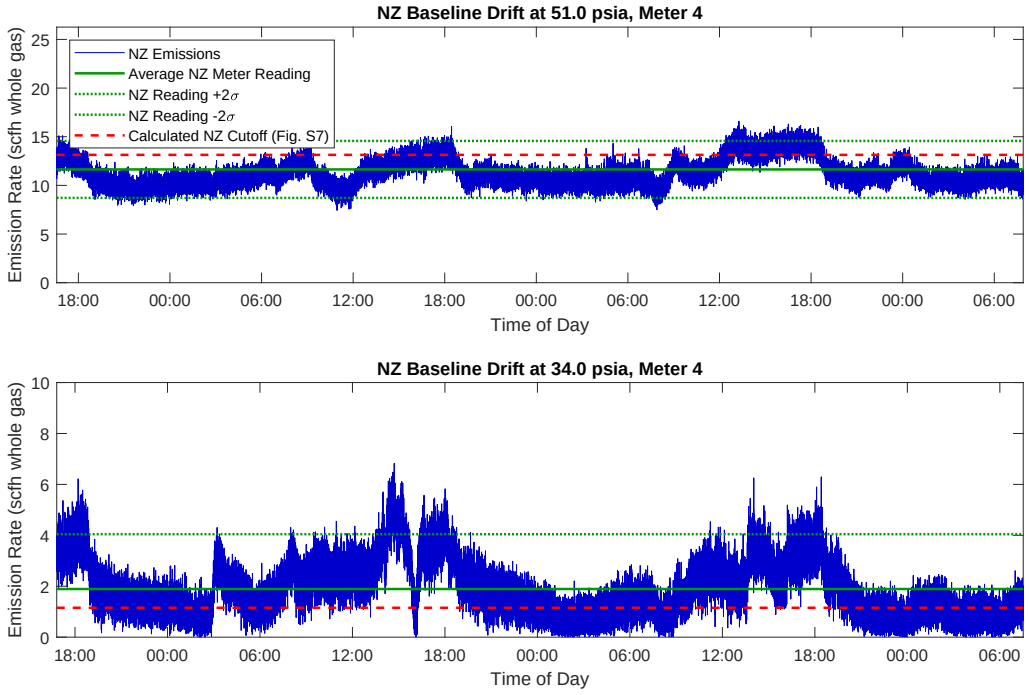

Figure S1-9: Drift of NZ baseline over 2.5 day tests. These tests were performed on each meter at two pressures: Once at the pressure where the NZ effect was present in all meters (34 psia) and once at the maximum pressure recorded in the field (54 psia). The standard deviations ($\pm 2\sigma$) plotted in Figures S1-8, S1-10 and S1-7 and used to zero NZ flow rates (Figures S1-11 and S1-12) are based on a linear fit between the standard deviations of meter readings from the long duration tests at 34 and 50 psia.

The average baseline meter reading was observed to deviate from the value calculated using the correction correlations from Figure S1-8 which demonstrates the level of uncertainty associated with differentiating between actual flow and meter error. Although visual inspection of the drift in the NZ baseline suggests that the value varies with gas temperature, no reliable or repeatable temperature correlation could be identified. Since the meter's response to changes in gas composition, pressure and temperature is non-linear and dependent on proprietary algorithms and heat transfer correlations programmed into the meter's micro-controllers, this likely made a simple correlation impossible.

To account for the variability in the meter's NZ reading, the standard deviation of NZ data from the low and high pressure long duration tests were used to assign the NZ cutoff value for each data

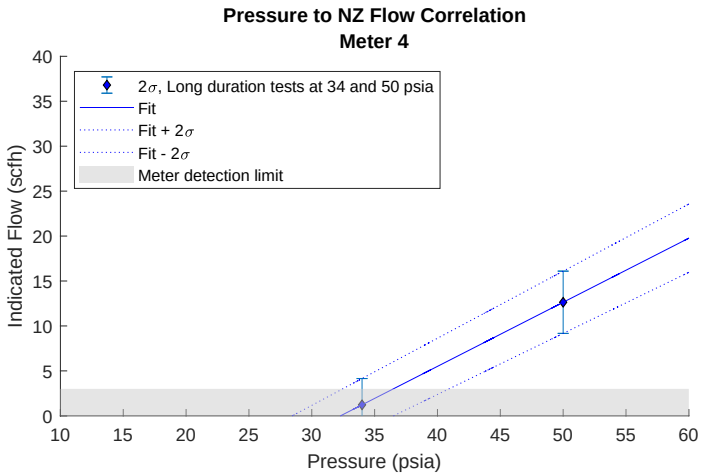

Figure S1-10: Example of a linear fit correlating NZ flow meter readings to operating pressure, with standard deviations from long duration tests (Figure S1-9)

set. In Figure S1-10, the solid line shows the fit from Figure S1-8, the error bars show two standard deviations from the low and high pressure tests plotted in Figure S1-9. Henceforth, all references to standard deviations used in NZ corrections refer to those calculated from long duration tests. The dashed lines are the fit between the error bars at 34 and 50 psia, which represent the uncertainty in identifying a NZ baseline for a given pressure.

The uncertainty limits identified by this process impact the evaluation of emissions data effected by the NZ meter error. In Figure S1-11, the PC being measured has an NZ cutoff of 17.1 scfh, calculated using its supply gas pressure of 46.6 psia and the curves in Figure S1-8. Based on the results of the long duration tests that show disagreement between calculated NZ cutoffs values and actual NZ readings (Figure S1-9), and the fact that >80% of the flow readings fall within $\pm 2\sigma$ of the NZ cutoff, it is very likely that all of the meter recordings for this test were a product of the

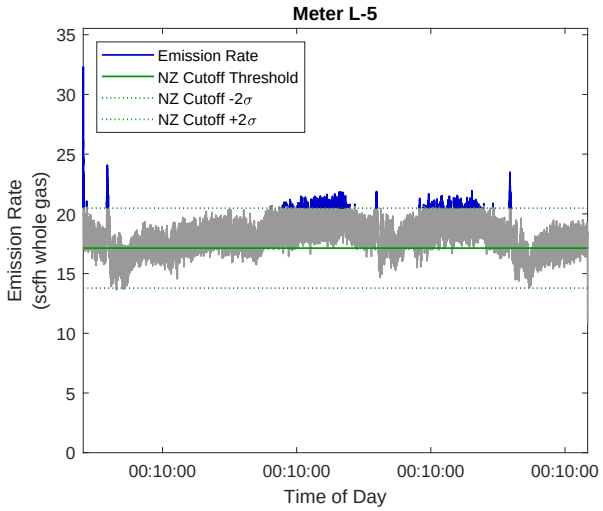

Figure S1-11: Example of an emissions recording impacted by NZ flow meter error. Because the majority of the measurements of this recording are within $+2\sigma$ of the mean NZ cutoff threshold, it is likely that this entire recording can be attributed to the NZ meter effect.

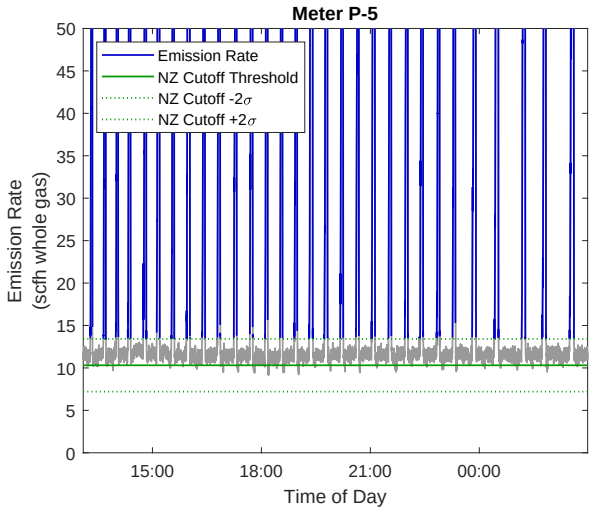

Figure S1-12: Another example of emissions recording heavily impacted by NZ flow meter error. In this recording, the NZ cutoff threshold calculated using Figure S1-8 curves did not capture the actual NZ baseline. To account for measurement noise and drift, all readings less than the calculated NZ cutoff $+2\sigma$ were set to zero.

NZ meter effect. However, due to noise in the signal and drift of the NZ baseline, zeroing meter readings below the calculated NZ cutoff threshold would only succeed in filtering 19% of the data points, and 83% of the emissions would remain. A similar issue can be seen in Figure S1-12, where the actual NZ baseline is slightly greater than the calculated NZ cutoff threshold. Because the calculated NZ threshold is less than the actual observed baseline, zeroing flows below the threshold would have no effect on the emission rate, even though there is a clear NZ baseline.

Many recordings exhibited the characteristic shown in Figures S1-11 and S1-12 where there is a clear NZ baseline that was not fully captured by the NZ cutoff threshold. To account for the uncertainty in calculating an NZ cutoff threshold for a data set with a given supply gas pressure

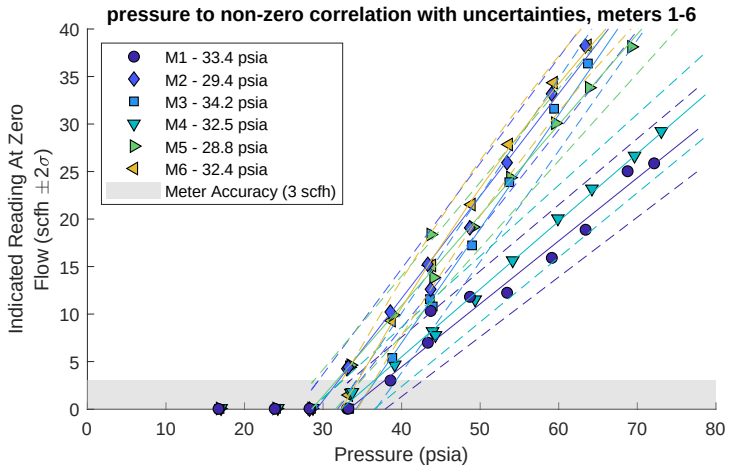

Figure S1-13: Correction curves and uncertainty bounds for all flow meters correlating NZ flow meter readings to operating pressure during measurement. The pressure at which NZ behavior starts is indicated in the legend for each meter.

Table S1-1: Correction curves fits for top uncertainty bounds used to assign NZ cutoff values

Linear Fits				
Meter	Slope	Intercept	NZ Threshold	
Meter 1	0.7	-20.27	33.43	
Meter 2	1.11	-29.64	29.4	
Meter 3	1.23	-39.25	34.24	
Meter 4	0.75	-21.24	32.46	
Meter 5	0.99	-25.43	28.83	
Parabolic Fit				
Meter	C1	C2	Intercept	NZ Threshold
Meter 6	-0.01	1.97	-52.54	32.38

due to meter noise and NZ baseline drift, all flows below the NZ cutoff $+2\sigma$ were set to zero. This increase in the NZ cutoff threshold was applied to all datasets that were identified as potentially having an NZ reading based on their supply pressure.

S1-4.3 Data Correction Summary

The specific process followed to apply corrections using correction curves shown in S1-13 was:

1. Correct gas flow for gas composition and apply noise filter.
2. Compute mean gas flow rate before NZ correction.
3. Compute the mean pressure for each recording. In all cases, supply gas pressure was stable and varied $< \pm 2$ psia during test duration.
4. Using the mean pressure, compute the flow rate at which the meter *may* be in NZ conditions, as per Figure S1-13.
5. Set all samples with indicated flow below the calculated NZ cutoff threshold $+2\sigma$ to zero (S1-1).
6. Recompute mean gas flow rate and compare with flow rate computed before the NZ correction.

S1-4.4 Impact of NZ Meter Error

The complete data correction methodology summarized in Section S1-4.3 was applied to 86 emissions recordings collected during the field campaign. The data corrections applied to correct for the NZ meter error had a non-trivial impact on the population of collected data. Data sets were classified as *zero impact*, *low impact*, *high impact* or *discarded* based on the percentage of emissions recorded that were attributed to the NZ meter error.

Zero Impact: Recordings that were installed on PC exhaust ports or had low enough supply gas pressures that their average emission rates were impacted by $< 1\%$ by the NZ correction (42 measurements or approximately $\frac{1}{2}$ of the measurements).

Low Impact: Recordings where the average emission rate changed by less than 20% after the NZ correction was applied (7 measurements).

High Impact: Recordings where the average emission rate changed by more than 20% after the NZ correction was applied . Recordings in this category include cases where nearly all data points were zeroed and/or a very small percentage of samples remain after the correction, but there were clearly emission or actuation events that were *not* impacted by the NZ error (see recording G-5 as an example). (23 measurements)

Discarded: Recordings where the average emission rate was effectively zeroed after applying the NZ correction ($>$ 80% change in emissions) *and* there were *not* distinct actuations or emission events above the NZ baseline (14 measurements).

S1-4.5 Validation of Data Correction Methods

A series of controlled tests were performed on the flow meters that simulated the supply pressures and gas flow rates encountered in the field. Data collected during these test were corrected using the methods outlined in Sections S1-4-S1-4.2 and compared to the actual flow through the meters to validate the correction methodology presented in the above sections.

Experimental Set Up

Validation tests were performed at the CSU Methane and Testing Evaluation Center (METEC). A similar set up to that described in Section S1-4.2 was used. The six Sierra flow meters were connected in series between a pressure regulated supply of 87.0% CH_4 natural gas and a manifold of automated valves that were operated to simulate leaks (Figure S1-14a). An Omega FMA 1700A series flow meter (±1% of span, or 1.59 scfh) monitored flow through the Sierra meters and provided timestamped flow rates for comparison (Figure S1-14a).

(a) Six Sierra flow meters connected in series at the CSU Methane Testing and Evaluation Center.

(b) Pressure regulators and Omega flowmeter used for Sierra meter verification

Figure S1-14: Experimental setup for validation tests to check accuracy of flow meters and data correction method.

Results

The setup described above was used to simulate a series of natural leaks at six supply pressures. These tests were performed on the range of pressure the meters were exposed to during field tests using a similar natural gas composition. The Sierra meters collected data on a three stepped flow rates pressures between 24 and 60 psia. The flow through the meters was returned to zero for at least 120 seconds between each test and each consecutive flow rate was maintained for at least 60 seconds to allow meter readings to stabilize (Figure S1-15).

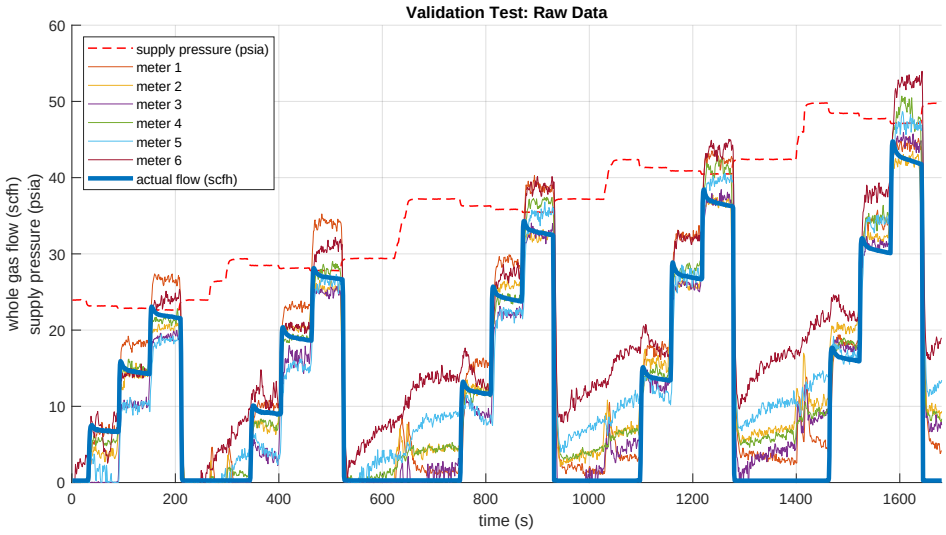

Figure S1-15: Comparison of Sierra meter recording to actual flow rates for measurements taken between 24-60 psia. Gas composition correction has been applied, filtering or NZ correction has not been applied. The tendency of flow meters to record non-zero flow rates under zero flow conditions under higher pressures is clear.

When pressure increases, the meters show a significant non-zero baseline when there is no flow through the meters and there is variability in the magnitude of this baseline between the six meters. Data in Figure S1-15 is corrected for gas composition but noise filter and NZ corrections have not been applied. Without the NZ correction over this range of pressures, the Sierra flow meters over-estimate the actual flow by between 1% (meter 3) and 58% (meter 6). On average, the meters over-estimate the actual flow by 22%.

The NZ flow correction methodology was then applied using the correction curves shown in Figure S1-13. Figure S1-16 shows the calculated NZ baseline for meter number 4 during this test. The shaded area represents the NZ baseline as a function of pressure. To apply the NZ correction to the meter's flow readings, all flow values that lie within this shaded region are set to zero. For meter 4, this correction reduces the overestimation of actual flow rates from 13% to 3%. Applying this correction reduces the average disagreement between the Sierra meters and the actual flow rate from 22% to 2%.

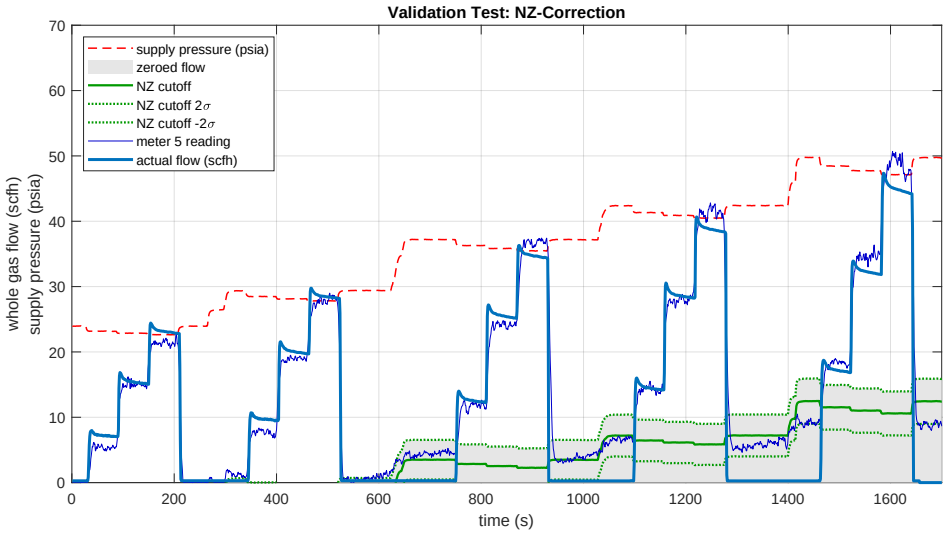

Figure S1-16: Comparison of Sierra meter number 5 recording to actual flow rates for measurements taken between 24-60 psia. Corrections for the NZ meter error, gas composition and signal filtering have been applied. After data correction methods are used, the recordings by Sierra flow meters used in the field agree reasonably well with the comparison flow meter.

S1-5 Pneumatic Controller Classification

To identify controllers by EPA classification (high, low or intermittent vent), the measurement team relied on site operator input, which was often inconsistent, resulting in conflicting classifications of controllers by the end of the study. Due to the wide variety of emission patterns observed, there was also interest in using the emission data and controller meta data to estimate whether controllers were operating as designed. To accomplish this, a panel of four industry experts and three study team members were assembled to review data for each controller recording. Based on the controller data the review panel classified each controller according to EPA subpart W venting categories (high, low or intermittent vent), determined if the controller was operating as designed or showed abnormal operation, identified possible common failure modes across the sample of abnormally operating controllers, and provide perspectives on possible causes of the irregular emissions patterns observed. Controllers were assigned as abnormally operating strictly based on the emissions behavior of the device. By this definition, a device identified as abnormally operating from an emissions perspective could still be performing its intended function and operating correctly from a process control perspective. The flowchart in Figure S1-17 illustrates the panel's selection process for classifying controllers (Section S1-5.2) and bucketing controllers by EPA classification type (Section S1-5.1).

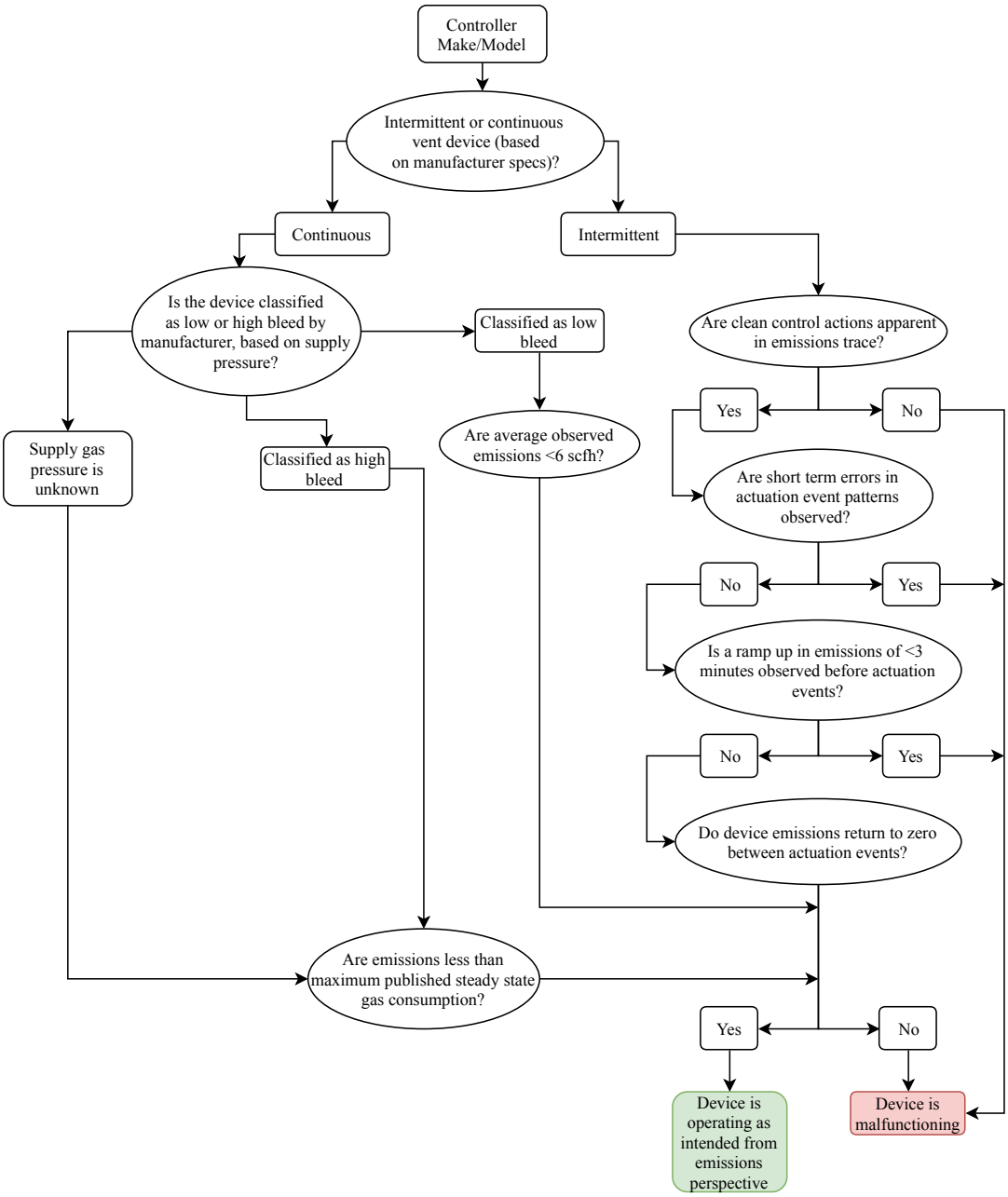

Figure S1-17: Flowchart summarizing the industry panel's criteria for classifying PCs according to their vent behavior and identifying PCs as normally operating or abnormally operating from an emissions perspective

S1-5.1 Classification by EPA Type

The panel's criteria for classifying each controller by EPA type was based on specifications given in manufacturer's literature. The highest level of classification (intermittent vs. continuous vent) is straightforward to assign based on device specifications. The secondary classification for continuous controllers (high vs low bleed) is not as straightforward, as continuous bleed rates can be a function of supply gas pressure to the controller. For devices where emissions were measured in supply gas lines, supply pressure was recored over the test run and bleed rate classifications were based on

steady state gas consumption rates for recorded supply pressure. If emissions were measured at controller exhaust ports, supply pressures were unknown and low vs high bleed classifications were assigned by consulting additional manufacturer literature or based on field experience of panel members. There are also several common models of electro-pneumatic controllers whose classification as low vs high bleed is dependent on the internal relay installed in the device; because the relay types were not noted during field work, classifications were assigned for these devices by consulting station operators.

S1-5.2 Classification as Normally or Abnormally Operating

Continuous Bleed Controllers: Devices classified as low bleed were identified as normally operating if their average emission rates were $\leq$6 scfh. Devices classified as high bleed were identified as normally operating if their average emission rates were consistent with their published steady state gas consumption values.

Intermittent Vent Controllers: Four criteria were assigned to classify intermittent vent controllers as normally or abnormally operating. If the emissions trace for an intermittent vent device was observed to violate any of these criteria, the controller was identified as abnormally operating. PC classification was performed by evaluating emission traces that were filtered for noise, corrected for gas composition, and had NZ correction algorithm applied. These criteria are:

1. **Continuous Emissions**: Emissions recording of an intermittent vent PC that does not show control actuations and emits gas continuously (Figure S1-18).

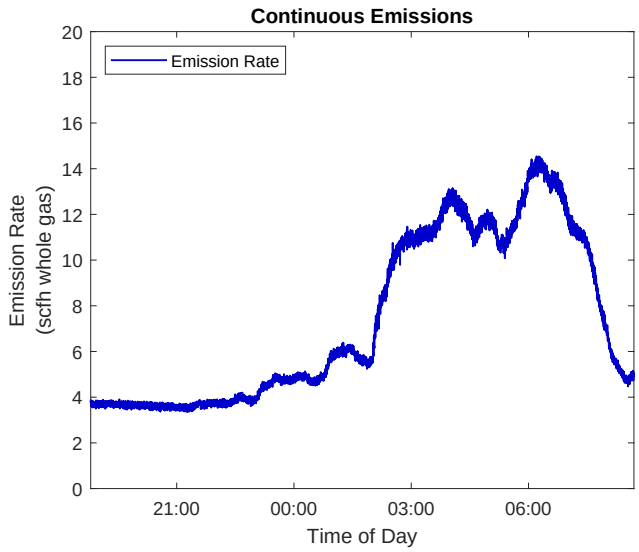

Figure S1-18: Intermittent vent PC that does not show distinct actuations and vents gas continuously.

2. **Extended Ramp**: PC shows an emission ramp longer than three minutes in duration leading up to an actuation event (Figure S1-19).

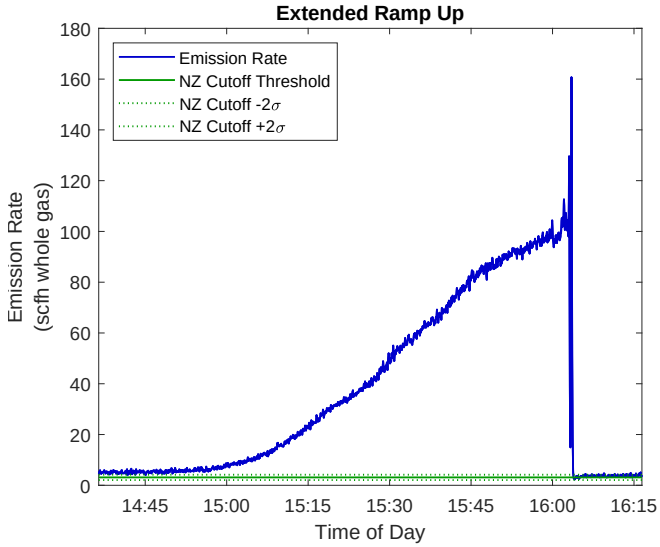

Figure S1-19: PC emissions gradually increase for 45 minutes leading to actuation event. This behavior is inconsistent with the design of the device and controllers exhibiting this behavior were identified as abnormally operating.

3. **Does Not Return to Zero**: PC shows control actuations but emission rates do not return to zero between actuation events (Figure S1-20)

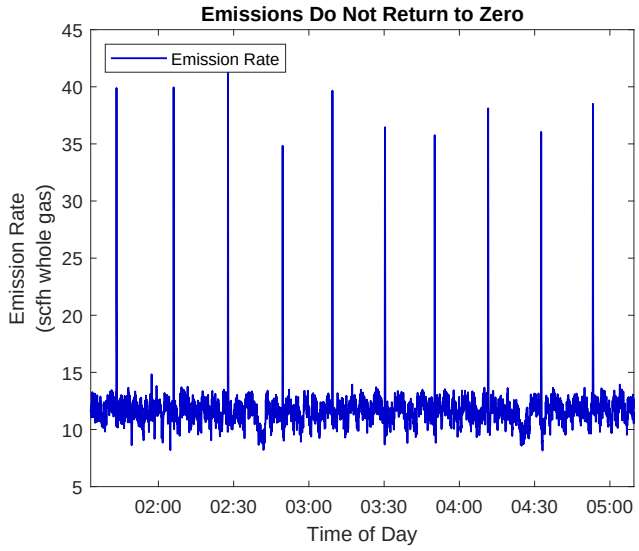

Figure S1-20: PC emissions do not return to zero between actuation events. Since NZ corrections have already been applied, this abnormally operation is visible *only* if emissions between actuations exceed the NZ threshold.

4. **Irregular Behavior**: Intermittent vent PC shows some combination of the the previous three behaviors or generally irregular emissions patterns (Figure S1-21).

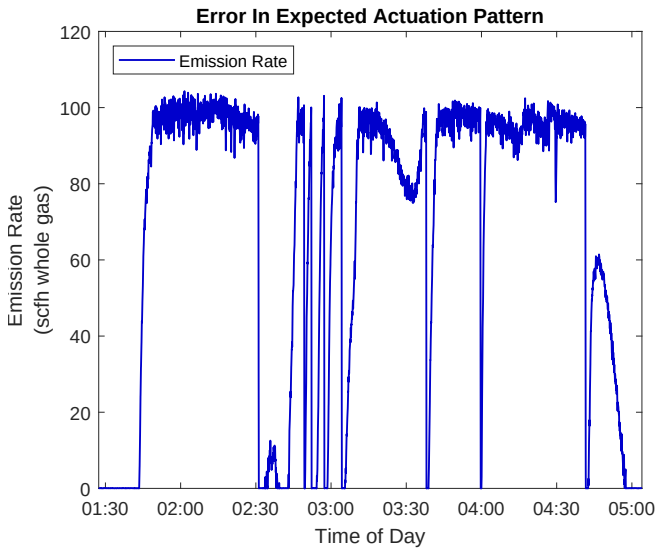

Figure S1-21: PC demonstrating irregular emissions behavior over the majority of the data collection period. The device was identified as abnormally operating.

Table S1-2 shows which of the above criteria were exhibited by each intermittent vent PC that was identified as abnormally operating.

Table S1-2: Classification of abnormally operations for intermittent PCs

Recording ID	Continuous Emissions	Extended Ramp	Does Not Return to Zero Between Actuations	Irregular Behavior	Total AO Classifications
A-3			✓		1
A-4	✓				1
D-1	✓	✓	✓	✓	4
D-4	✓		✓	✓	3
D-6			✓	✓	2
G-5	✓			✓	2
H-1		✓			1
H-6			✓	✓	2
I-5	✓			✓	2
N-1	✓				1
N-2	✓			✓	2
N-3				✓	1
N-4	✓				1
O-6		✓		✓	2
P-1				✓	1
P-5		✓			1
S-2	✓			✓	2
S-4	✓			✓	2
T-4		✓			1
T-5		✓			1
T-6		✓		✓	2
U-5		✓			1
U-6		✓			1
V-2	✓			✓	2
V-6	✓	✓	✓		3
Fraction Impacted	48%	40%	24%	58%	

S1-6 Supporting Figures

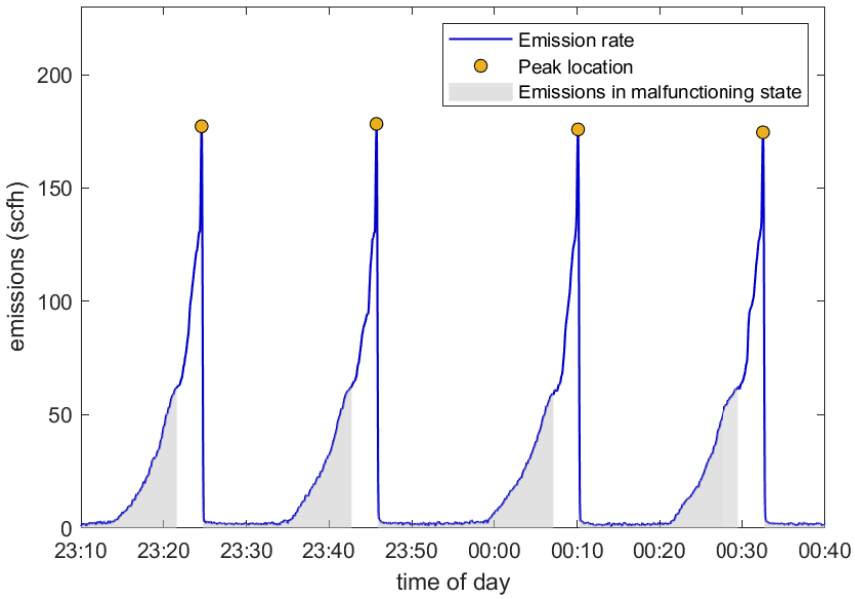

Figure S1-22: The pneumatic controller with the emissions profile shown here (device H-1) was identified as malfunctioning because of the extended ramp in emissions leading to actuation events. Emissions from device's abnormally operating states were assigned as all emissions *except* those during three minutes preceding and 5 seconds after peaks. This algorithm was applied to the emissions profile for each abnormally operating pneumatic controller to determine the emissions contribution from abnormally/normally operating states and percent time each PC was abnormally operating.

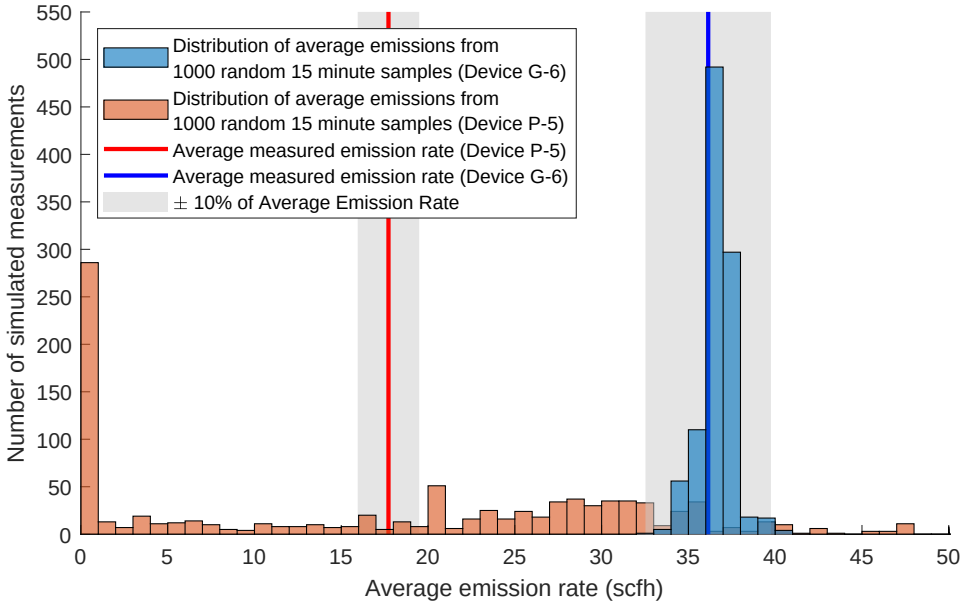

Figure S1-23: Distribution of 1000, randomly selected 15 minute average emission samples for an intermittent vent and high bleed pneumatic controller.

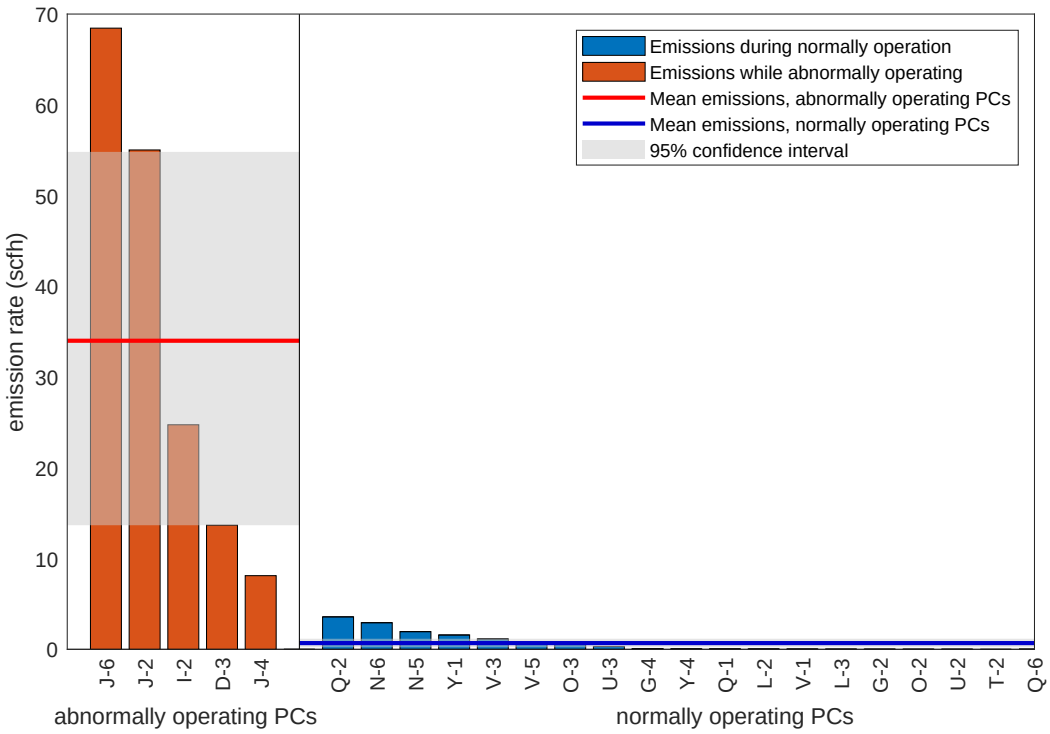

Figure S1-24: Emissions for low bleed pneumatic controllers. Emissions during abnormal operations were isolated from normal emissions by isolating emissions greater than the EPA low bleed threshold of 6 scfh. Controllers with average emission rates greater than this threshold exhibited abnormally high emissions through the entire observation period. Mean total emissions from abnormally operating controllers are far higher than emissions from controllers exhibiting only normal operations.

References

[1] D. Zimmerle, T. Vaughn, B. Luck, T. Lauderdale, K. Keen, M. Harrison, A. J. Marchese, and L. L. Williams, "Methane Emissions from Gathering Compressor Stations in the USA," *Environmental Science & Technology*, vol. in review, 2019.

[2] D. T. Allen, A. P. Pacsi, D. W. Sullivan, D. Zavala-Araiza, M. Harrison, K. Keen, M. P. Fraser, A. Daniel Hill, R. F. Sawyer, and J. H. Seinfeld, "Methane emissions from process equipment at natural gas production sites in the united states: Pneumatic controllers," *Environmental Science & Technology*, vol. 49, no. 1, pp. 633–640, 2015, pMID: 25488196. [Online]. Available: https://doi.org/10.1021/es5040156

[3] E. D. Thoma, P. Deshmukh, R. Logan, M. Stovern, C. Dresser, and H. L., "Assessment of uinta basin oil and natural gas well pad pneumatic controller emissions," *Journal of Environmental Protection*, vol. 8, no. 4, April 2017.

[4] Prasino Group, "Final Report for determining bleed rates for pneumatic devices in British Columbia," Report to British Columbia Ministry of Environment, Tech. Rep., December 2013.

[5] Greenpath Energy, "Alberta fugitive and vented emissions inventory study," Tech. Rep., 2016, Prepared for Alberta Energy Regulator. [Online]. Available: https://www.aer.ca/documents/GreenPathAER%20Survey-Methane.pdf

[6] U.S. Environmental Protection Agency & Gas Research Institute, "Methane emissions from the natural gas industry, volume 12: Pneumatic devices," June 1996, EPA-600/R-96-0801, GRI-94-0257.29.

[7] "METEC." [Online]. Available: https://energy.colostate.edu/metec/

S1-7 Meter Recordings

Data on each PC measured is summarized on one page, below, grouped into sections as described above. Each page starts with a listing of relevant parameters about the PC, with the following variables:

Site Class: *Class I*: Station was selected during original site selection exercise using randomized clustered sampling method. Meta-data was collected and instruments were installed by CSU personnel. *Class II*: Station was selected by hand from list of volunteered industry partner resources to improve geographic diversity and total number of measured PCs. Meta-data was collected and instruments were installed by CSU personnel. *Class III*: Station was selected by hand from list of volunteered industry partner resources to improve geographic diversity and total number of measured PCs. Meta-data was collected and instruments were installed by industry partner personnel, under the same protocols used by CSU personnel for site Classes I and II.

NEMS Region: National Energy Model region in which measurement was made.

Install Location: Location where measurement meter was installed. *Inline* indicates the meter was installed in the supply gas to the controller. *Exhaust* indicates the meter was installed on the exhaust port of the controller.

Controller Location: Major equipment category where pneumatic controller was installed.

Process Controlled: The process variable controlled by the PC. Values include:] liquid level, temperature, and pressure.

Controller Model: Make and model of the PC

EPA Bleed Type: PC classification in accordance with the EPA classification method or intermittent, low- and high-bleed devices. Continuous bleed PCs are listed as *continuous* is the intended bleed rate is unknown, *low bleed* if the intended bleed rate was $\leq 6scfh$, or *high bleed* if intended bleed rate is $> 6scfh$.

Gas Methane Fraction: Mole faction of methane in gas composition used to power the PC

Measurement Duration: Time measured on the PC

Avg. Gas Temperature: Temperature of the supply gas, as reported by the installed meter.

Avg. Supply Pressure: Pressure of the supply gas, as reported by the installed meter.

Corrected for Gas Comp.: Indicates whether flow rates are corrected for gas composition.

NZ Cutoff: For recordings impacted by the NZ correction, any flow below this cutoff level (in scfh whole gas) could represent erroneous readings from the meter, rather than real gas flows.

Emission Rate: Whole gas emission rate, with 95% confidence interval.

Samples Remaining The fraction of samples in the recording that *were not* impacted by the NZ correction.

Emissions Remaining The fraction of total indicated emissions in the recording that *were not* impacted by the NZ correction. Note that these emissions were *slightly* impacted by filtering noise from the flow recordings.

Evaluation The opinion of the expert panel on whether the PC is working correctly *from an emissions perspective*; a PC may be effectively completing its assigned function but emitting more gas than it is designed to emit.

Notes: Additional notes made by the field team or clarification on classifications.

S1-7.1 Zero Impact

This section contains recordings made on PCs where average emission rates were unaffected by the NZ meter error. This includes all recordings where meter was connected to a PC's exhaust port, as measurements were made at atmospheric pressure well below the NZ baseline pressure thresholds. This section also includes recordings where either supply gas pressures were low enough that no NZ baseline was observable, or the NZ correction had a minor (<1%) effect on average emissions.

Device A-1

Site Class: II	NEMS Region: Southwest
Install Location: Exhaust	Measurement Duration: 69.3 hrs
Controller Location: Glycol Dehydrator	Avg. Gas Temperature: 48.8 $^{\circ}F$
Process Controlled: Temperature	Avg. Supply Pressure: 13.2 psia
Controller Model: Kimray T12	Gas Methane Fraction: 92%
EPA Bleed Type: Intermittent	Emission Factor: 0.019 [0.0065 to 0.044]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

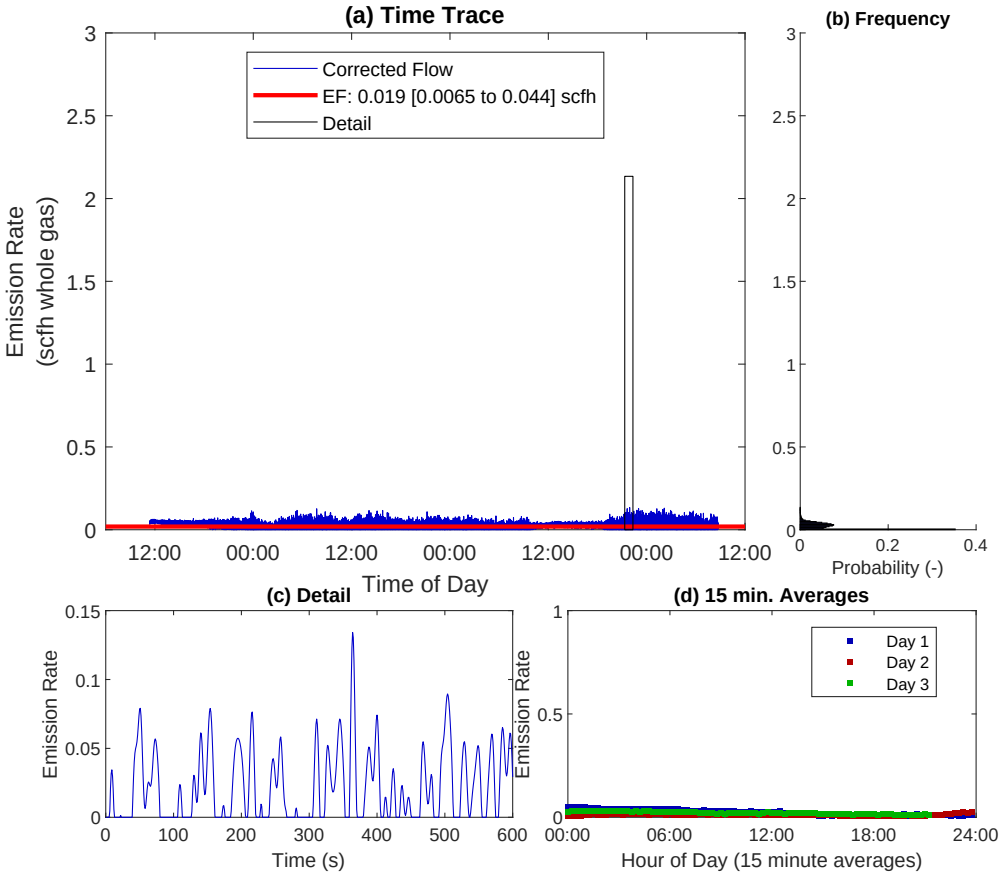

Figure S1-25: Device A-1

Device D-1

Site Class: I	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 85.6 hrs
Controller Location: Compressor	Avg. Gas Temperature: 50.6 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 32.4 psia
Controller Model: Murphy, L1200N	Gas Methane Fraction: 99.2%
EPA Bleed Type: Intermittent	Emission Factor: 39 [8.6 to 1.3e+02]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Abnormally Operating	

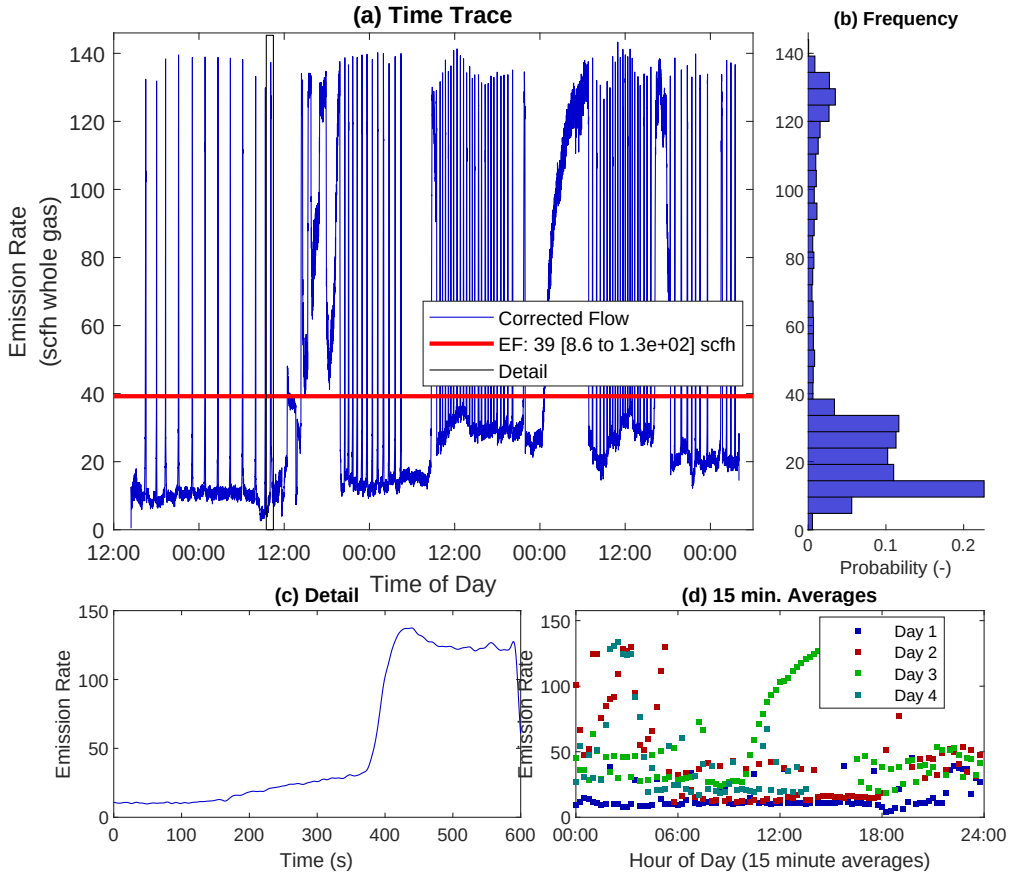

Figure S1-26: Device D-1

Device D-4

Site Class: I	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 90.8 hrs
Controller Location: Compressor	Avg. Gas Temperature: 41.8 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 33 psia
Controller Model: Mallard, 3100-P1	Gas Methane Fraction: 99.2%
EPA Bleed Type: Intermittent	Emission Factor: 12 [0 to 51]
Non-zero Correction:	NZ Cutoff: 0.485 scfh
Samples Remaining: 40%	Emissions Remaining: 99%
Evaluation: Abnormally Operating	

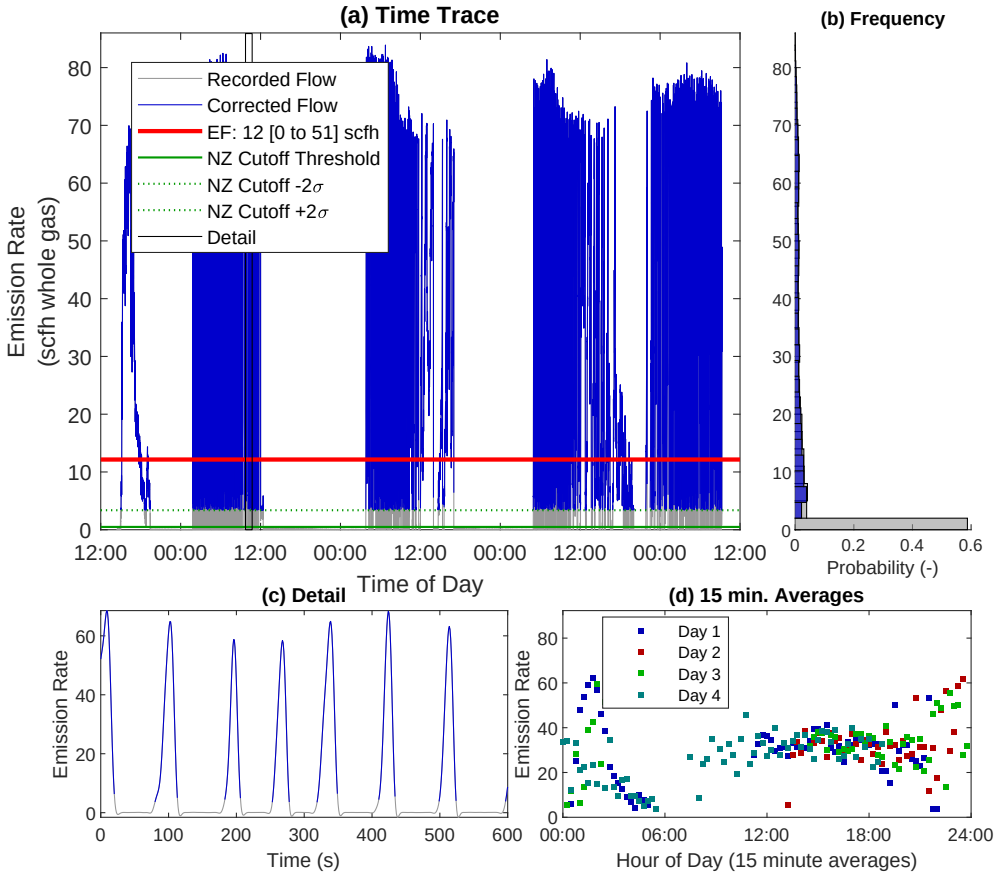

Figure S1-27: Device D-4

Device D-6

Site Class: I	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 72.3 hrs
Controller Location: Compressor	Avg. Gas Temperature: 59.7 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 32.7 psia
Controller Model: Mallard, 3100-P1	Gas Methane Fraction: 99.2%
EPA Bleed Type: Intermittent	Emission Factor: 10 [7.1 to 14]
Non-zero Correction:	NZ Cutoff: 0.466 scfh
Samples Remaining: 96%	Emissions Remaining: 100%
Evaluation: Abnormally Operating	

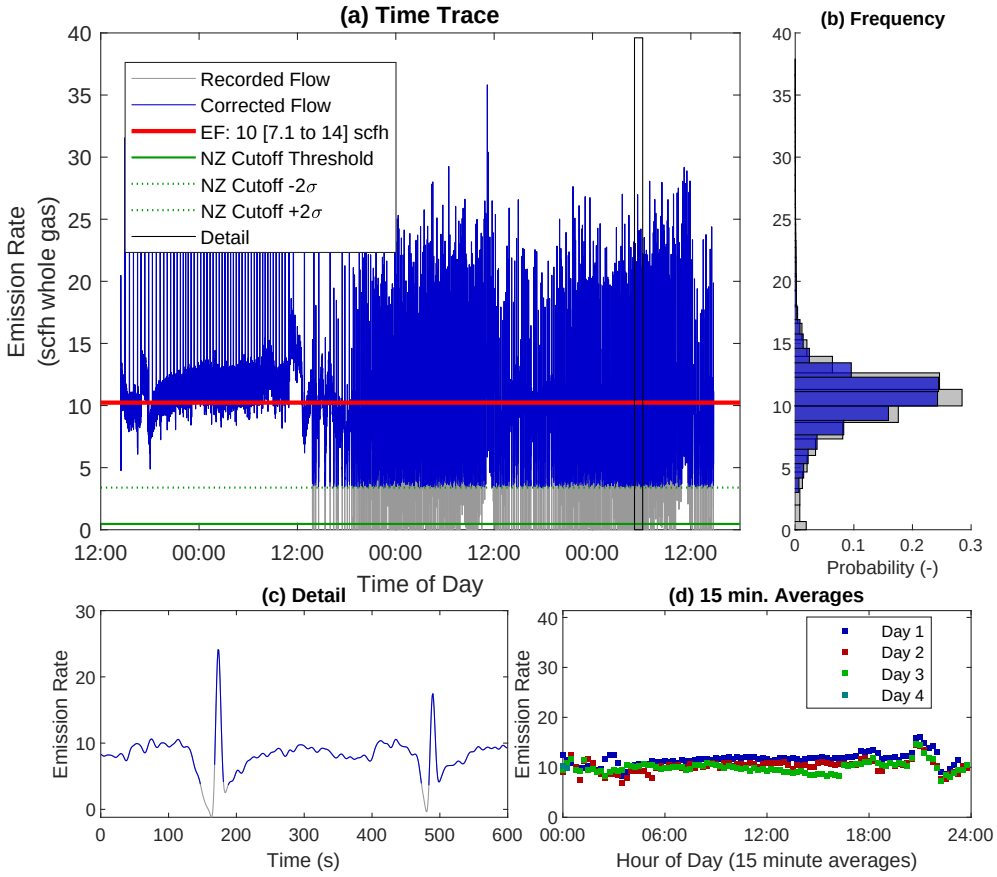

Figure S1-28: Device D-6

Device G-2

Site Class: II	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 50.9 hrs
Controller Location: Compressor	Avg. Gas Temperature: 37.8 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14.4 psia
Controller Model: Control Air Inc 950XP	Gas Methane Fraction: 94.5%
EPA Bleed Type: Low Bleed	Emission Factor: 0.011 [0.0058 to 0.018]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

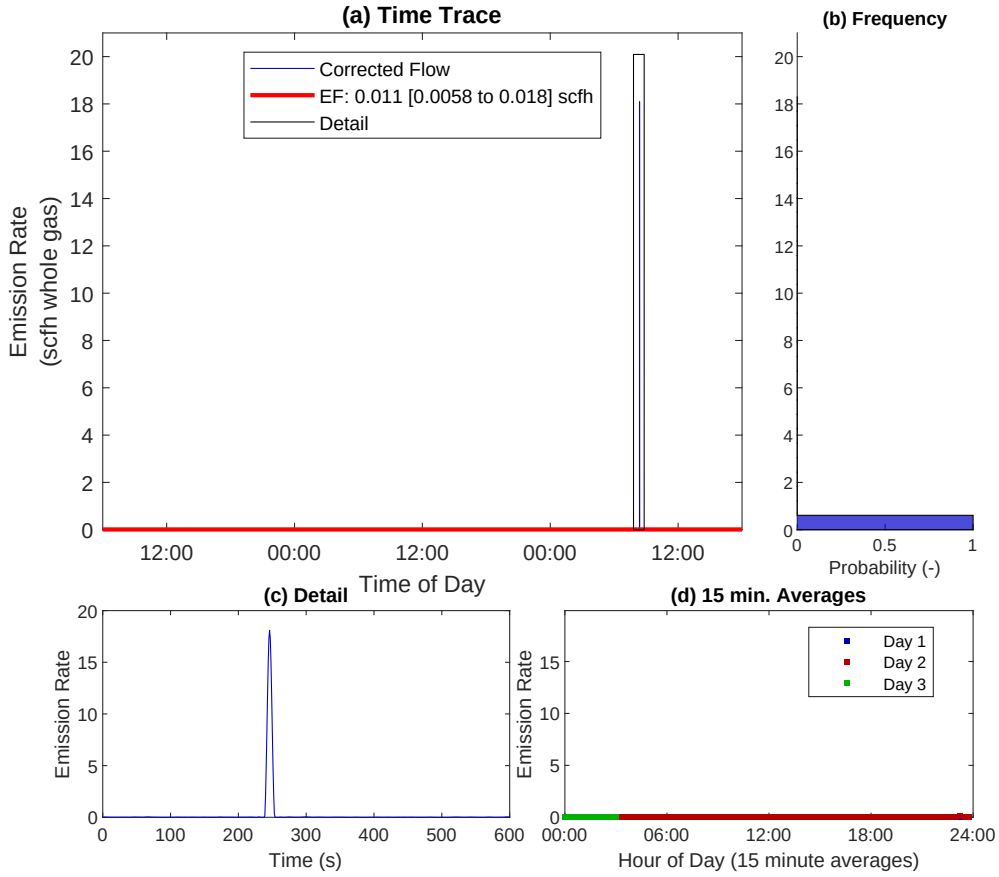

Figure S1-29: Device G-2

Device G-3

Site Class: II	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 50.4 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 50.4 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 14.6 psia
Controller Model: Fisher 582i	Gas Methane Fraction: 94.5%
EPA Bleed Type: High Bleed	Emission Factor: 0.028 [0.0046 to 0.044]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

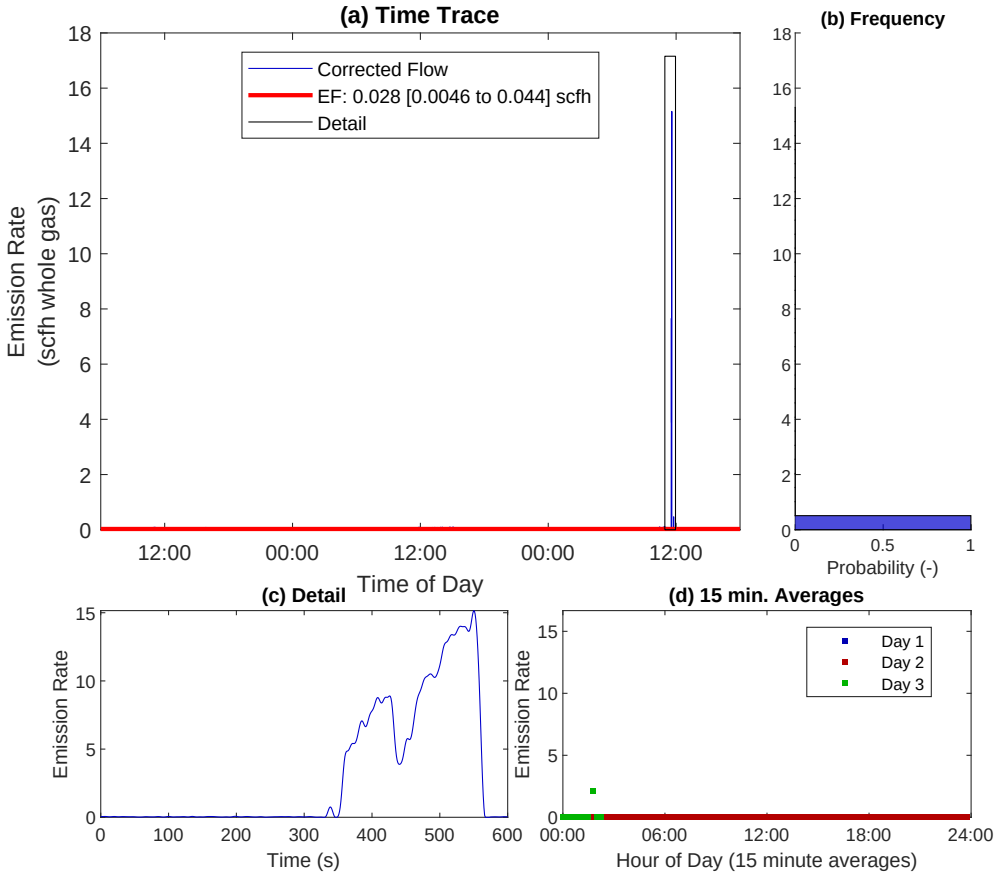

Figure S1-30: Device G-3

Device G-4

Site Class: II	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 50.2 hrs
Controller Location: Compressor	Avg. Gas Temperature: 33.8 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14.7 psia
Controller Model: Control Air Inc 950XP	Gas Methane Fraction: 94.5%
EPA Bleed Type: Low Bleed	Emission Factor: 0.087 [0.038 to 0.27]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

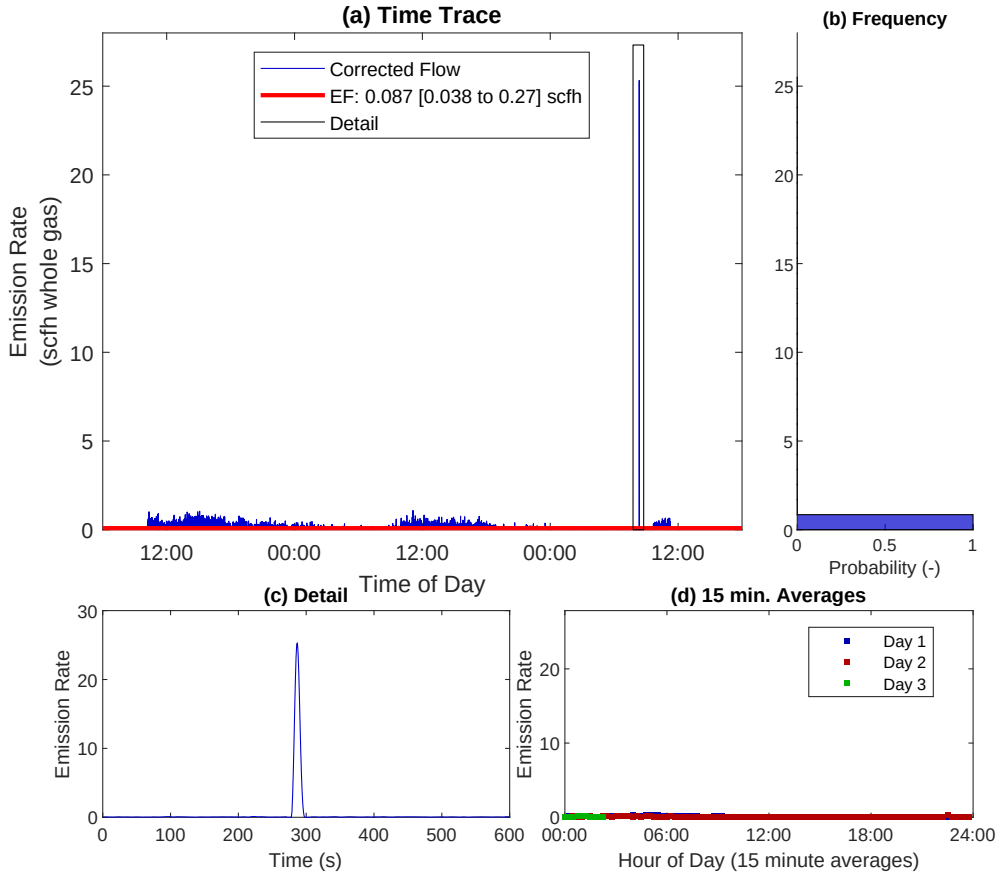

Figure S1-31: Device G-4

Device G-6

Site Class: II	NEMS Region: Gulf Coast
Install Location: Inline	Measurement Duration: 49.4 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 33.5 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 34.6 psia
Controller Model: Fisher 546	Gas Methane Fraction: 94.5%
EPA Bleed Type: High Bleed	Emission Factor: 36 [32 to 38]
Non-zero Correction:	NZ Cutoff: 3.31 scfh
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

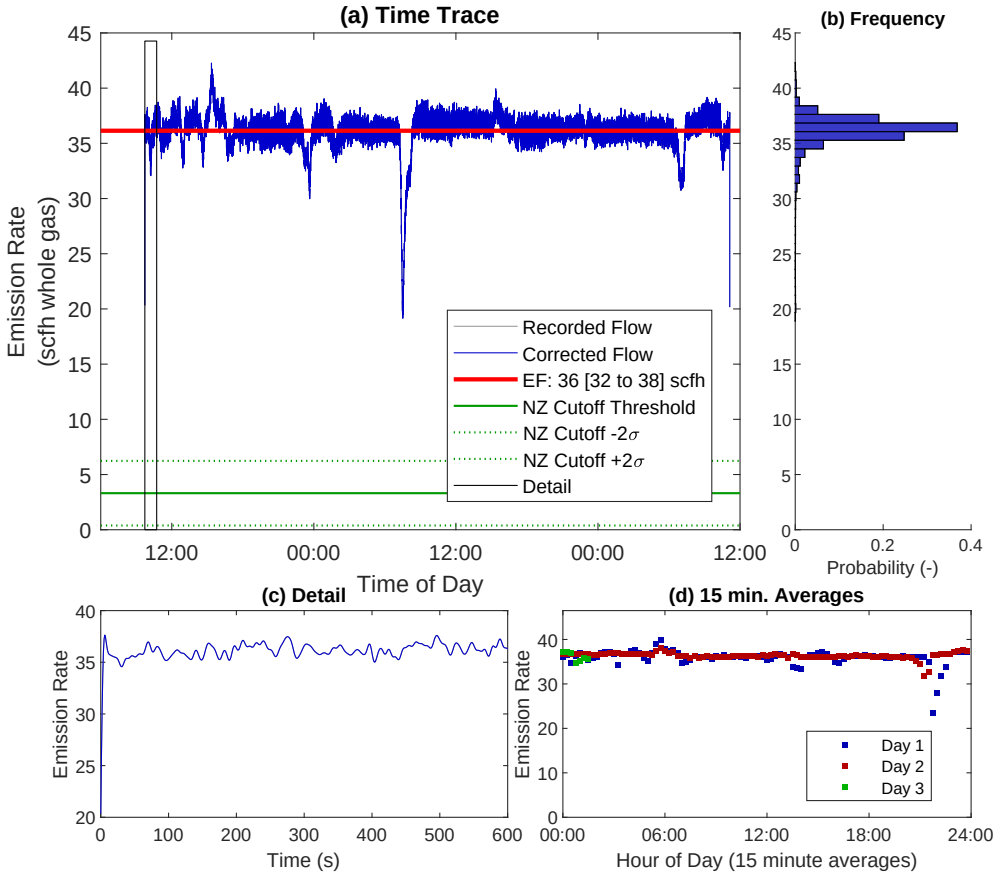

Figure S1-32: Device G-6

Device H-4

Site Class: I	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 92.1 hrs
Controller Location: Separator	Avg. Gas Temperature: 73.1 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 41 psia
Controller Model: Wellmark 1800	Gas Methane Fraction: 70%
EPA Bleed Type: Intermittent	Emission Factor: 0.13 [0.054 to 0.6]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

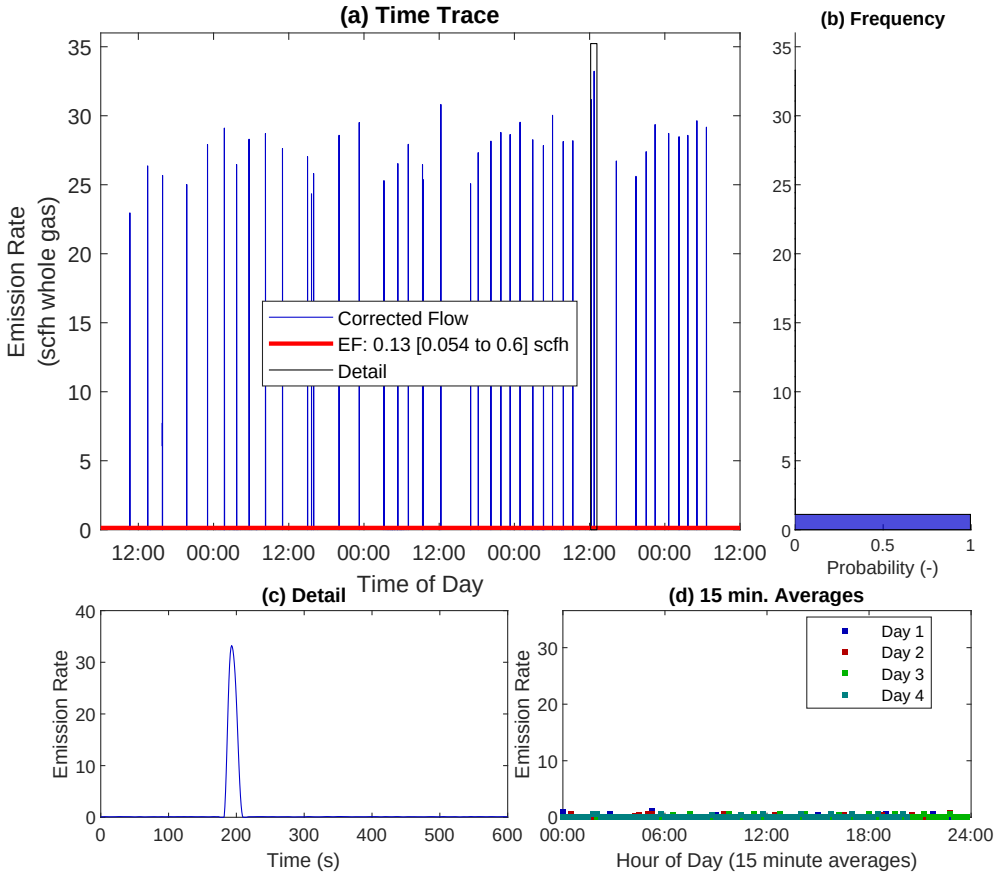

Figure S1-33: Device H-4

Device H-6

Site Class: I	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 83.9 hrs
Controller Location: Compressor	Avg. Gas Temperature: 85.7 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 39.4 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 70%
EPA Bleed Type: Intermittent	Emission Factor: 40 [21 to 75]
Non-zero Correction:	NZ Cutoff: 9.88 scfh
Samples Remaining: 99%	Emissions Remaining: 100%
Evaluation: Abnormally Operating	

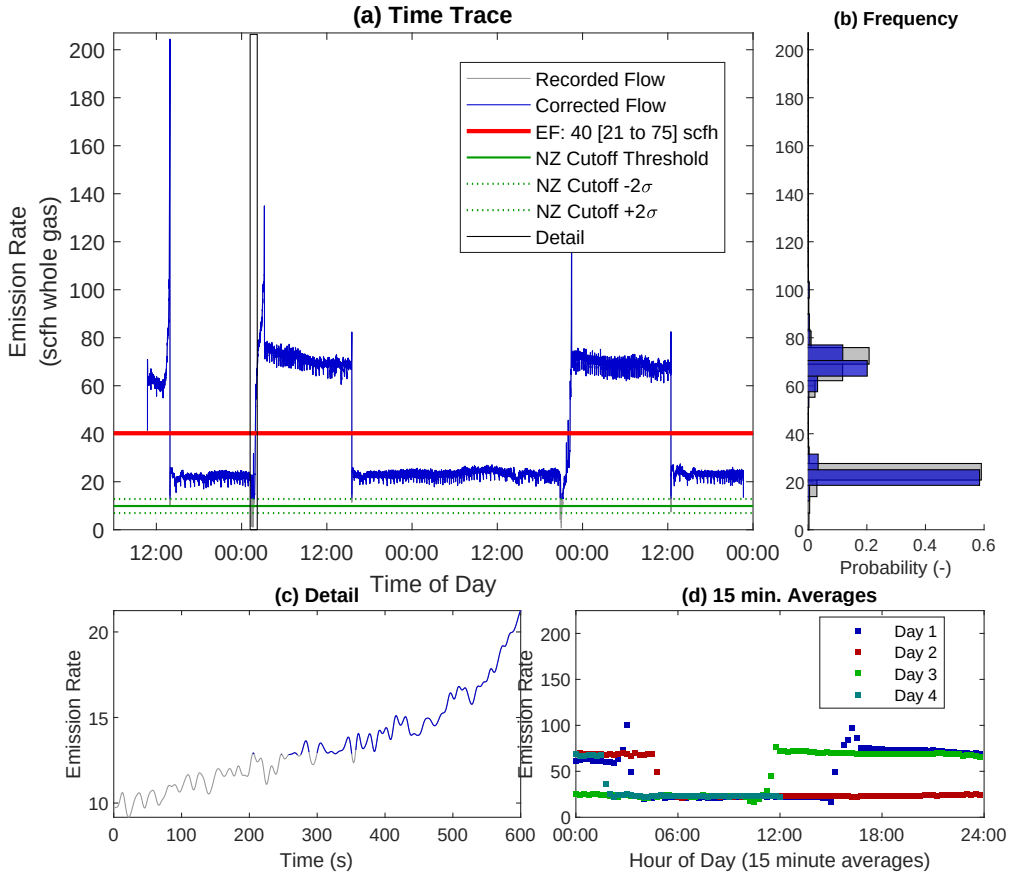

Figure S1-34: Device H-6

Device I-2

Site Class: I	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 51.1 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 67.2 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14.4 psia
Controller Model: Norriseal Series 4900	Gas Methane Fraction: 90.8%
EPA Bleed Type: Low Bleed	Emission Factor: 25 [19 to 32]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Abnormally Operating	

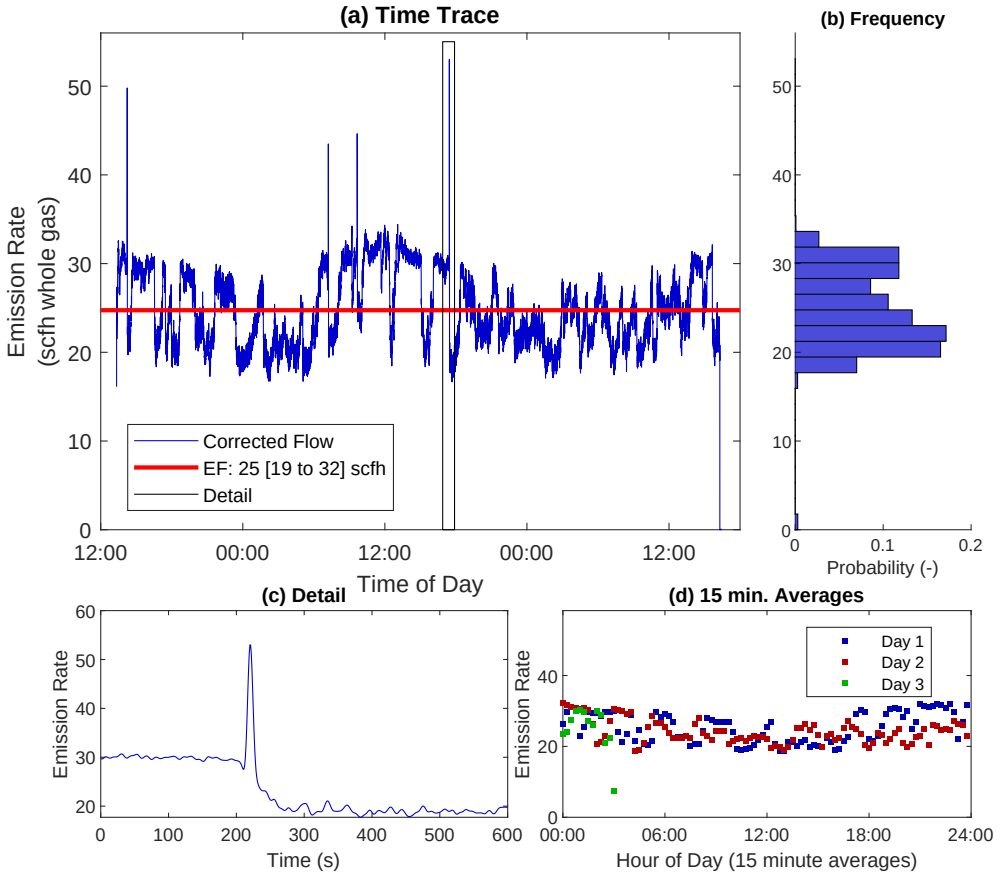

Figure S1-35: Device I-2

Device I-3

Site Class: I	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 49.7 hrs
Controller Location: Compressor	Avg. Gas Temperature: 82 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 14.5 psia
Controller Model: Noriseal Series 1005E	Gas Methane Fraction: 90.8%
EPA Bleed Type: Intermittent	Emission Factor: 0.042 [0.023 to 0.075]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

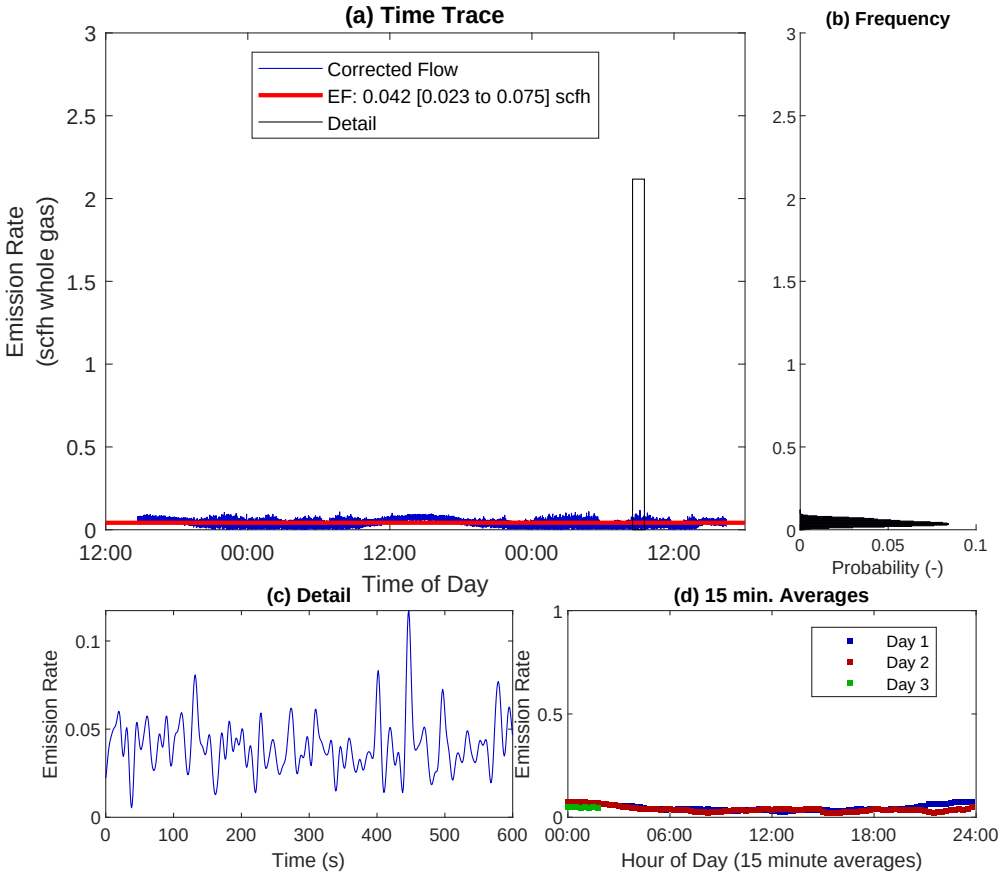

Figure S1-36: Device I-3

Device I-4

Site Class: I	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 50 hrs
Controller Location: Compressor	Avg. Gas Temperature: 76.8 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 14.7 psia
Controller Model: Norriseal Series 1005E	Gas Methane Fraction: 90.8%
EPA Bleed Type: Intermittent	Emission Factor: 0.08 [0.059 to 0.12]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

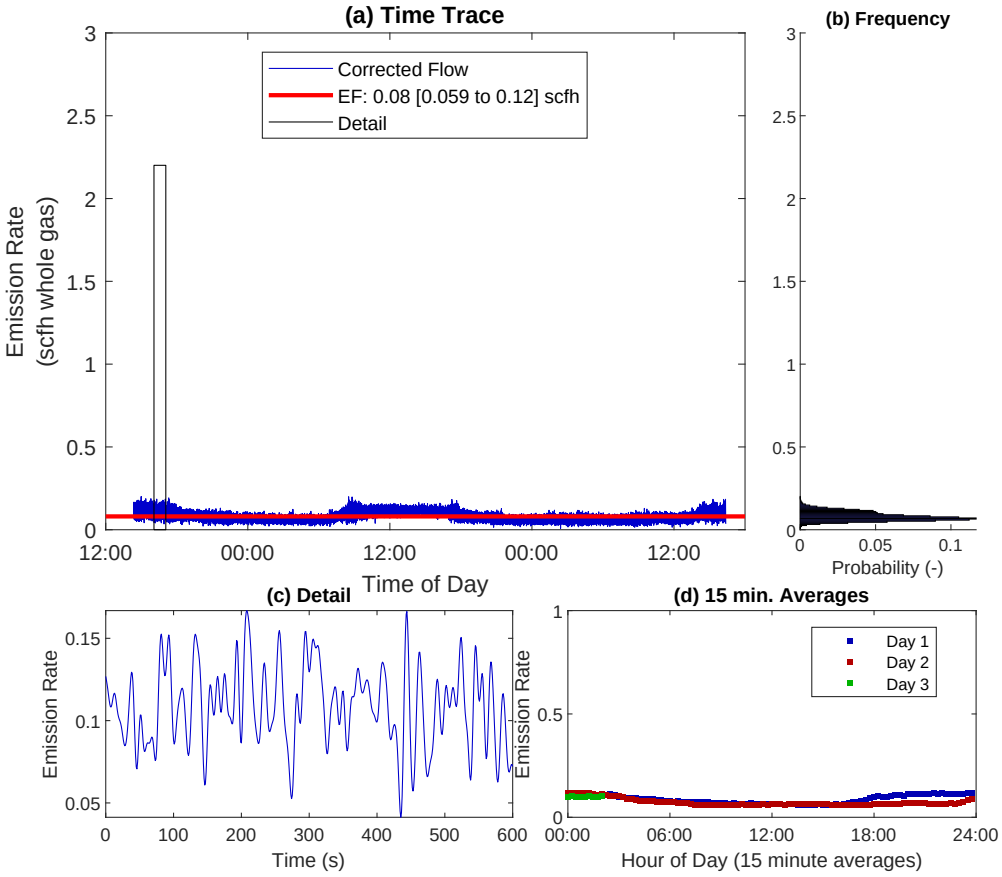

Figure S1-37: Device I-4

Device I-5

Site Class: I	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 50 hrs
Controller Location: Compressor	Avg. Gas Temperature: 67.3 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 18.2 psia
Controller Model: Norriseal Series 1005P1	Gas Methane Fraction: 90.8%
EPA Bleed Type: Intermittent	Emission Factor: 63 [0.057 to 99]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Abnormally Operating	

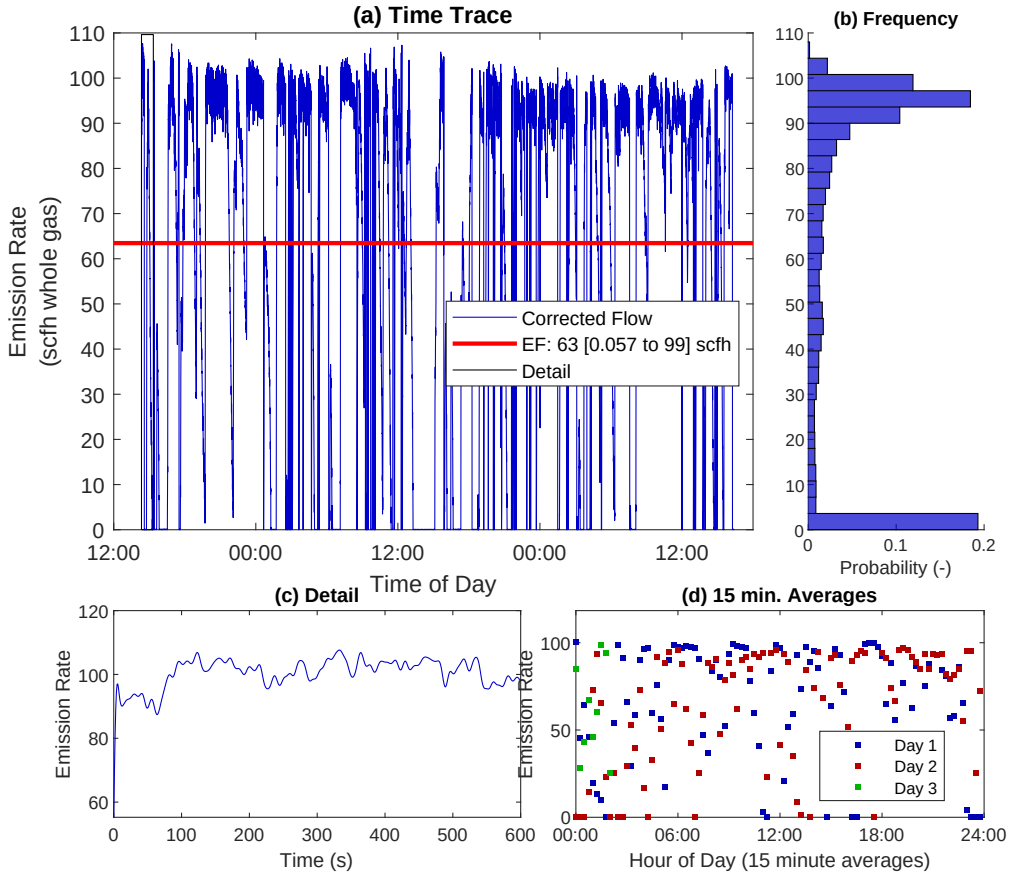

Figure S1-38: Device I-5

Device J-1

Site Class: III	NEMS Region: Southwest
Install Location: Exhaust	Measurement Duration: 102 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 56.4 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 13.2 psia
Controller Model: Fisher L2	Gas Methane Fraction: 92%
EPA Bleed Type: Intermittent	Emission Factor: 0.022 [0.0099 to 0.038]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

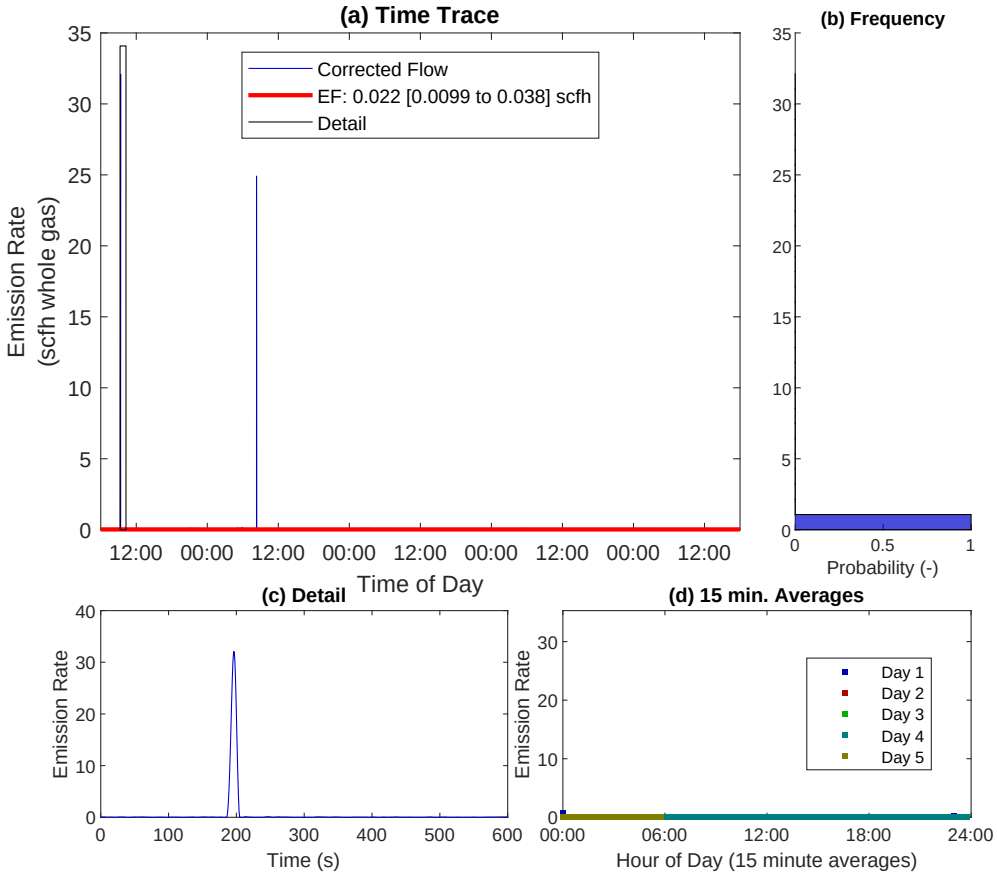

Figure S1-39: Device J-1

Device J-2

Site Class: III	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 81.7 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 56.4 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 45.1 psia
Controller Model: Fisher C1	Gas Methane Fraction: 92%
EPA Bleed Type: Low Bleed	Emission Factor: 55 [50 to 59]
Non-zero Correction:	NZ Cutoff: 17.2 scfh
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Abnormally Operating	

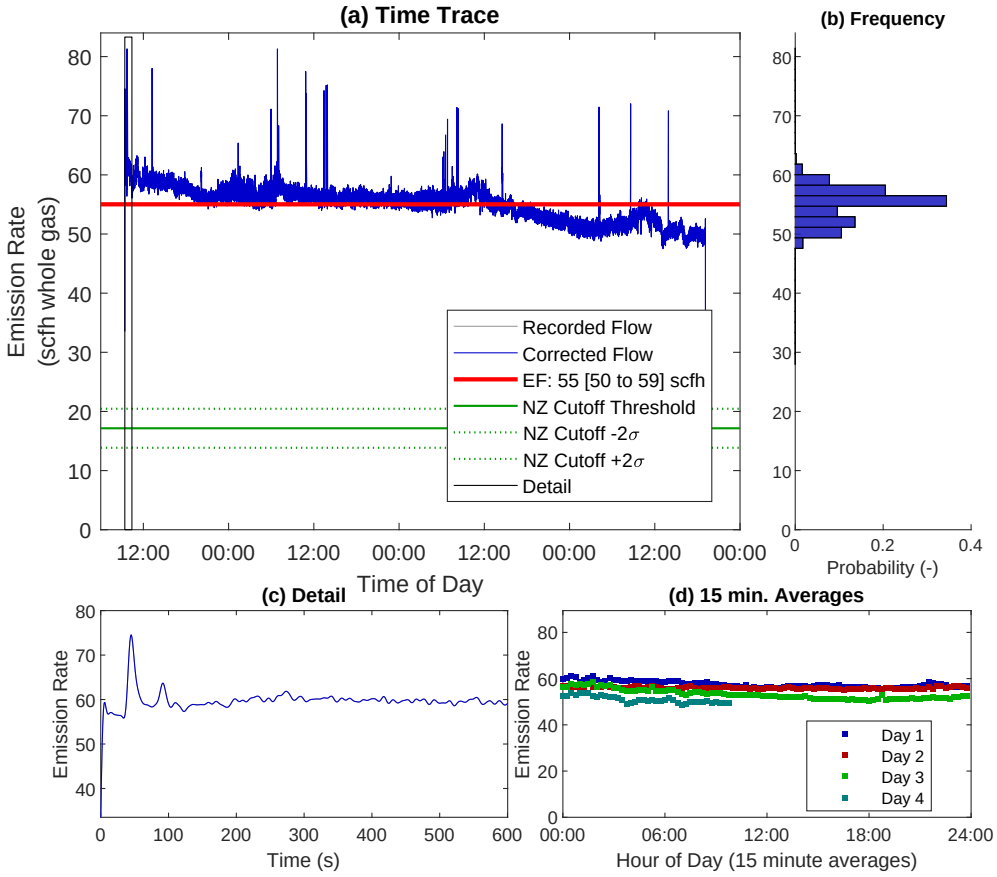

Figure S1-40: Device J-2

Device J-3

Site Class: III	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 80.2 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 54.8 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 47.8 psia
Controller Model: Fisher 4160k	Gas Methane Fraction: 92%
EPA Bleed Type: High Bleed	Emission Factor: 55 [53 to 57]
Non-zero Correction:	NZ Cutoff: 16.4 scfh
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

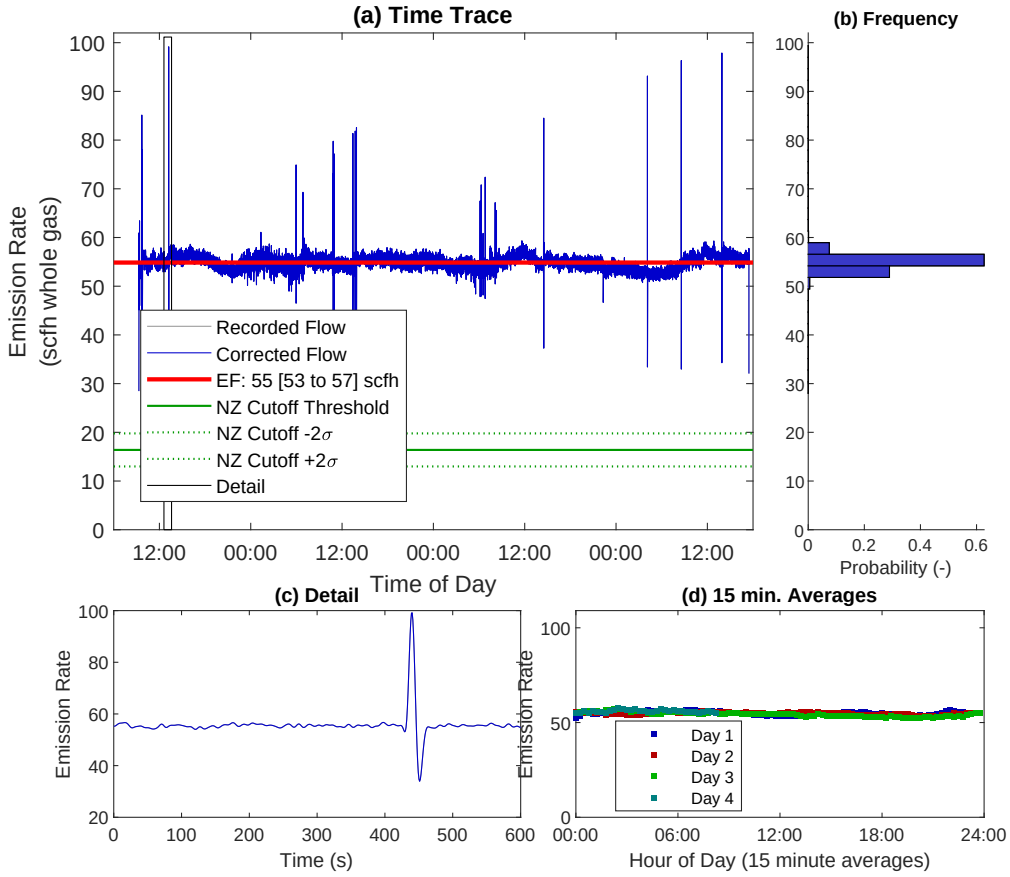

Figure S1-41: Device J-3

Device J-6

Site Class: III	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 81.4 hrs
Controller Location: Compressor	Avg. Gas Temperature: 56.7 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 46.3 psia
Controller Model: Dynaflo 4000 LBR	Gas Methane Fraction: 92%
EPA Bleed Type: Low Bleed	Emission Factor: 68 [26 to 75]
Non-zero Correction:	NZ Cutoff: 18.8 scfh
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Abnormally Operating	

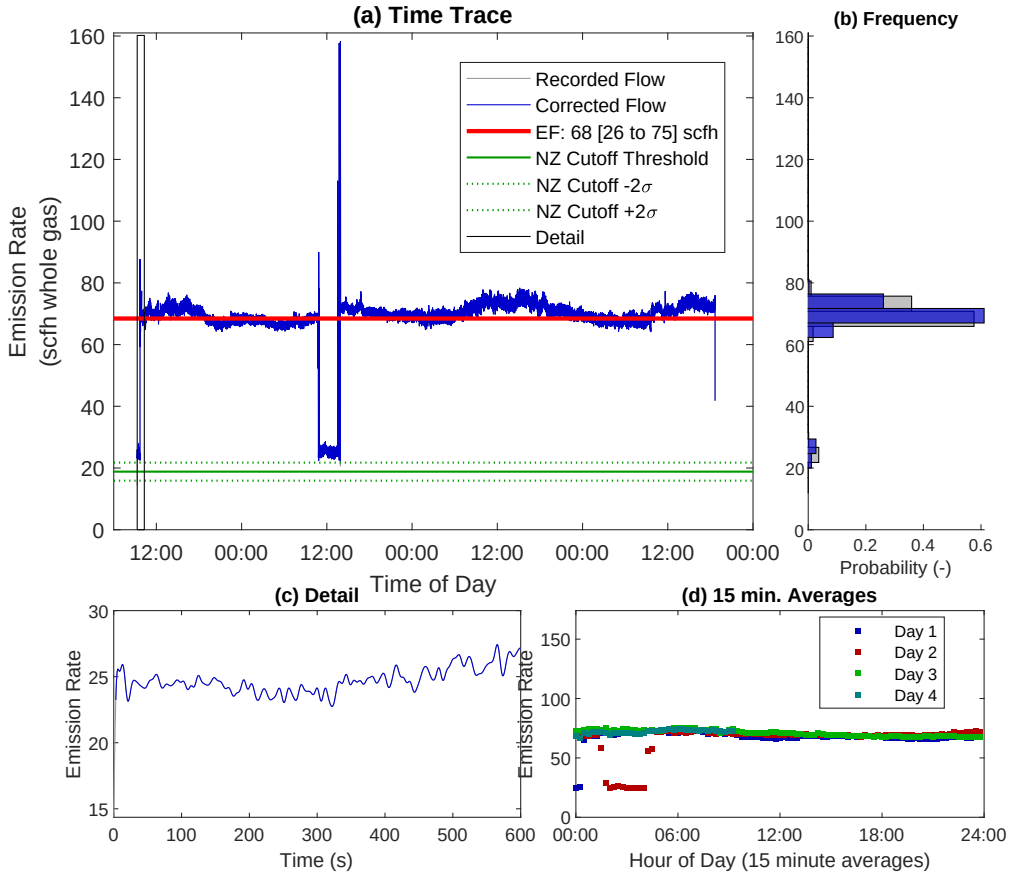

Figure S1-42: Device J-6

Device L-2

Site Class: III	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 94.7 hrs
Controller Location: Compressor	Avg. Gas Temperature: 28.2 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14.3 psia
Controller Model: Control Air 950XP	Gas Methane Fraction: 94.5%
EPA Bleed Type: Low Bleed	Emission Factor: 0.035 [0.0032 to 0.022]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

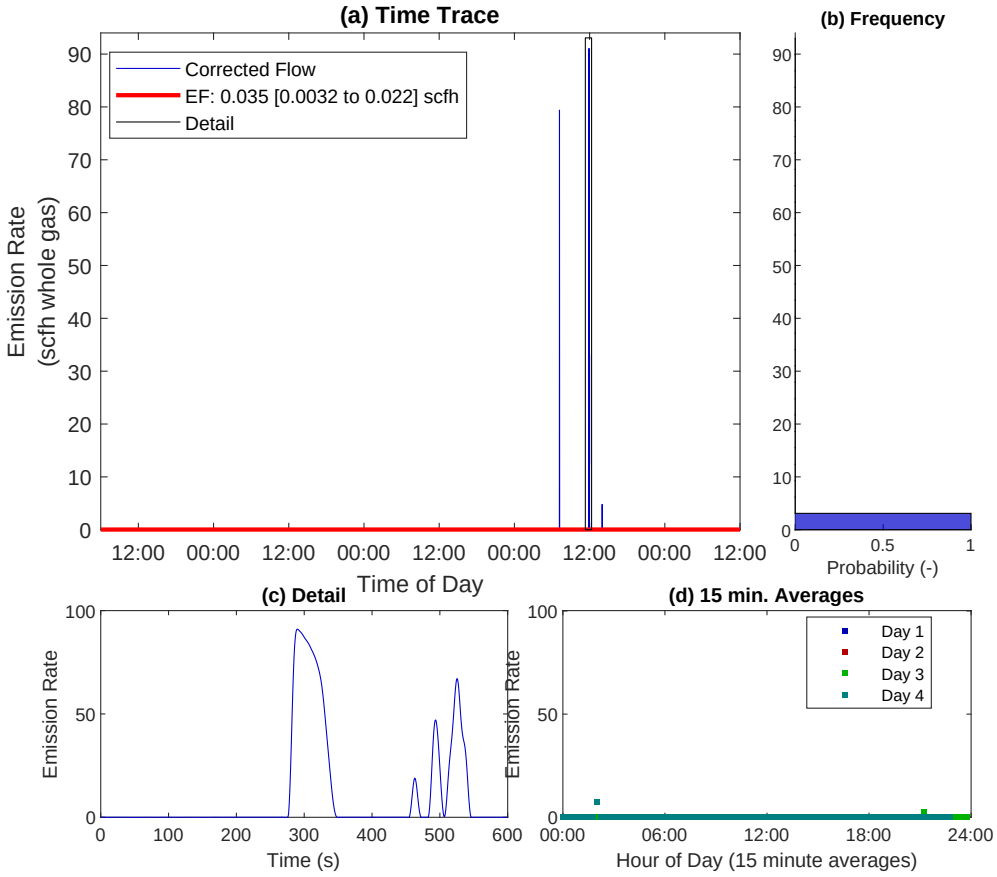

Figure S1-43: Device L-2

Device L-3

Site Class: III	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 94.7 hrs
Controller Location: Compressor	Avg. Gas Temperature: 30.7 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14.5 psia
Controller Model: Control Air 950XP	Gas Methane Fraction: 94.5%
EPA Bleed Type: Low Bleed	Emission Factor: 0.015 [0.0047 to 0.04]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

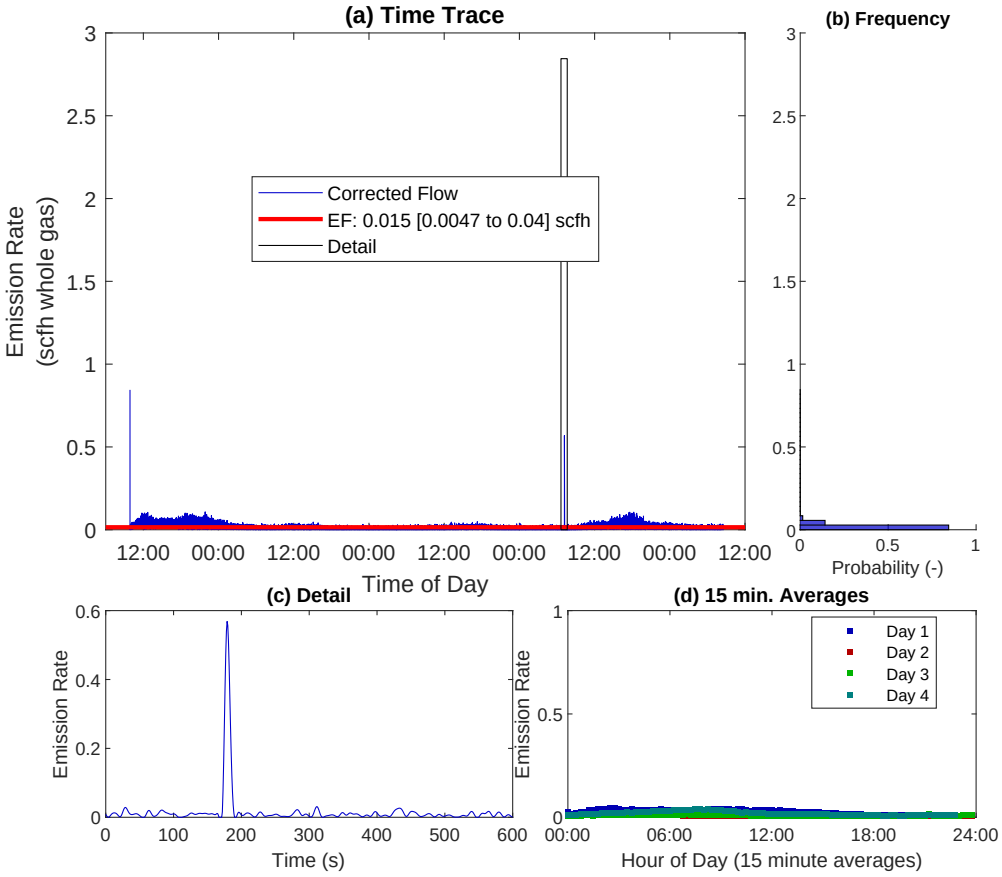

Figure S1-44: Device L-3

Device L-4

Site Class: III	NEMS Region: Gulf Coast
Install Location: Exhaust	Measurement Duration: 94.9 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 19.2 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14.6 psia
Controller Model: Fisher 582i	Gas Methane Fraction: 94.5%
EPA Bleed Type: High Bleed	Emission Factor: 0.56 [0.019 to 2.5]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

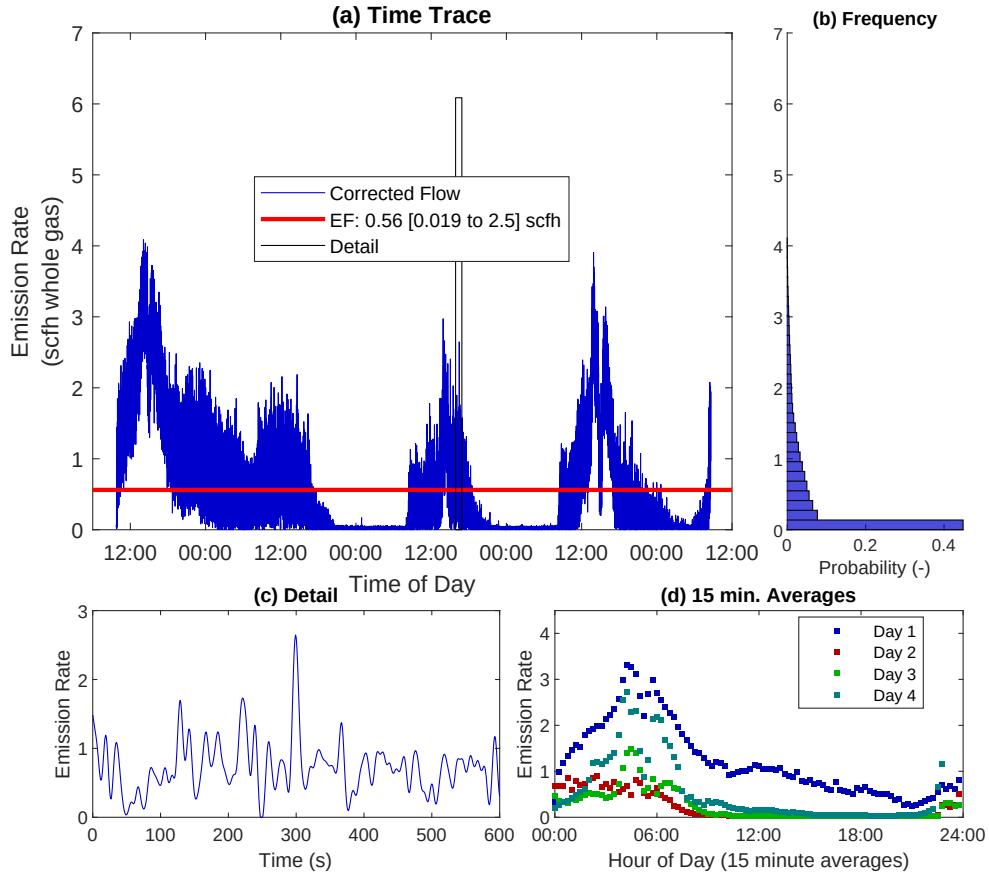

Figure S1-45: Device L-4

Device N-1

Site Class: I	NEMS Region: Midcontinent
Install Location: Inline	Measurement Duration: 80.7 hrs
Controller Location: Separator	Avg. Gas Temperature: 76.8 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 33.9 psia
Controller Model: Solenoid Operated	Gas Methane Fraction: 77.1%
EPA Bleed Type: Intermittent	Emission Factor: 9 [3.9 to 15]
Non-zero Correction:	NZ Cutoff: 0.395 scfh
Samples Remaining: 99%	Emissions Remaining: 100%
Evaluation: Abnormally Operating	

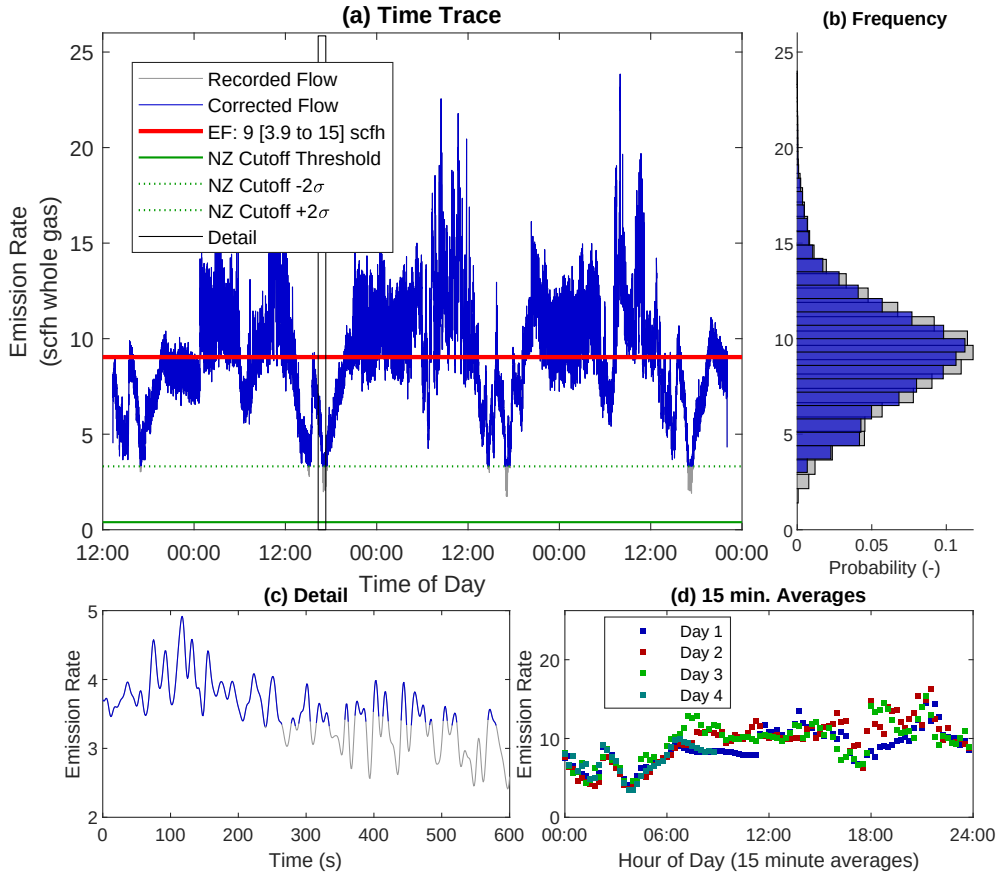

Figure S1-46: Device N-1

Device N-3

Site Class: I	NEMS Region: Midcontinent
Install Location: Inline	Measurement Duration: 74.9 hrs
Controller Location: Compressor	Avg. Gas Temperature: 75.8 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 39.1 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 77.1%
EPA Bleed Type: Intermittent	Emission Factor: 57 [0 to 1.7e+02]
Non-zero Correction:	NZ Cutoff: 5.9 scfh
Samples Remaining: 95%	Emissions Remaining: 99%
Evaluation: Abnormally Operating	

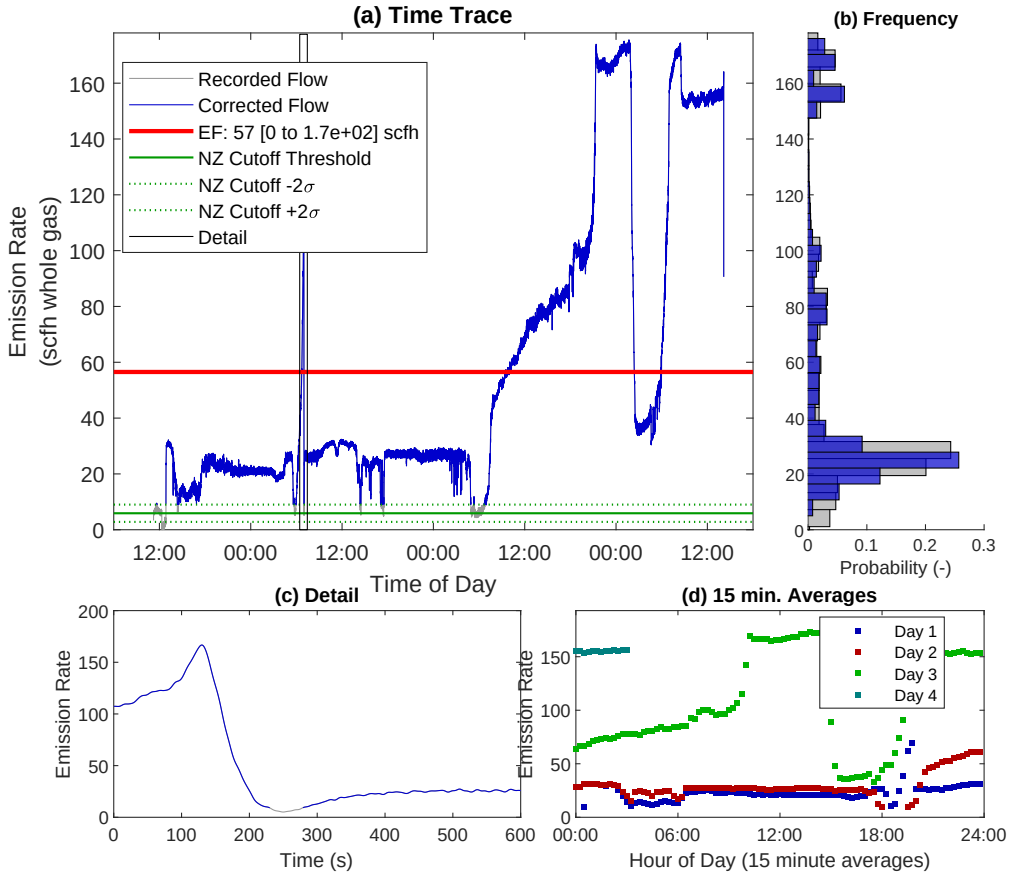

Figure S1-47: Device N-3

Device N-6

Site Class: I	NEMS Region: Midcontinent
Install Location: Inline	Measurement Duration: 83.5 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 67 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 31.9 psia
Controller Model: Moore IPX2	Gas Methane Fraction: 77.1%
EPA Bleed Type: Low Bleed	Emission Factor: 2.9 [1.3e-05 to 6.2]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

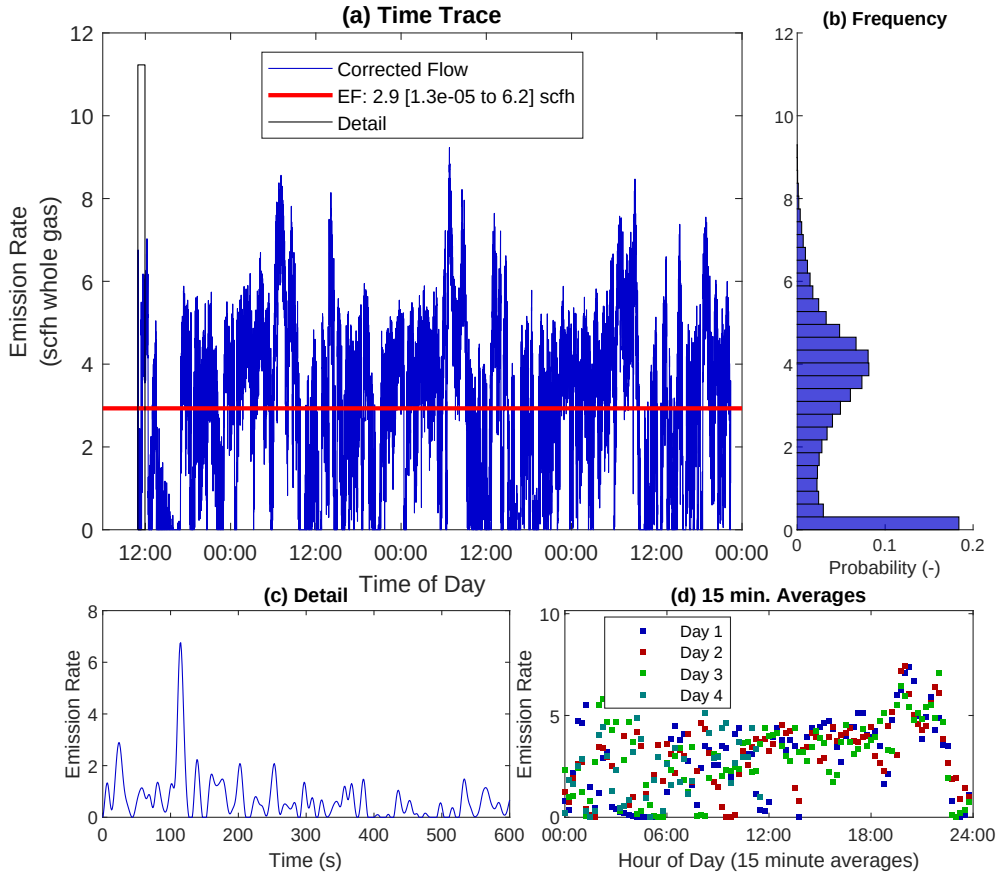

Figure S1-48: Device N-6

Device O-1

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 74.3 hrs
Controller Location: Separator	Avg. Gas Temperature: 19.9 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 29.4 psia
Controller Model: Solenoid Operated	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 0.046 [0.0012 to 0.042]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

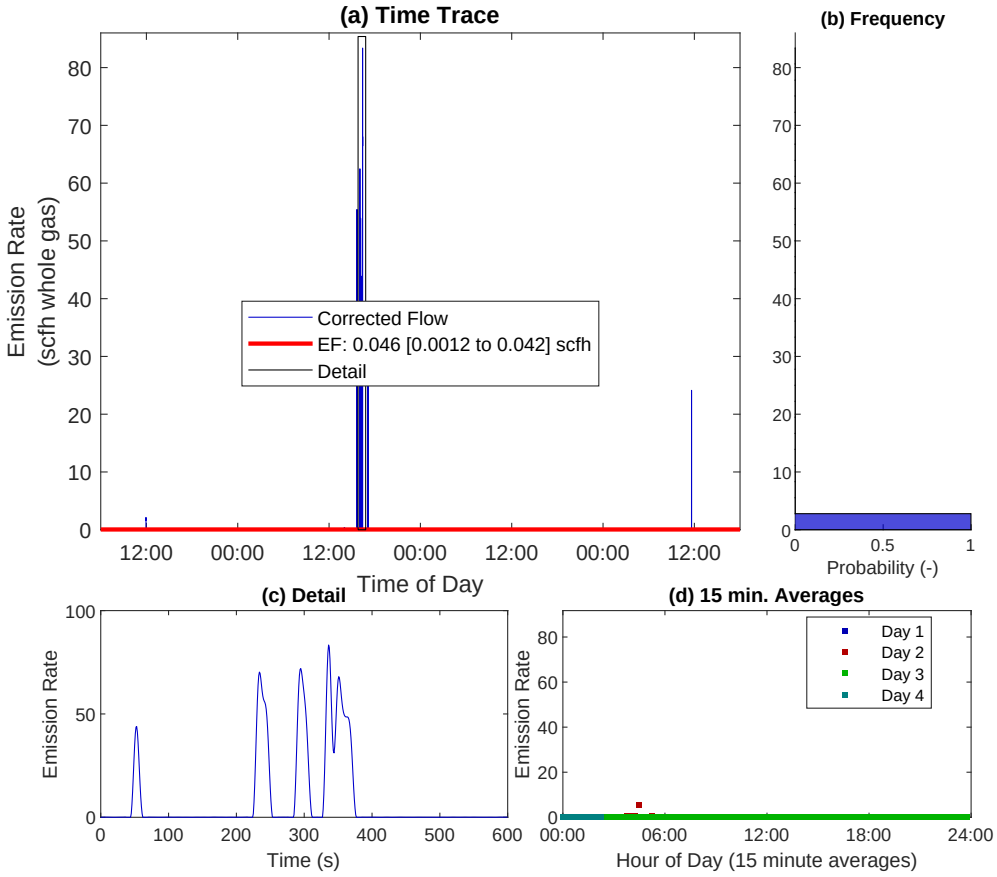

Figure S1-49: Device O-1

Device O-2

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Exhaust	Measurement Duration: 73.8 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 11.1 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 12.1 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Low Bleed	Emission Factor: 0.0051 [0.001 to 0.01]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

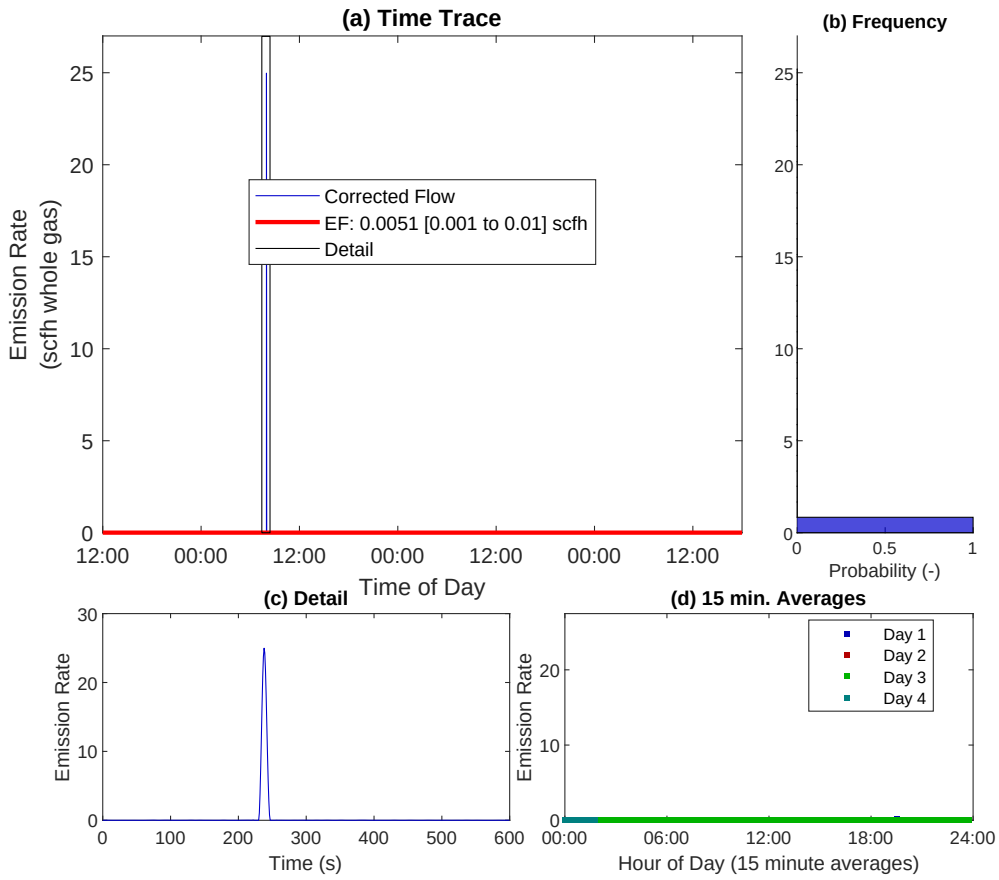

Figure S1-50: Device O-2

Device O-3

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Exhaust	Measurement Duration: 74 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 14 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 12.2 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Low Bleed	Emission Factor: 0.53 [0.0052 to 6.9]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

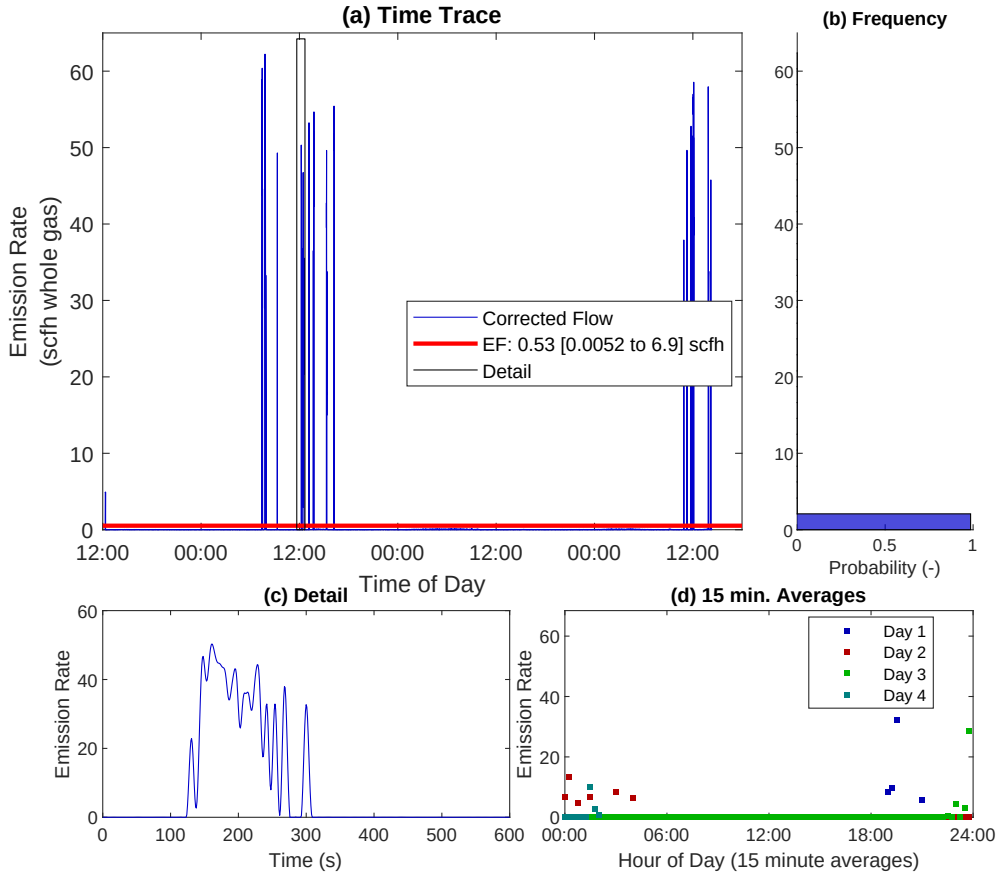

Figure S1-51: Device O-3

Device Q-1

Site Class: III	NEMS Region: Southwest
Install Location: Exhaust	Measurement Duration: 101 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 74.6 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 13.1 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 80%
EPA Bleed Type: Low Bleed	Emission Factor: 0.043 [0.02 to 0.083]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

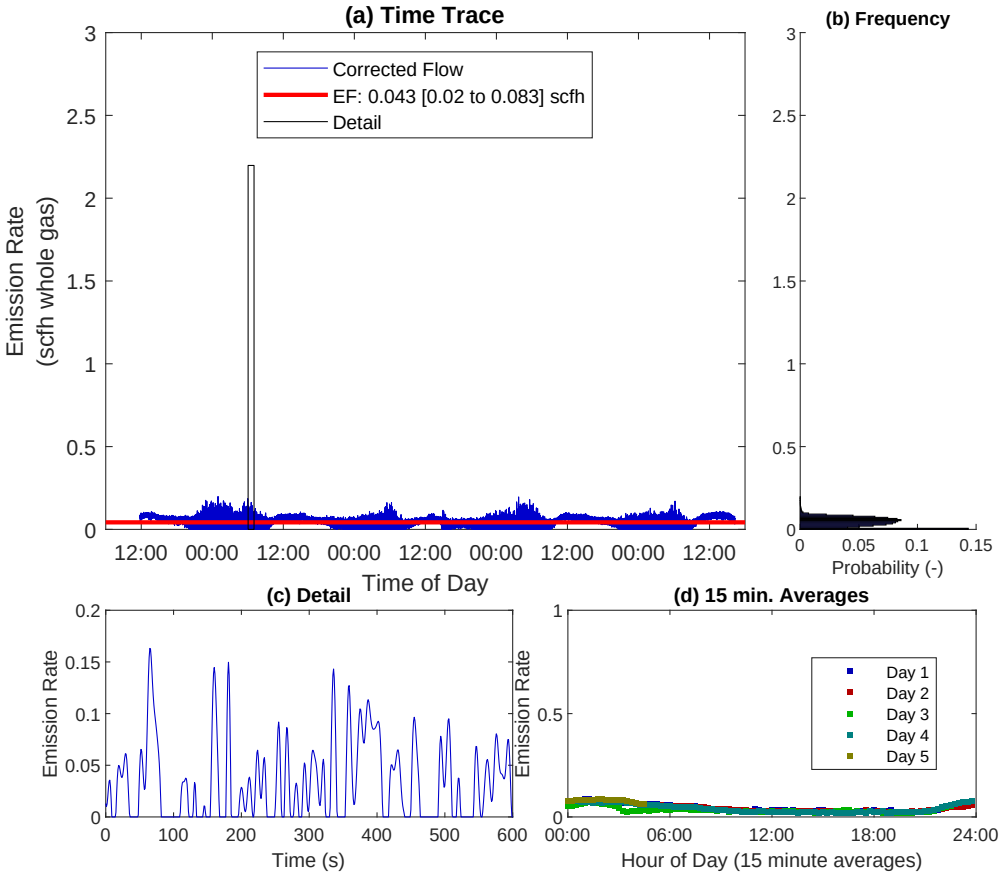

Figure S1-52: Device Q-1

Device Q-4

Site Class: III	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 91.6 hrs
Controller Location: Compressor	Avg. Gas Temperature: 64.7 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 27.3 psia
Controller Model: Fisher 4160k	Gas Methane Fraction: 80%
EPA Bleed Type: High Bleed	Emission Factor: 25 [17 to 32]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

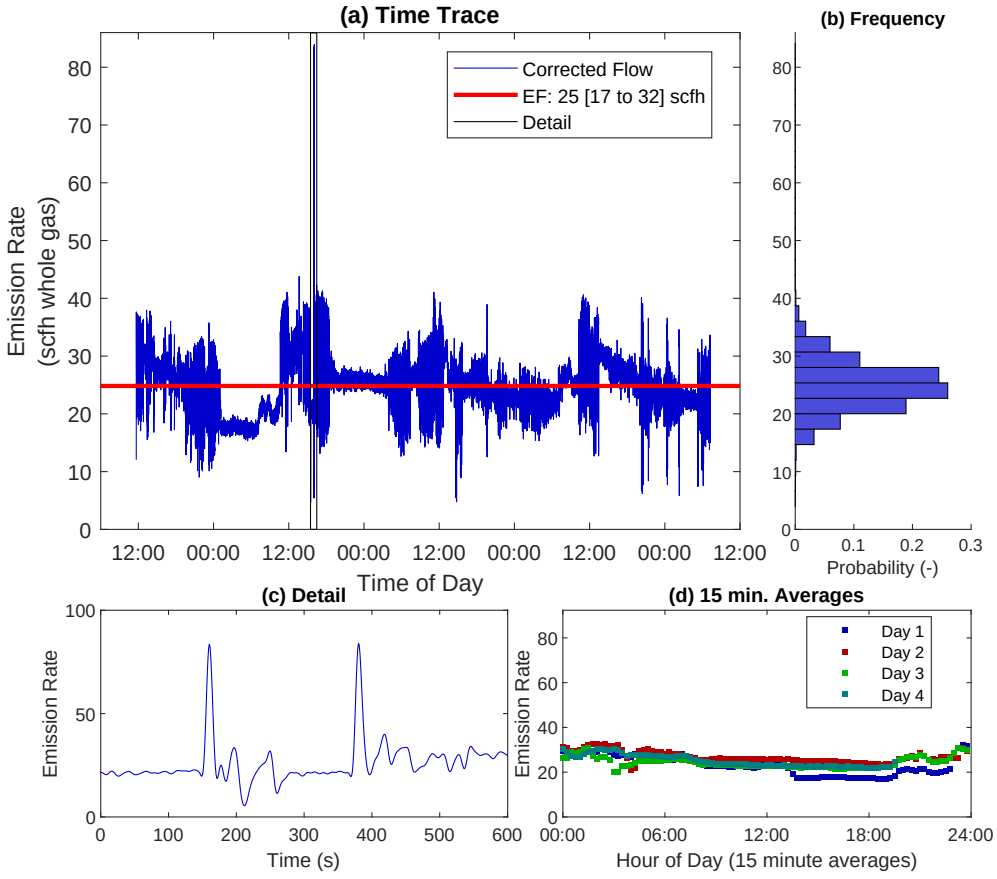

Figure S1-53: Device Q-4

Device Q-6

Site Class: III	NEMS Region: Southwest
Install Location: Exhaust	Measurement Duration: 99.7 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 70.8 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 13.2 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 80%
EPA Bleed Type: Low Bleed	Emission Factor: 0 [0 to 0]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

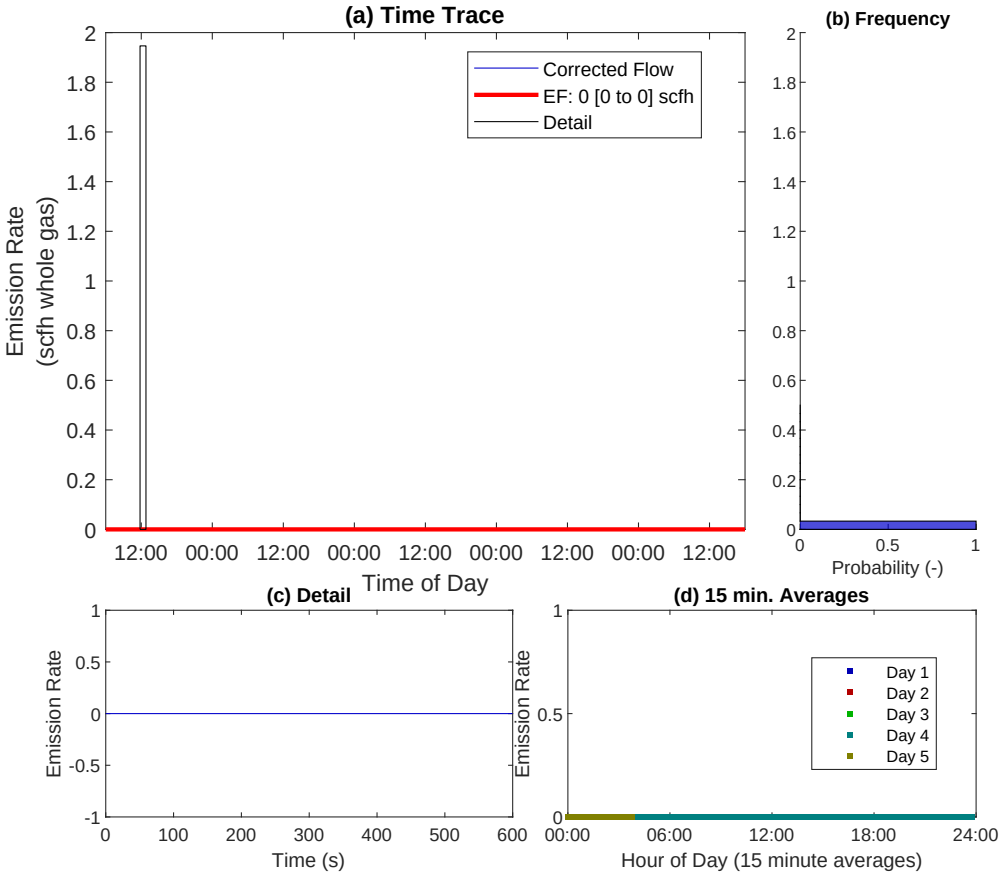

Figure S1-54: Device Q-6

Device S-2

Site Class: I	NEMS Region: Midcontinent
Install Location: Exhaust	Measurement Duration: 97.8 hrs
Controller Location: Glycol Dehydrator	Avg. Gas Temperature: 62.7 $°F$
Process Controlled: Temperature	Avg. Supply Pressure: 14.2 psia
Controller Model: Kimray T12	Gas Methane Fraction: 96.8%
EPA Bleed Type: Intermittent	Emission Factor: 1.3 [0.0092 to 38]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Abnormally Operating	

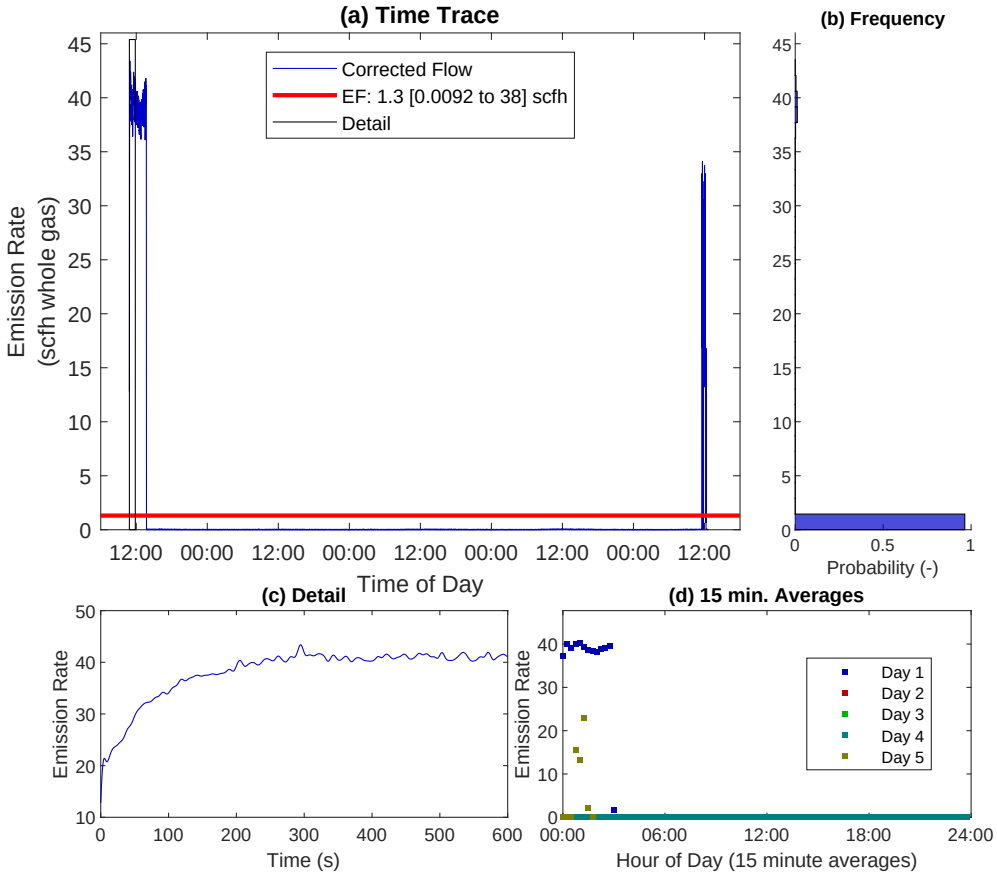

Figure S1-55: Device S-2

Device S-6

Site Class: I	NEMS Region: Midcontinent
Install Location: Exhaust	Measurement Duration: 94.9 hrs
Controller Location: Glycol Dehydrator	Avg. Gas Temperature: 61.1 $^{\circ}F$
Process Controlled: Temperature	Avg. Supply Pressure: 14.3 psia
Controller Model: Kimray T12	Gas Methane Fraction: 96.8%
EPA Bleed Type: Intermittent	Emission Factor: 0.015 [0 to 0.0014]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

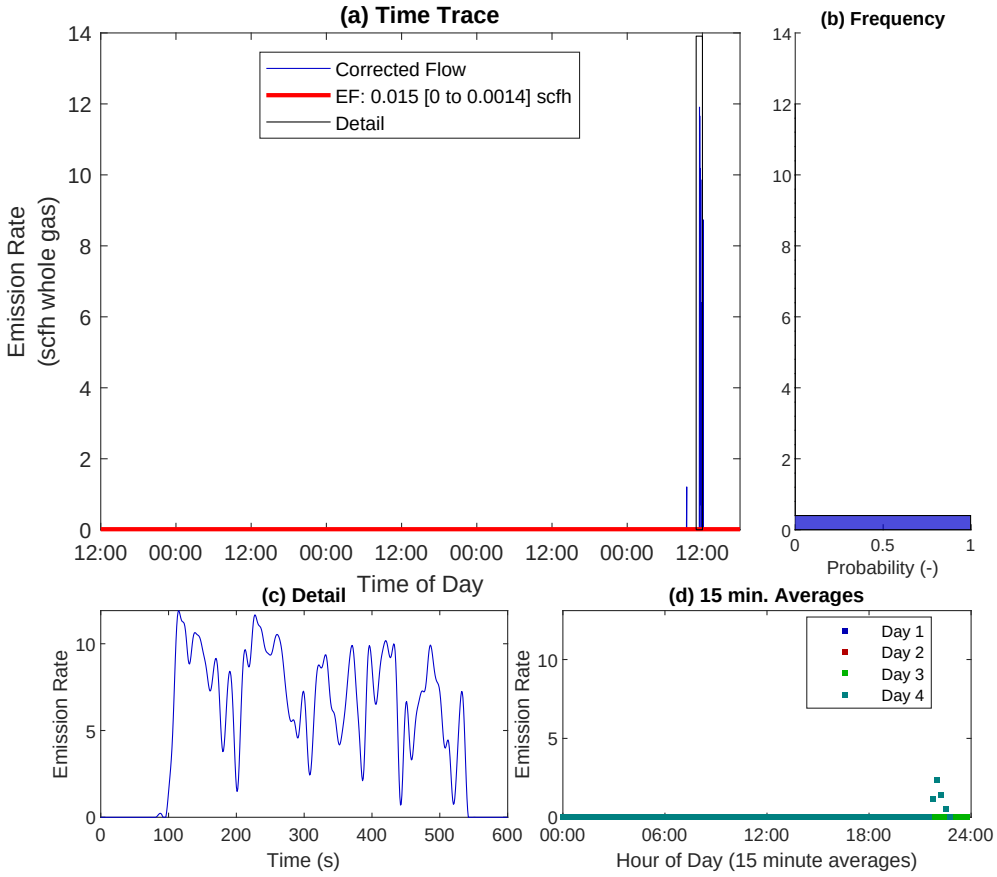

Figure S1-56: Device S-6

Device T-2

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Exhaust	Measurement Duration: 68.6 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 0.893 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 12.2 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Low Bleed	Emission Factor: 4.4e-06 [0 to 4.4e-05]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

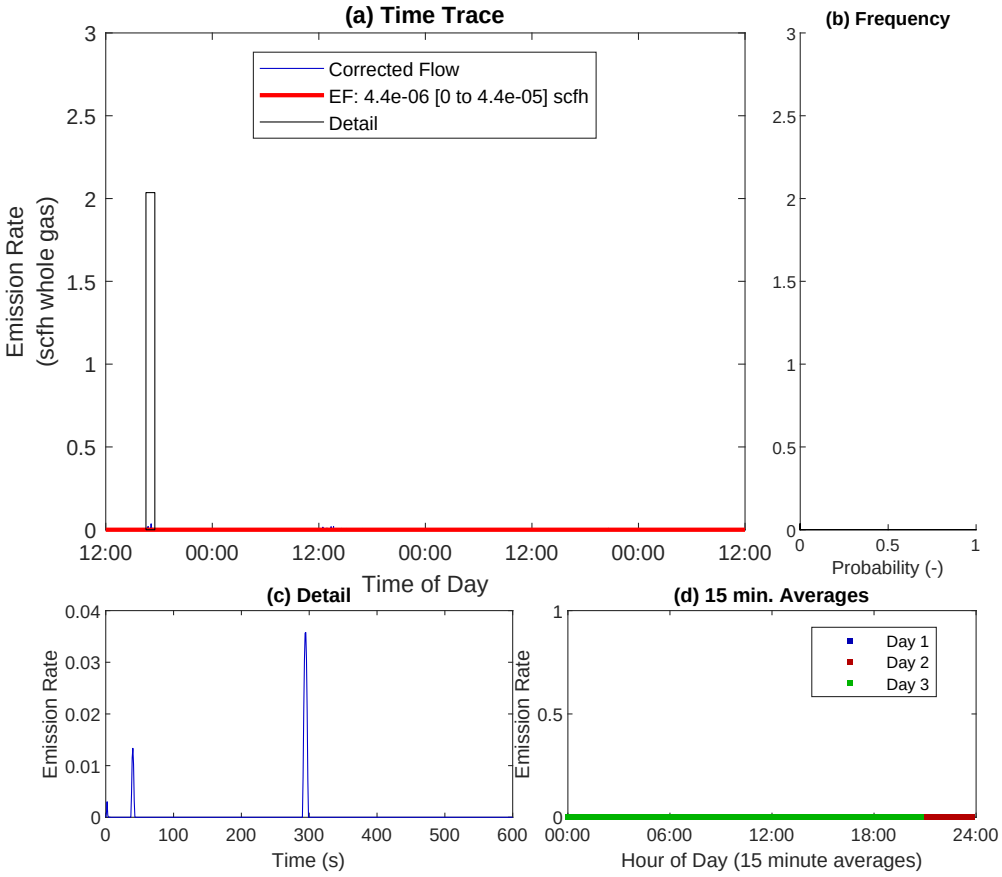

Figure S1-57: Device T-2

Device U-2

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Exhaust	Measurement Duration: 76.6 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 12.6 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 12 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Low Bleed	Emission Factor: 0.0048 [0.0015 to 0.011]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

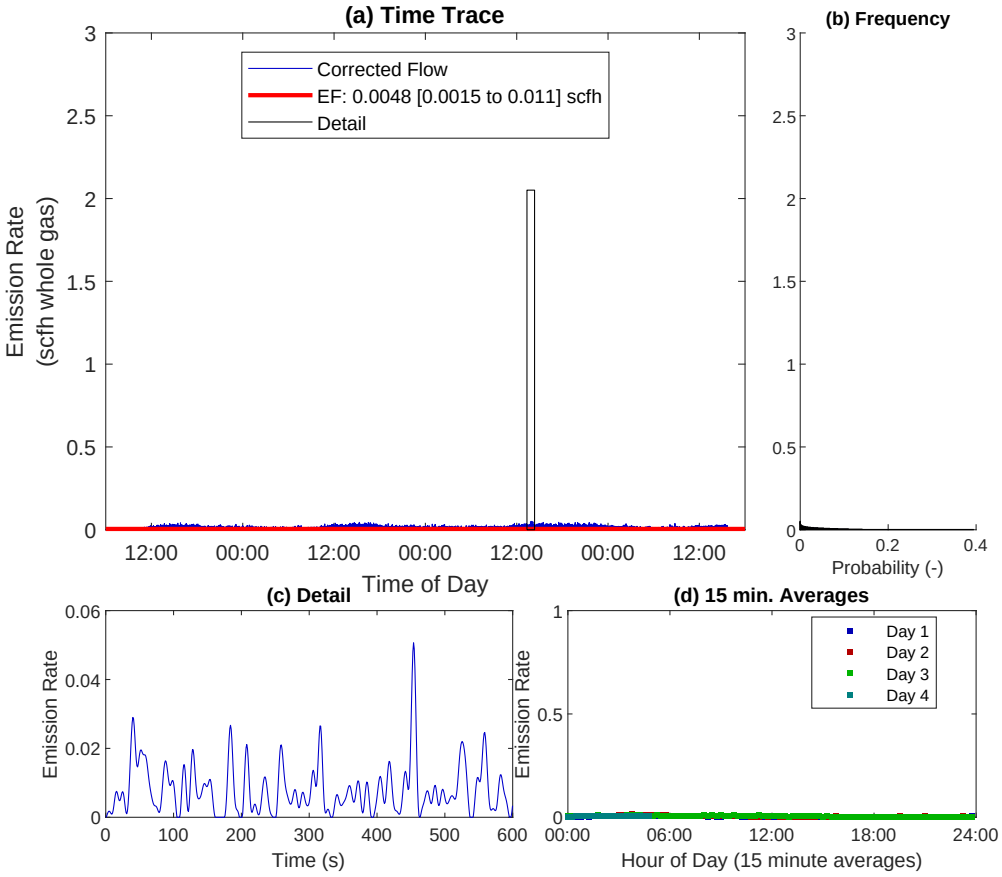

Figure S1-58: Device U-2

Device U-3

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Exhaust	Measurement Duration: 76.6 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 10.6 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 12.2 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Low Bleed	Emission Factor: 0.31 [0.006 to 0.034]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

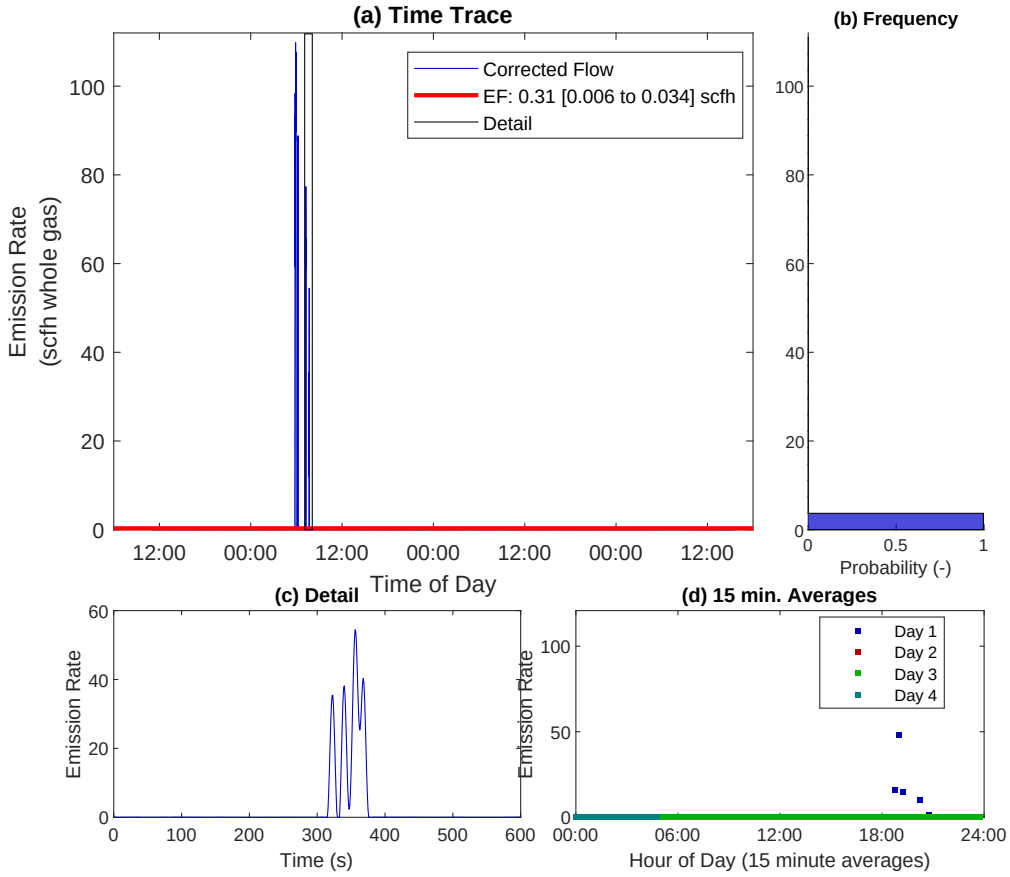

Figure S1-59: Device U-3

Device V-1

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 78.3 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 16.5 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 30.1 psia
Controller Model: Fisher C1	Gas Methane Fraction: 75%
EPA Bleed Type: Low Bleed	Emission Factor: 0.027 [0 to 0.32]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

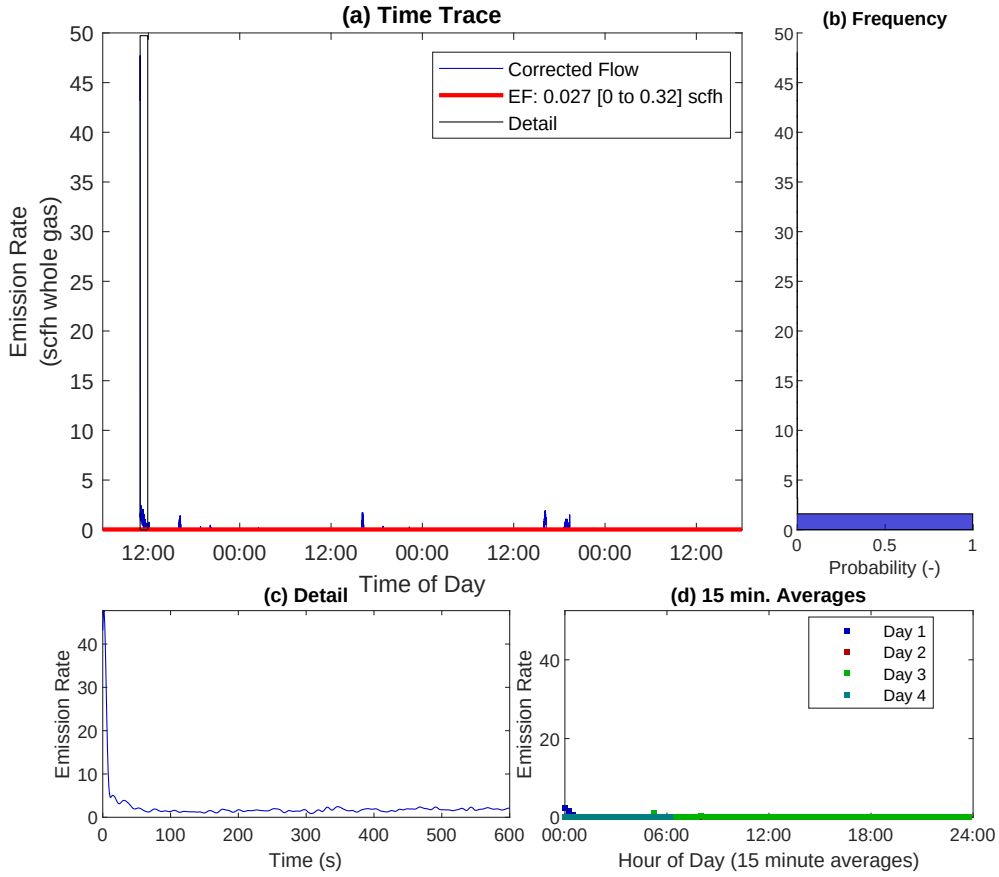

Figure S1-60: Device V-1

Device V-4

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Exhaust	Measurement Duration: 78.2 hrs
Controller Location: Separator	Avg. Gas Temperature: 42 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 12.4 psia
Controller Model: Murphy L1200N	Gas Methane Fraction: 75%
EPA Bleed Type: Intermittent	Emission Factor: 0.72 [0.014 to 2.7]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

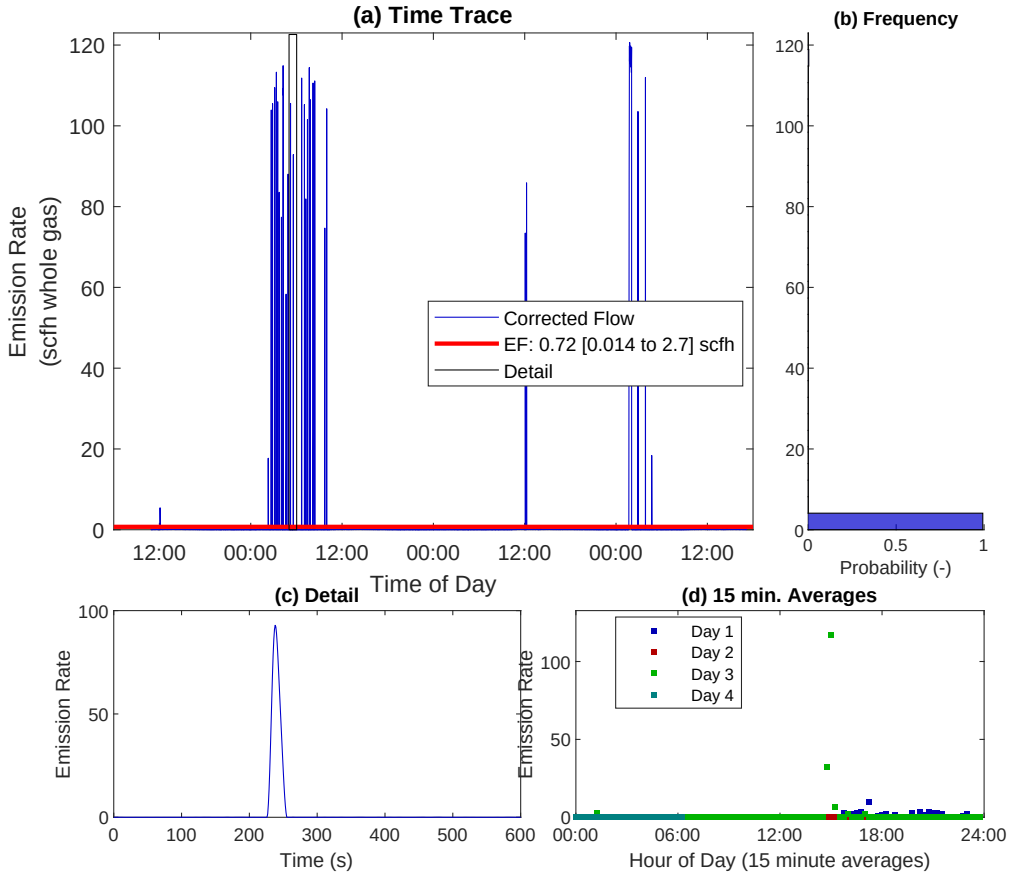

Figure S1-61: Device V-4

Device Y-1

Site Class: I	NEMS Region: Appalachian
Install Location: Exhaust	Measurement Duration: 95.9 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 41.4 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 77.8%
EPA Bleed Type: Low Bleed	Emission Factor: 1.6 [0.0099 to 8.5]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

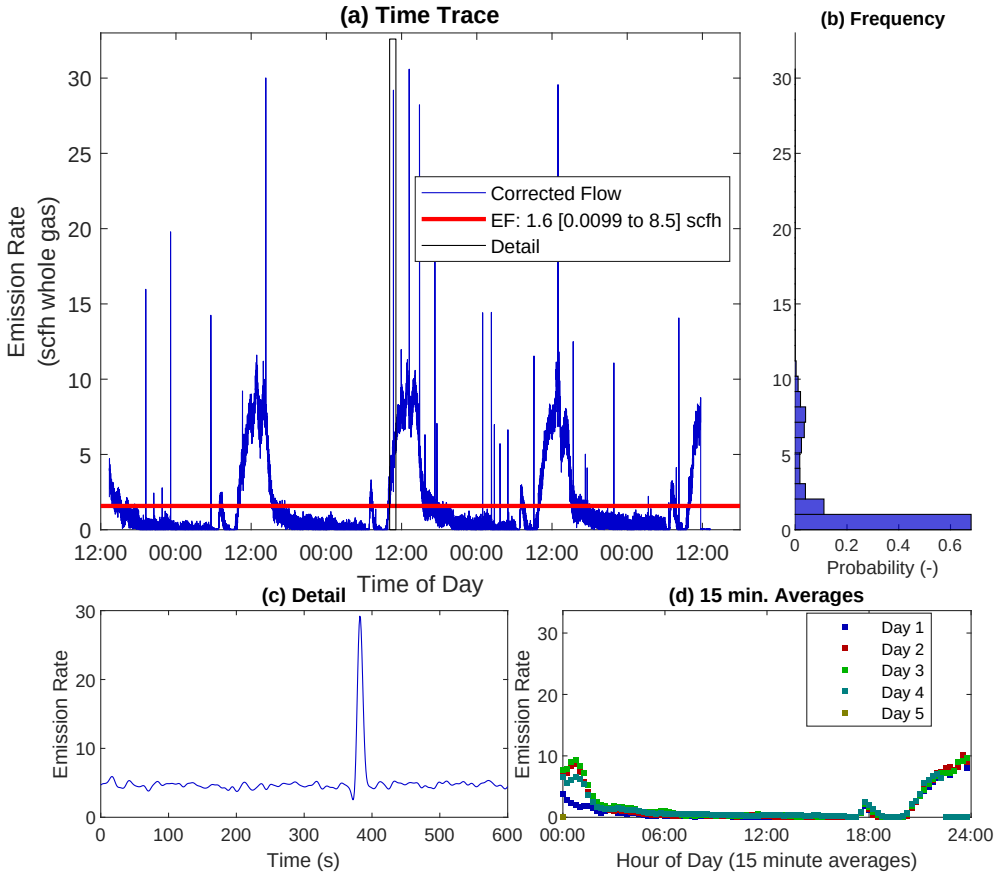

Figure S1-62: Device Y-1

Device Y-2

Site Class: I	NEMS Region: Appalachian
Install Location: Exhaust	Measurement Duration: 92 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 27.2 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 77.8%
EPA Bleed Type: High Bleed	Emission Factor: 15 [12 to 18]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

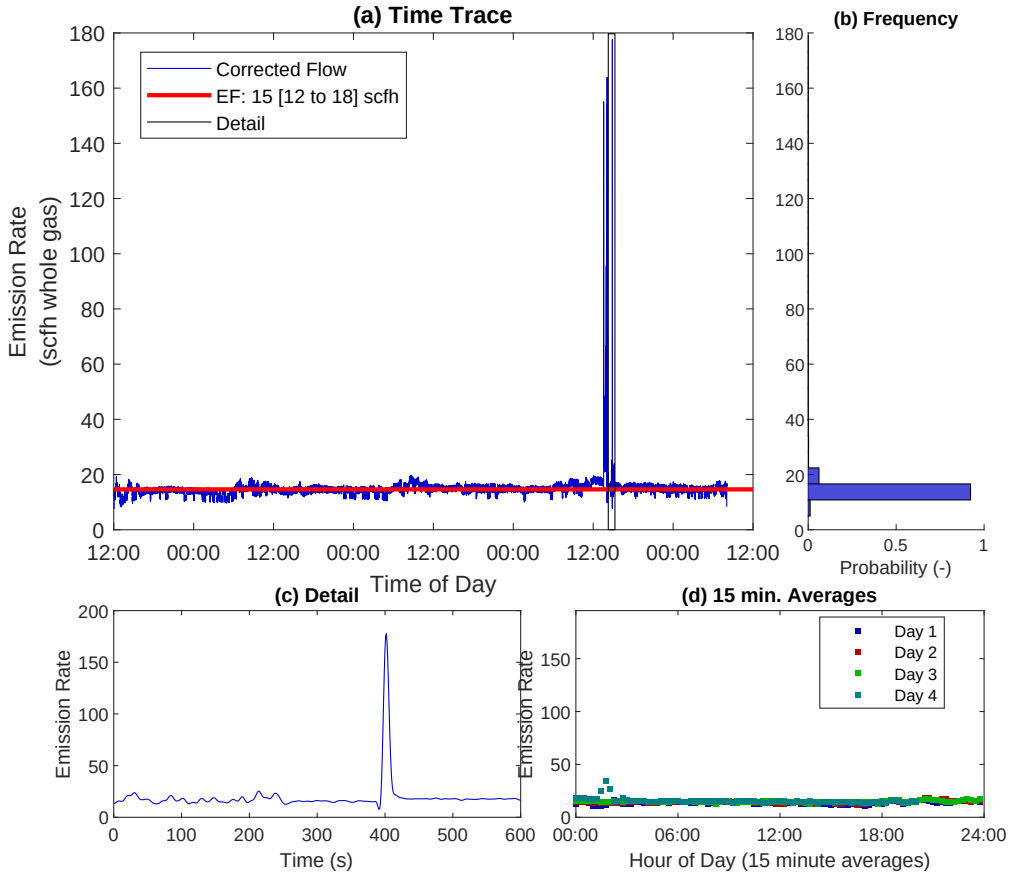

Figure S1-63: Device Y-2

Device Y-4

Site Class: I	NEMS Region: Appalachian
Install Location: Exhaust	Measurement Duration: 101 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 30.5 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14.3 psia
Controller Model: Fisher C1	Gas Methane Fraction: 77.8%
EPA Bleed Type: Low Bleed	Emission Factor: 0.047 [0.015 to 0.085]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

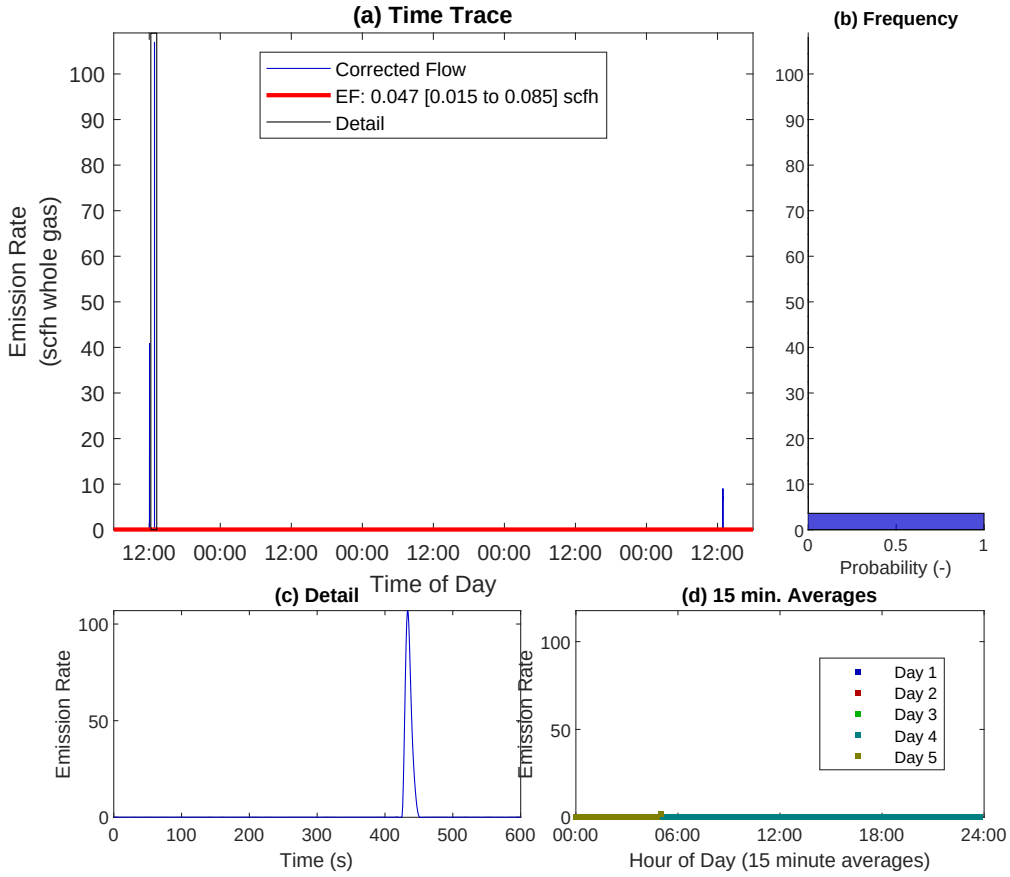

Figure S1-64: Device Y-4

Device Y-5

Site Class: I	NEMS Region: Appalachian
Install Location: Exhaust	Measurement Duration: 94.8 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 23.4 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 14.2 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 77.8%
EPA Bleed Type: High Bleed	Emission Factor: 11 [9.7 to 13]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

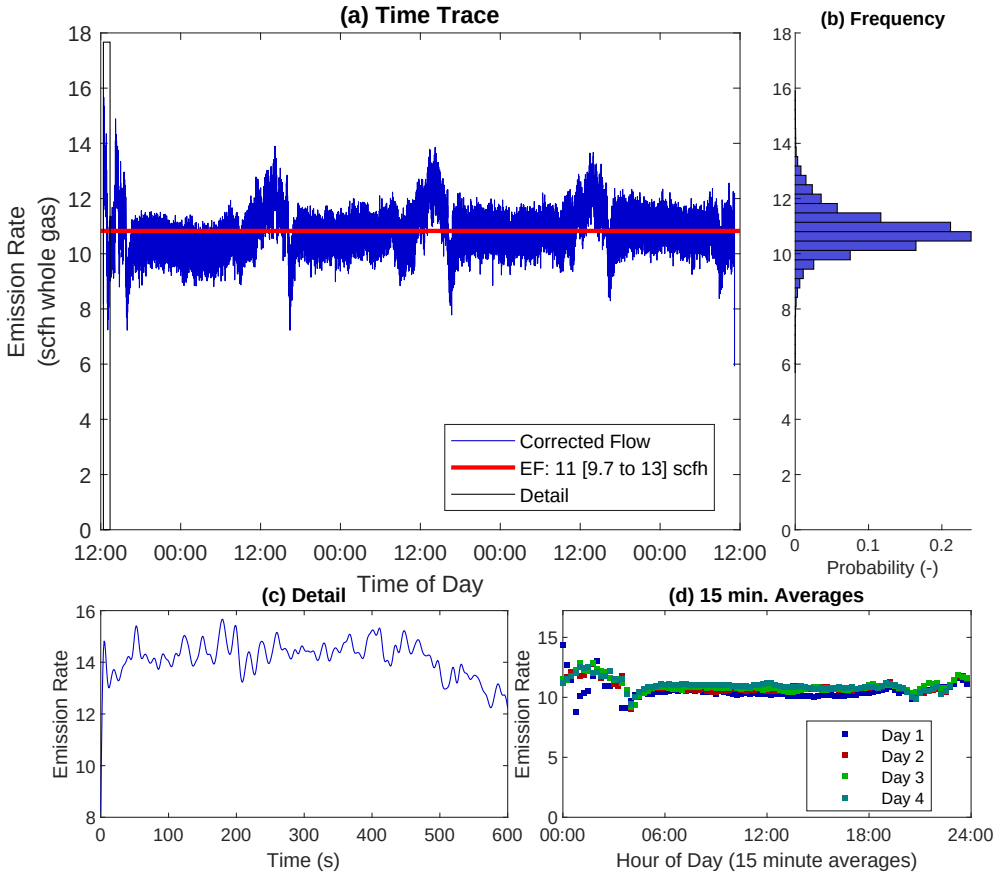

Figure S1-65: Device Y-5

Device Y-6

Site Class: I	NEMS Region: Appalachian
Install Location: Exhaust	Measurement Duration: 90.9 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 24.9 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 14.1 psia
Controller Model: Fisher FieldVue DCV 6200	Gas Methane Fraction: 77.8%
EPA Bleed Type: High Bleed	Emission Factor: 12 [10 to 15]
Non-zero Correction:	NZ Cutoff: None
Samples Remaining: 100%	Emissions Remaining: 100%
Evaluation: Normally Operating	

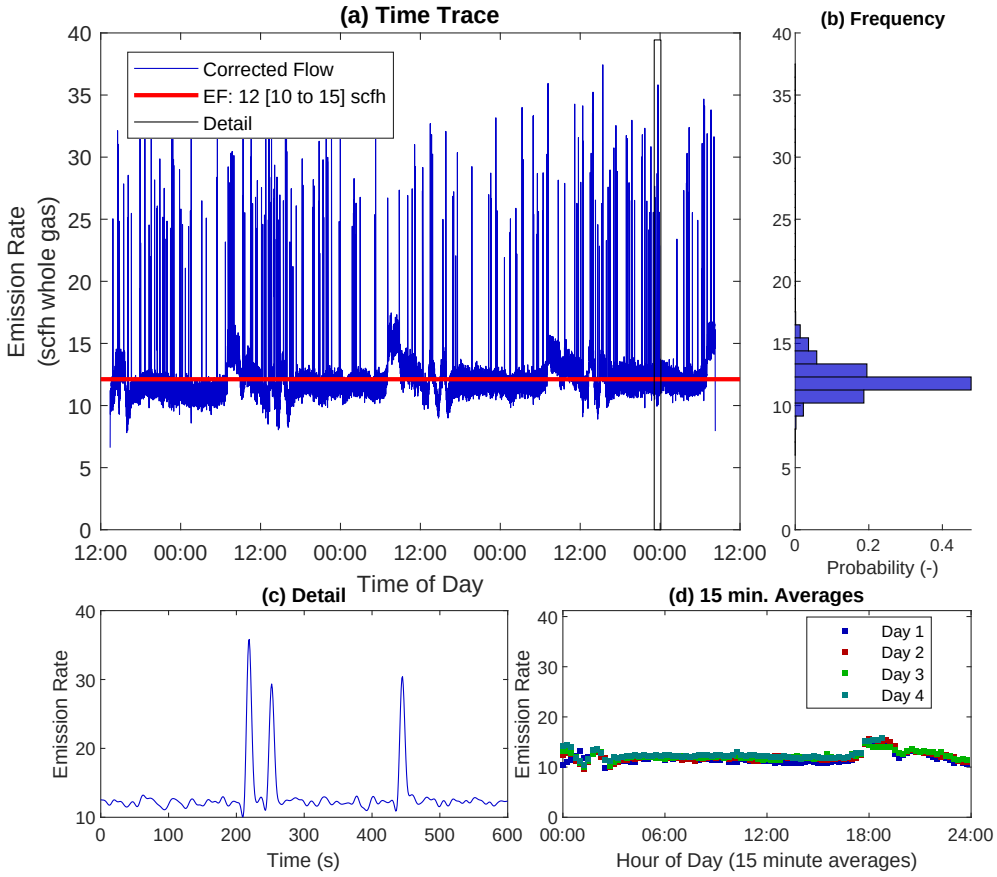

Figure S1-66: Device Y-6

S1-7.2 Low Impact

This section contains recordings that showed a clear NZ baseline, but average emission rates were decreased by <20% after applying the NZ correction.

Device D-2

Site Class: I	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 89.5 hrs
Controller Location: Compressor	Avg. Gas Temperature: 52 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 32.4 psia
Controller Model: Mallard, 3100-P1	Gas Methane Fraction: 99.2%
EPA Bleed Type: Intermittent	Emission Factor: 20 [9.2 to 32]
Non-zero Correction:	NZ Cutoff: 3.5 scfh
Samples Remaining: 73%	Emissions Remaining: 96%
Evaluation: Normally Operating	

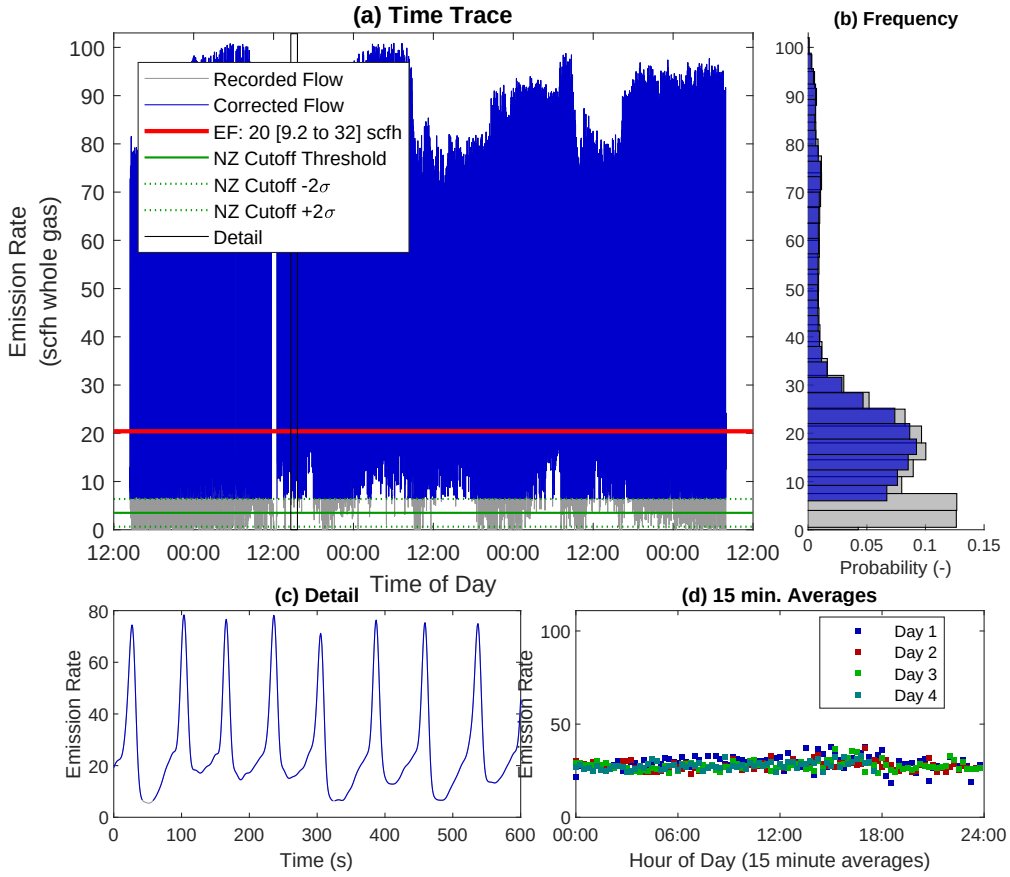

Figure S1-67: Device D-2

Device D-3

Site Class: I	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 88.6 hrs
Controller Location: Compressor	Avg. Gas Temperature: 43.3 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 44.1 psia
Controller Model: Fisher C1	Gas Methane Fraction: 99.2%
EPA Bleed Type: Low Bleed	Emission Factor: 14 [0 to 23]
Non-zero Correction:	NZ Cutoff: 11.9 scfh
Samples Remaining: 77%	Emissions Remaining: 81%
Evaluation: Abnormally Operating	

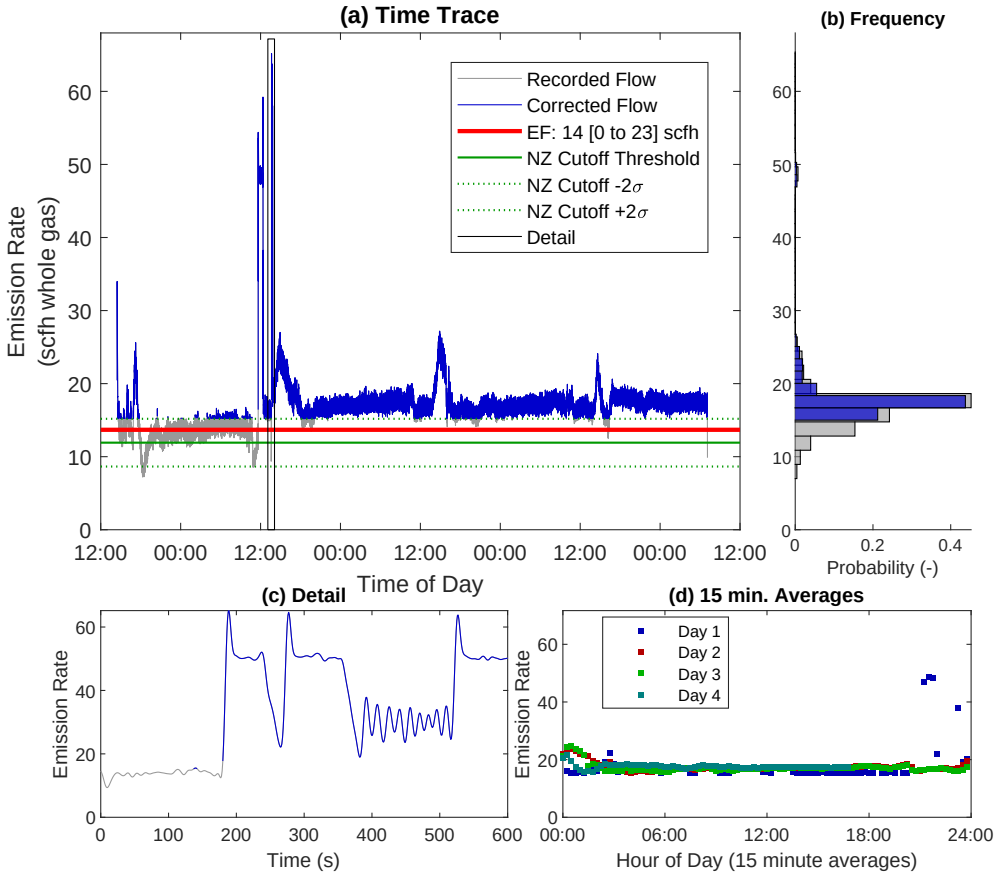

Figure S1-68: Device D-3

Device H-1

Site Class: I	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 86.8 hrs
Controller Location: Compressor	Avg. Gas Temperature: 73 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 39.2 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 70%
EPA Bleed Type: Intermittent	Emission Factor: 21 [0 to 42]
Non-zero Correction:	NZ Cutoff: 3.94 scfh
Samples Remaining: 42%	Emissions Remaining: 95%
Evaluation: Abnormally Operating	

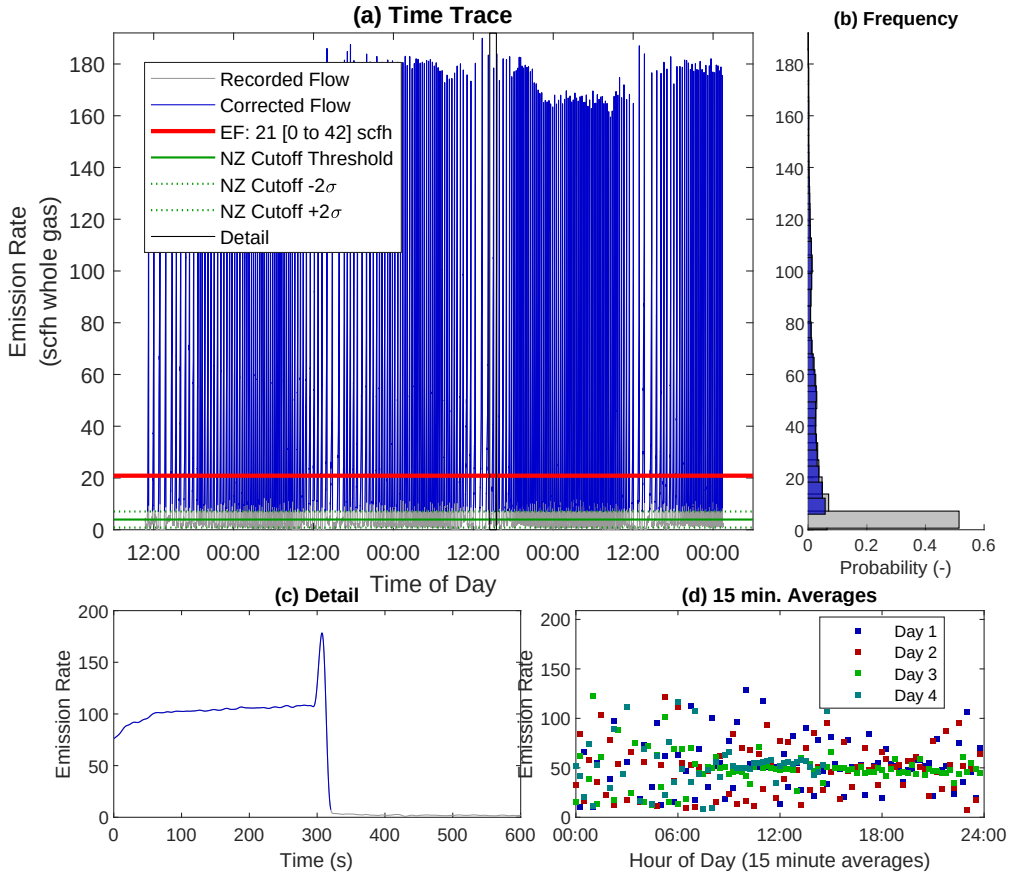

Figure S1-69: Device H-1

Device S-4

Site Class: I	NEMS Region: Midcontinent
Install Location: Inline	Measurement Duration: 90.8 hrs
Controller Location: Glycol Dehydrator	Avg. Gas Temperature: 50.6 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 42.4 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 96.8%
EPA Bleed Type: Intermittent	Emission Factor: 0.4 [0 to 0]
Non-zero Correction:	NZ Cutoff: 7.22 scfh
Samples Remaining: 1.8%	Emissions Remaining: 86%
Evaluation: Abnormally Operating	

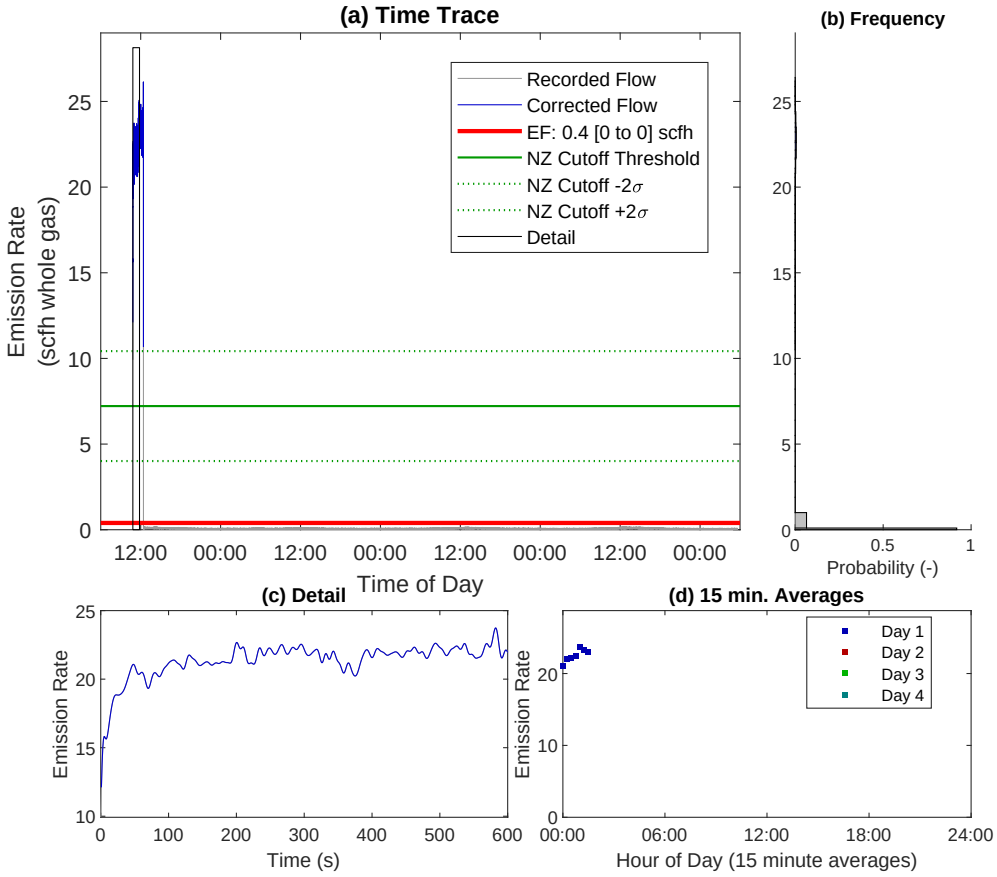

Figure S1-70: Device S-4

Device T-4

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 70.3 hrs
Controller Location: Compressor	Avg. Gas Temperature: 35.4 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 36.6 psia
Controller Model: Mallard 3200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 13 [0 to 84]
Non-zero Correction:	NZ Cutoff: 3.11 scfh
Samples Remaining: 31%	Emissions Remaining: 84%
Evaluation: Abnormally Operating	

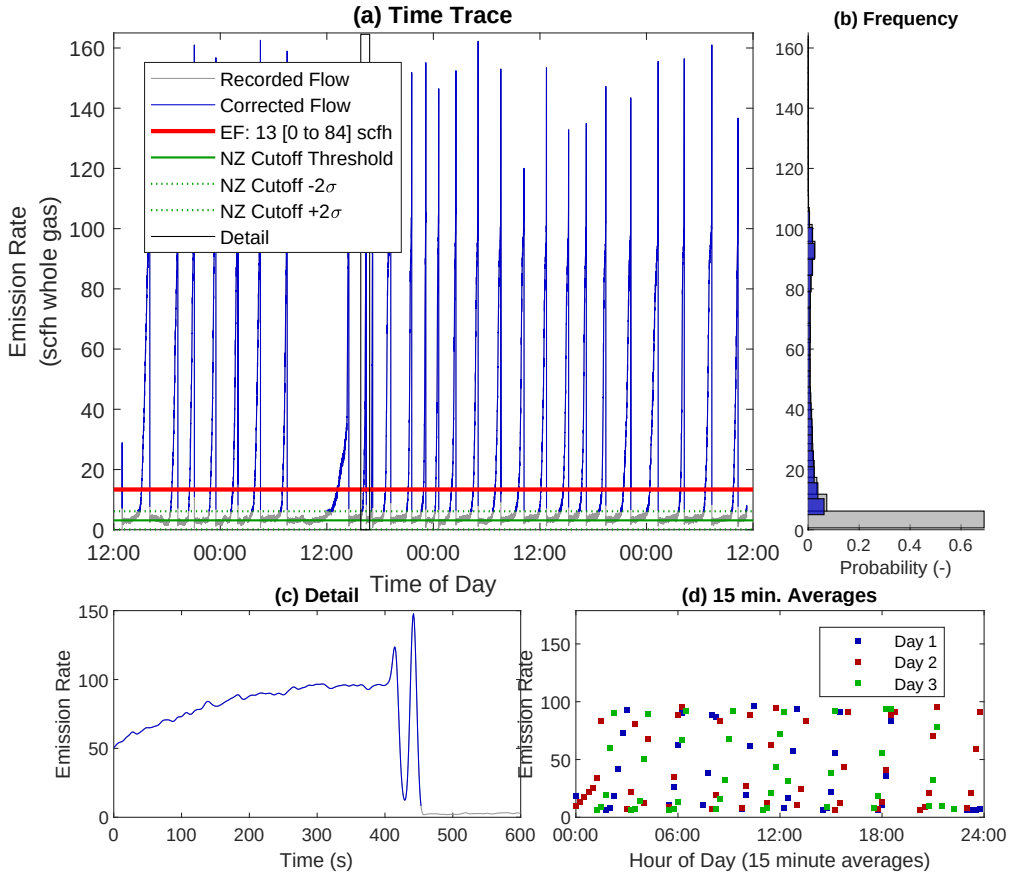

Figure S1-71: Device T-4

Device U-5

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 77 hrs
Controller Location: Compressor	Avg. Gas Temperature: 45.6 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 31.9 psia
Controller Model: Mallard 3200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 1.6 [0 to 25]
Non-zero Correction:	NZ Cutoff: 3.22 scfh
Samples Remaining: 4.7%	Emissions Remaining: 90%
Evaluation: Abnormally Operating	

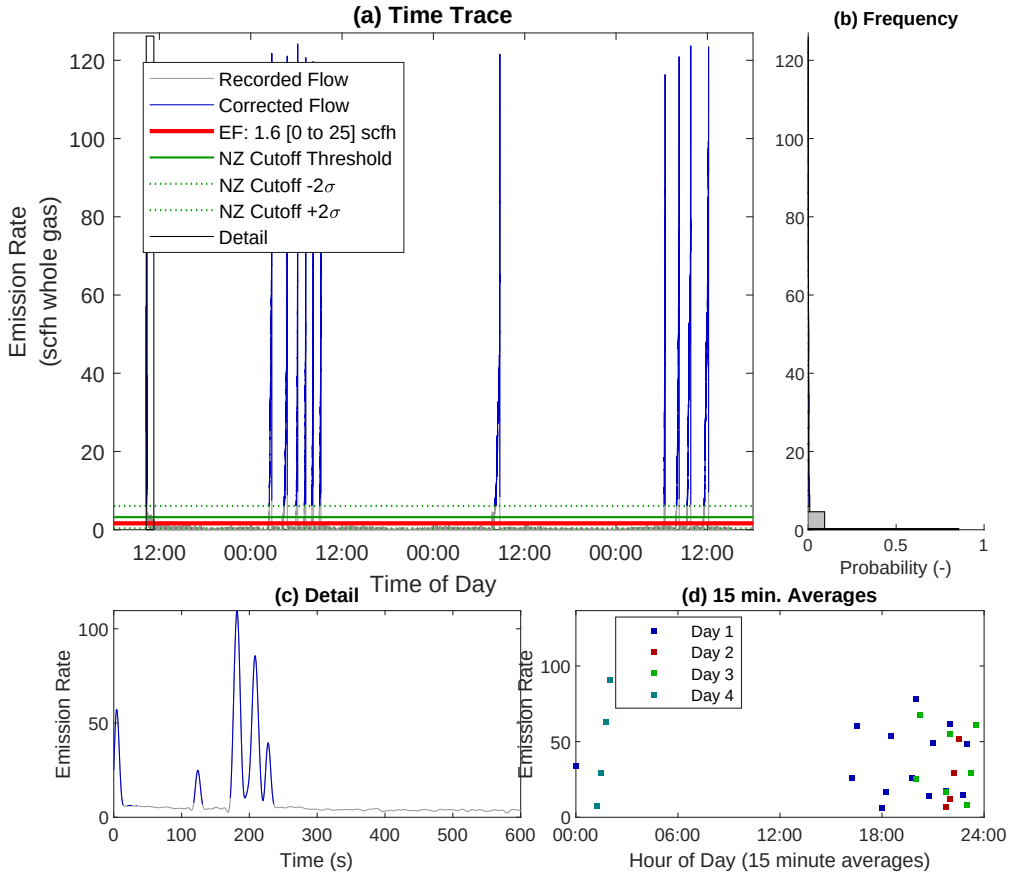

Figure S1-72: Device U-5

Device V-6

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 78.2 hrs
Controller Location: Separator	Avg. Gas Temperature: 21.5 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 48 psia
Controller Model: Murphy, L1200N	Gas Methane Fraction: 75%
EPA Bleed Type: Intermittent	Emission Factor: 25 [0 to 41]
Non-zero Correction:	NZ Cutoff: 20.8 scfh
Samples Remaining: 79%	Emissions Remaining: 85%
Evaluation: Abnormally Operating	

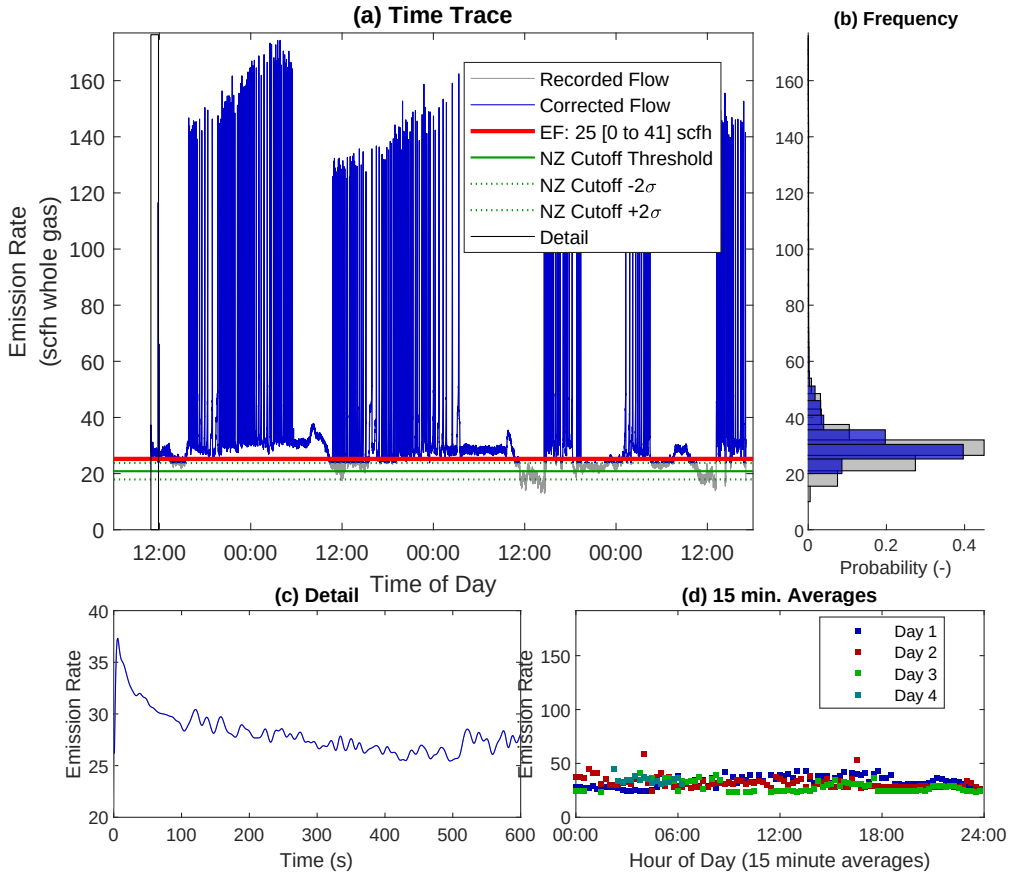

Figure S1-73: Device V-6

S1-7.3 High Impact

This section contains recordings that showed a clear NZ baseline and average emission rates were decreased by >20% after applying the NZ correction.

Device A-2

Site Class: II	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 69.8 hrs
Controller Location: Compressor	Avg. Gas Temperature: 52.8 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 34.7 psia
Controller Model: Murphy LS200N	Gas Methane Fraction: 92%
EPA Bleed Type: Intermittent	Emission Factor: 8.8 [0 to 24]
Non-zero Correction:	NZ Cutoff: 5.97 scfh
Samples Remaining: 32%	Emissions Remaining: 70%
Evaluation: Normally Operating	

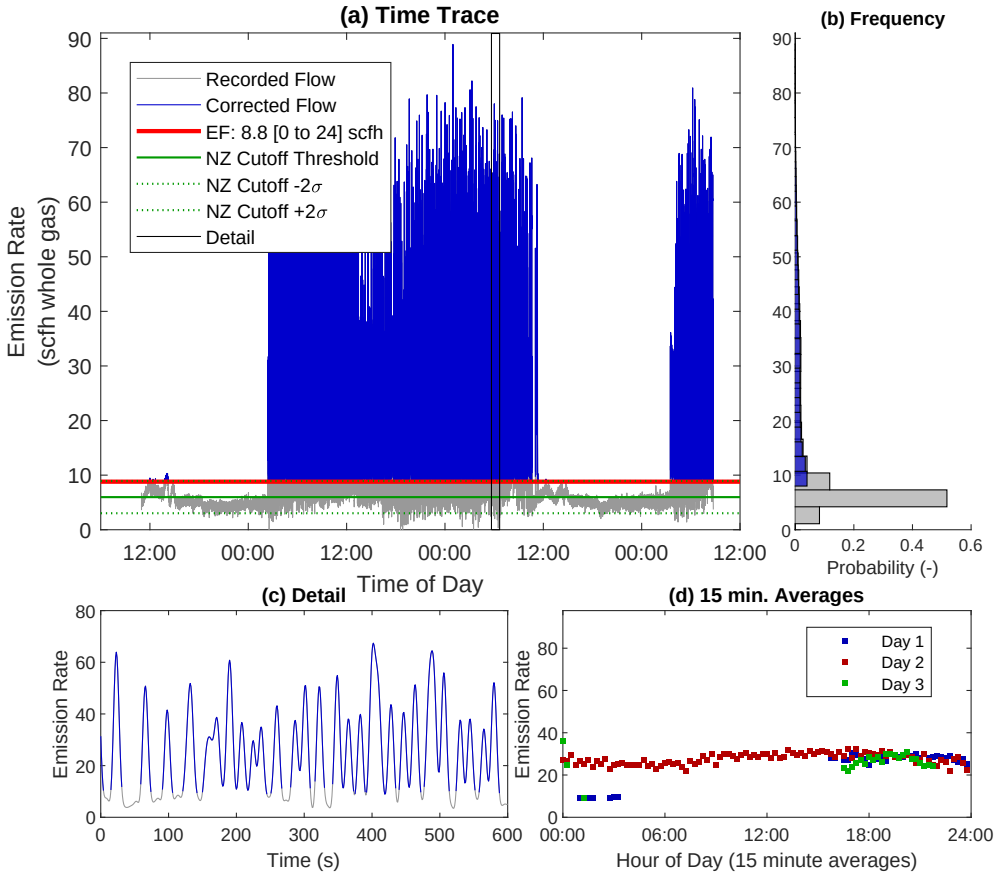

Figure S1-74: Device A-2

Device A-3

Site Class: II	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 69.9 hrs
Controller Location: Glycol Dehydrator	Avg. Gas Temperature: 41 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 37.5 psia
Controller Model: Wellmark 2100NB	Gas Methane Fraction: 92%
EPA Bleed Type: Intermittent	Emission Factor: 3.5 [0 to 7.4]
Non-zero Correction:	NZ Cutoff: 3.96 scfh
Samples Remaining: 40%	Emissions Remaining: 58%
Evaluation: Abnormally Operating	

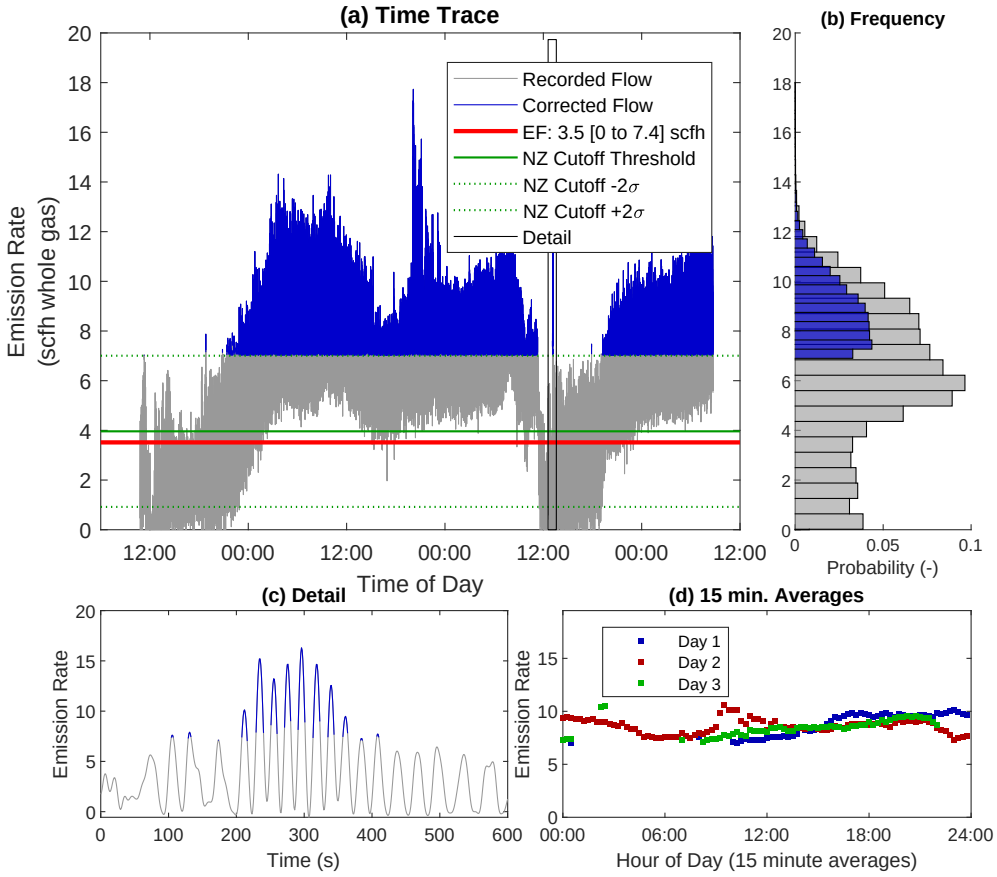

Figure S1-75: Device A-3

Device A-4

Site Class: II	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 69.1 hrs
Controller Location: Compressor	Avg. Gas Temperature: 44.4 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 52 psia
Controller Model: Kimray 30 HPG D	Gas Methane Fraction: 92%
EPA Bleed Type: Intermittent	Emission Factor: 15 [0 to 39]
Non-zero Correction:	NZ Cutoff: 14 scfh
Samples Remaining: 60%	Emissions Remaining: 73%
Evaluation: Abnormally Operating	

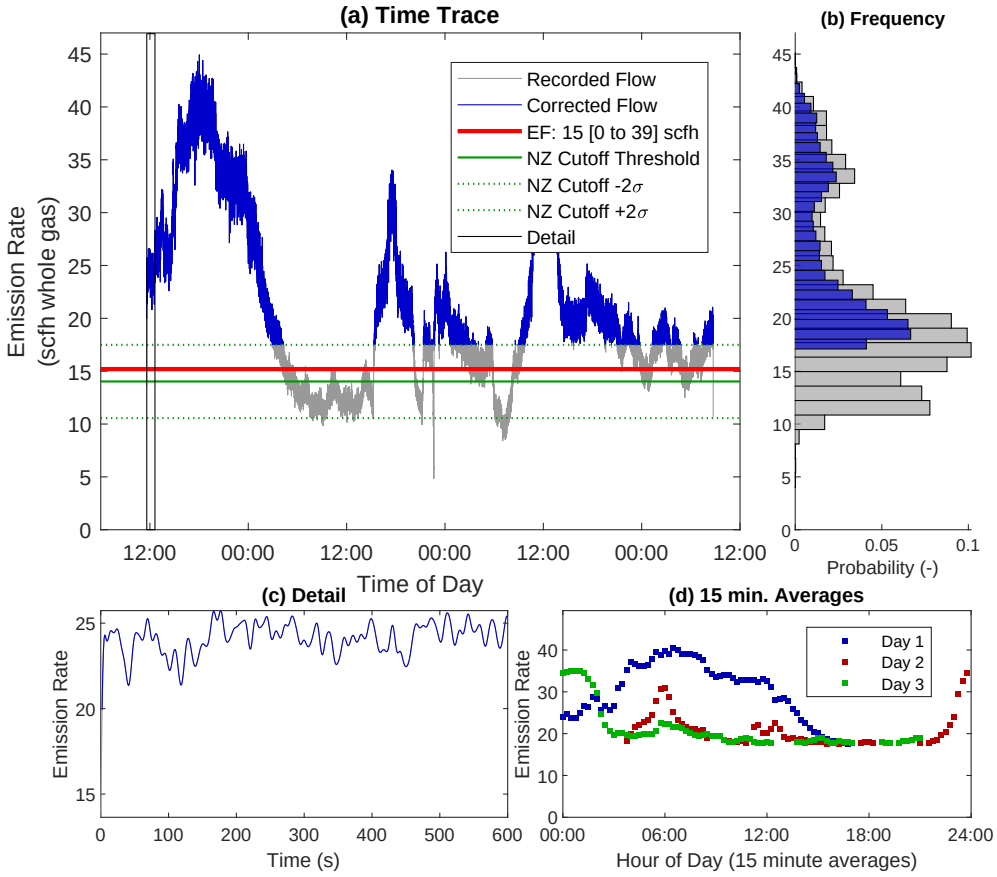

Figure S1-76: Device A-4

Device A-6

Site Class: II	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 69.2 hrs
Controller Location: Compressor	Avg. Gas Temperature: 45.2 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 34.9 psia
Controller Model: Murphy, LS200N	Gas Methane Fraction: 92%
EPA Bleed Type: Intermittent	Emission Factor: 8.7 [0 to 34]
Non-zero Correction:	NZ Cutoff: 3.67 scfh
Samples Remaining: 29%	Emissions Remaining: 73%
Evaluation: Normally Operating	

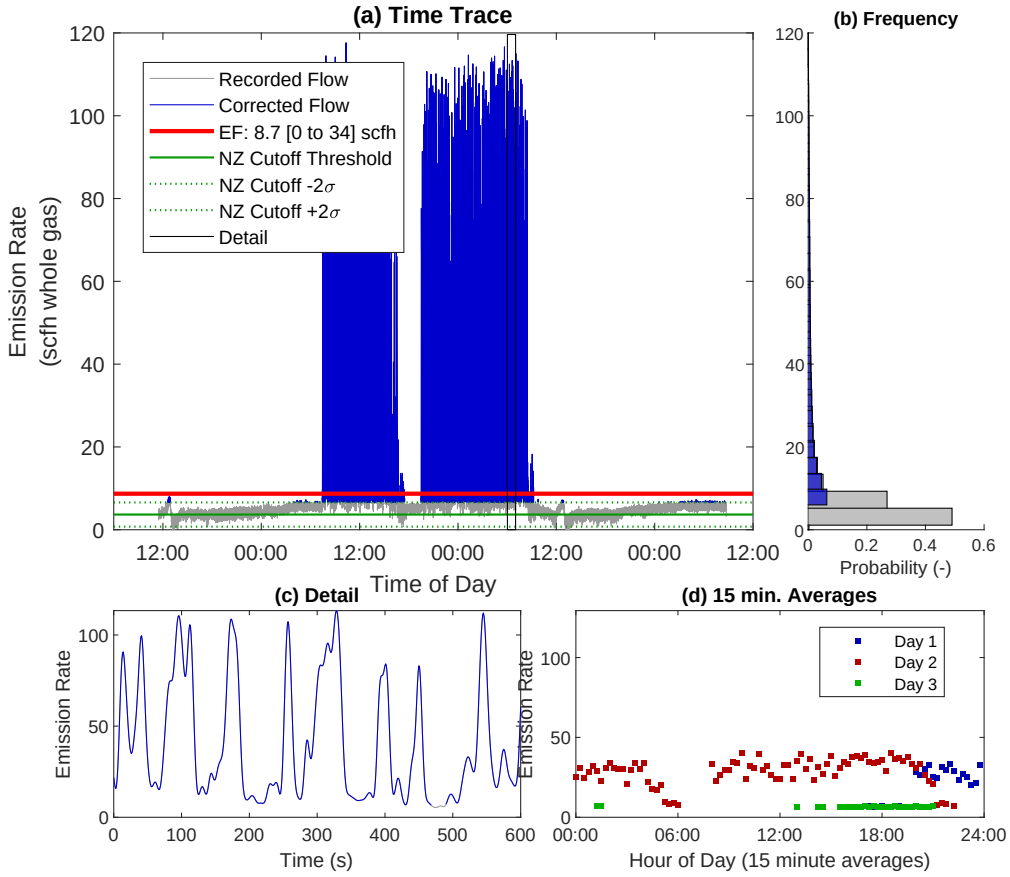

Figure S1-77: Device A-6

Device G-5

Site Class: II	NEMS Region: Gulf Coast
Install Location: Inline	Measurement Duration: 49.7 hrs
Controller Location: Separator	Avg. Gas Temperature: 36.8 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 41.3 psia
Controller Model: Norriseal 1001, 25M60N	Gas Methane Fraction: 94.5%
EPA Bleed Type: Intermittent	Emission Factor: 2 [0 to 33]
Non-zero Correction:	NZ Cutoff: 12.1 scfh
Samples Remaining: 3.2%	Emissions Remaining: 17%
Evaluation: Abnormally Operating	

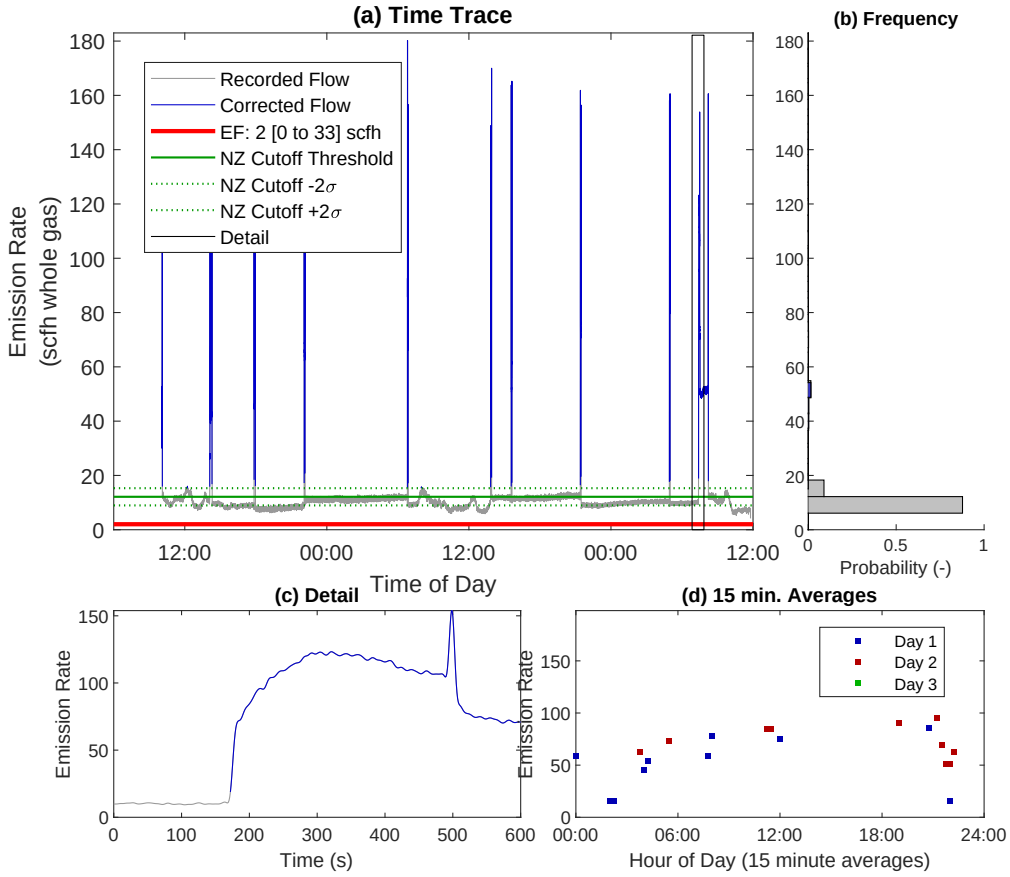

Figure S1-78: Device G-5

Device J-4

Site Class: III	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 15.5 hrs
Controller Location: Compressor	Avg. Gas Temperature: 63.5 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 43.1 psia
Controller Model: Dynaflo 4000 LBR	Gas Methane Fraction: 92%
EPA Bleed Type: Low Bleed	Emission Factor: 8.1 [0 to 15]
Non-zero Correction:	NZ Cutoff: 7.69 scfh
Samples Remaining: 65%	Emissions Remaining: 70%
Evaluation: Abnormally Operating	

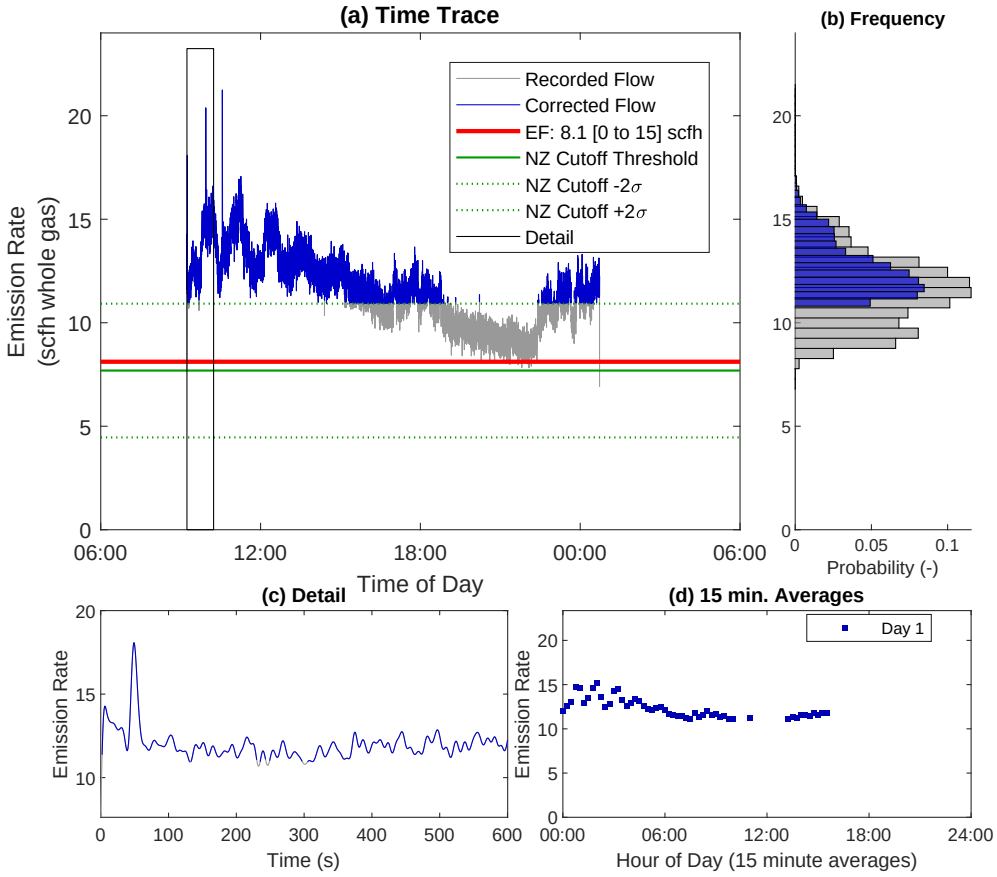

Figure S1-79: Device J-4

Device N-2

Site Class: I	NEMS Region: Midcontinent
Install Location: Inline	Measurement Duration: 83.8 hrs
Controller Location: Compressor	Avg. Gas Temperature: 76.5 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 38.7 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 77.1%
EPA Bleed Type: Intermittent	Emission Factor: 11 [0 to 30]
Non-zero Correction:	NZ Cutoff: 10.2 scfh
Samples Remaining: 65%	Emissions Remaining: 73%
Evaluation: Abnormally Operating	

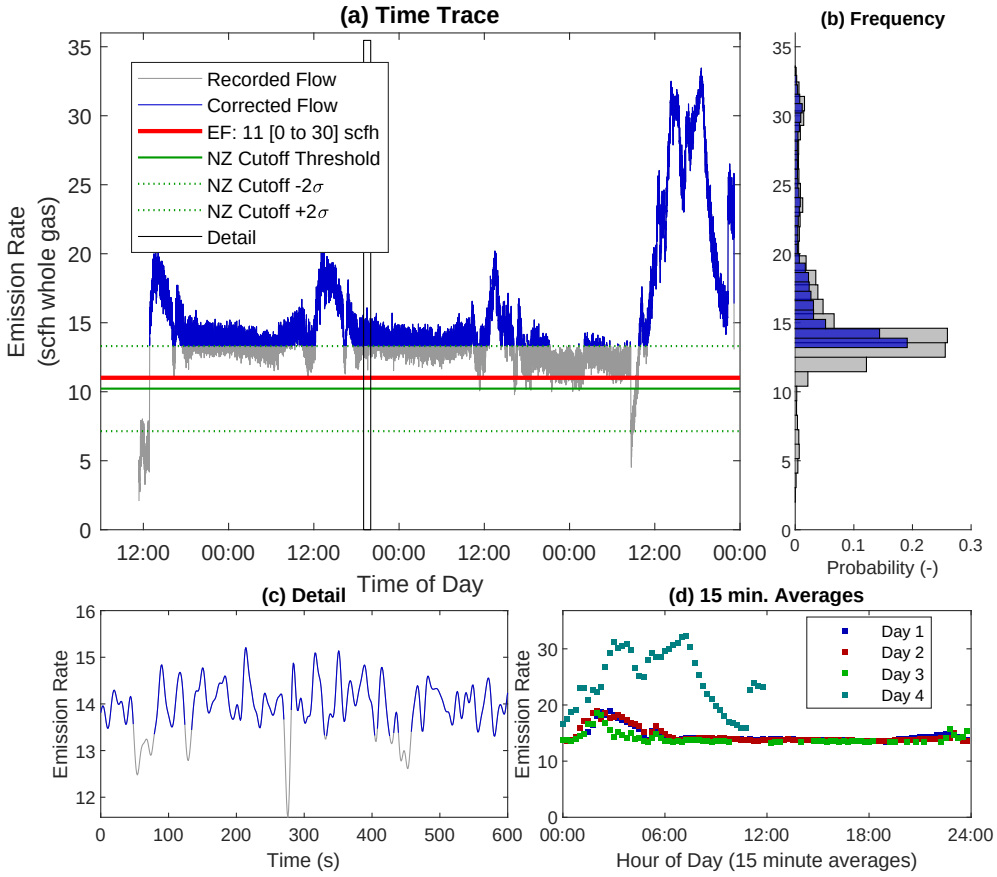

Figure S1-80: Device N-2

Device N-4

Site Class: I	NEMS Region: Midcontinent
Install Location: Inline	Measurement Duration: 83.1 hrs
Controller Location: Compressor	Avg. Gas Temperature: 68.2 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 39 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 77.1%
EPA Bleed Type: Intermittent	Emission Factor: 2.8 [0 to 22]
Non-zero Correction:	NZ Cutoff: 4.79 scfh
Samples Remaining: 19%	Emissions Remaining: 46%
Evaluation: Abnormally Operating	

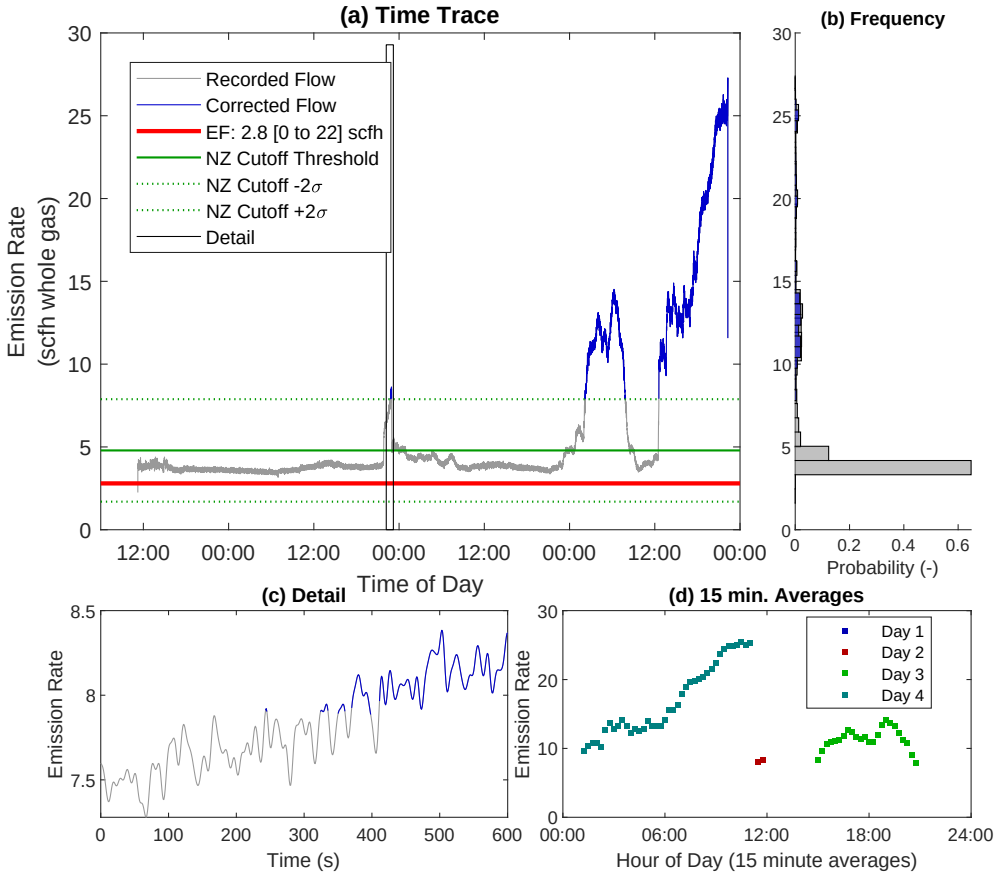

Figure S1-81: Device N-4

Device N-5

Site Class: I	NEMS Region: Midcontinent
Install Location: Inline	Measurement Duration: 85.8 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 73.6 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 34.6 psia
Controller Model: Fisher C1	Gas Methane Fraction: 77.1%
EPA Bleed Type: Low Bleed	Emission Factor: 1.9 [0 to 12]
Non-zero Correction:	NZ Cutoff: 5.78 scfh
Samples Remaining: 18%	Emissions Remaining: 29%
Evaluation: Normally Operating	

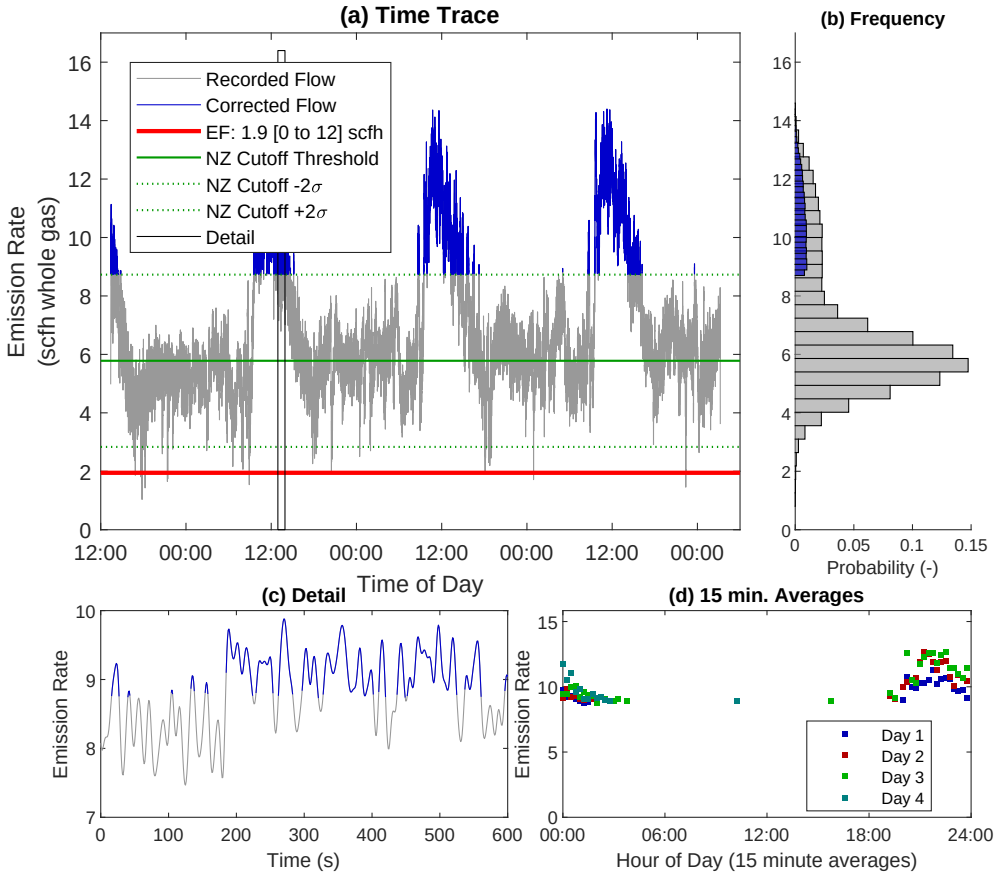

Figure S1-82: Device N-5

Device O-6

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 74.1 hrs
Controller Location: Compressor	Avg. Gas Temperature: 70.1 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 36.8 psia
Controller Model: Mallard 3200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 11 [0 to 47]
Non-zero Correction:	NZ Cutoff: 6.41 scfh
Samples Remaining: 56%	Emissions Remaining: 75%
Evaluation: Abnormally Operating	

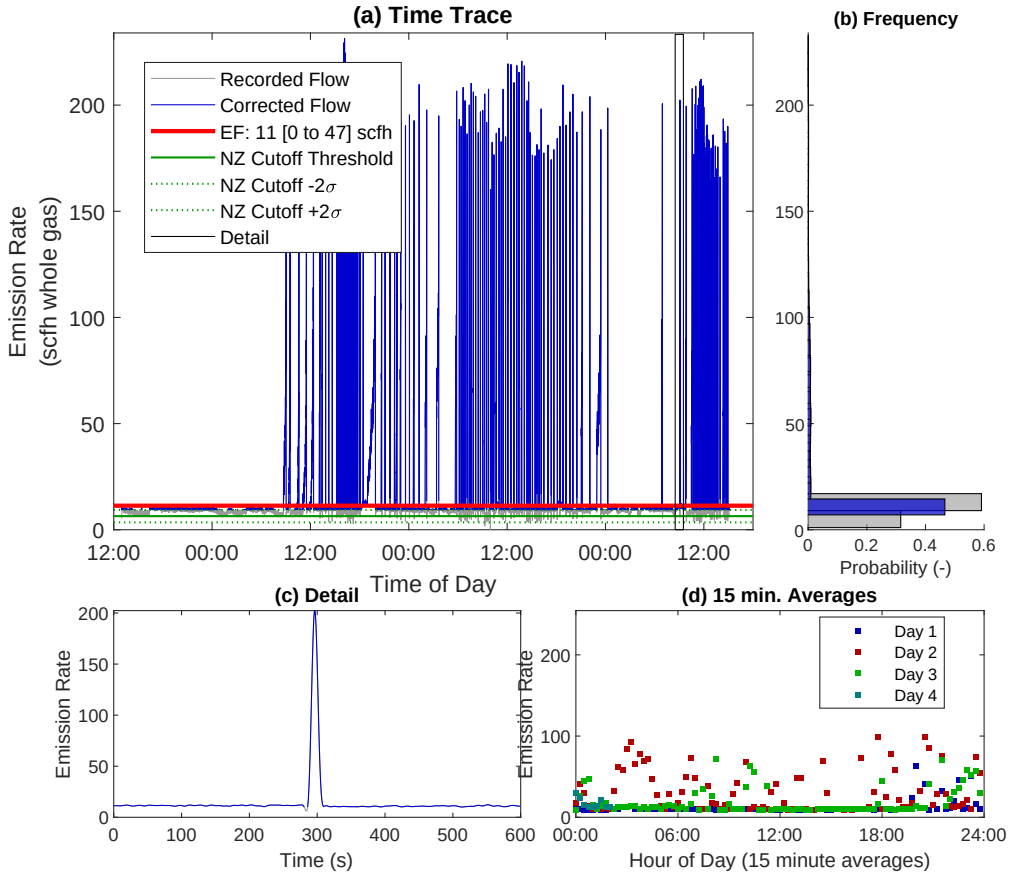

Figure S1-83: Device O-6

Device P-1

Site Class: III	NEMS Region: Gulf Coast
Install Location: Inline	Measurement Duration: 69.1 hrs
Controller Location: Compressor	Avg. Gas Temperature: 50.2 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 67.6 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 94.5%
EPA Bleed Type: Intermittent	Emission Factor: 1.1 [0 to 9.2]
Non-zero Correction:	NZ Cutoff: 22.8 scfh
Samples Remaining: 2.4%	Emissions Remaining: 4.6%
Evaluation: Abnormally Operating	

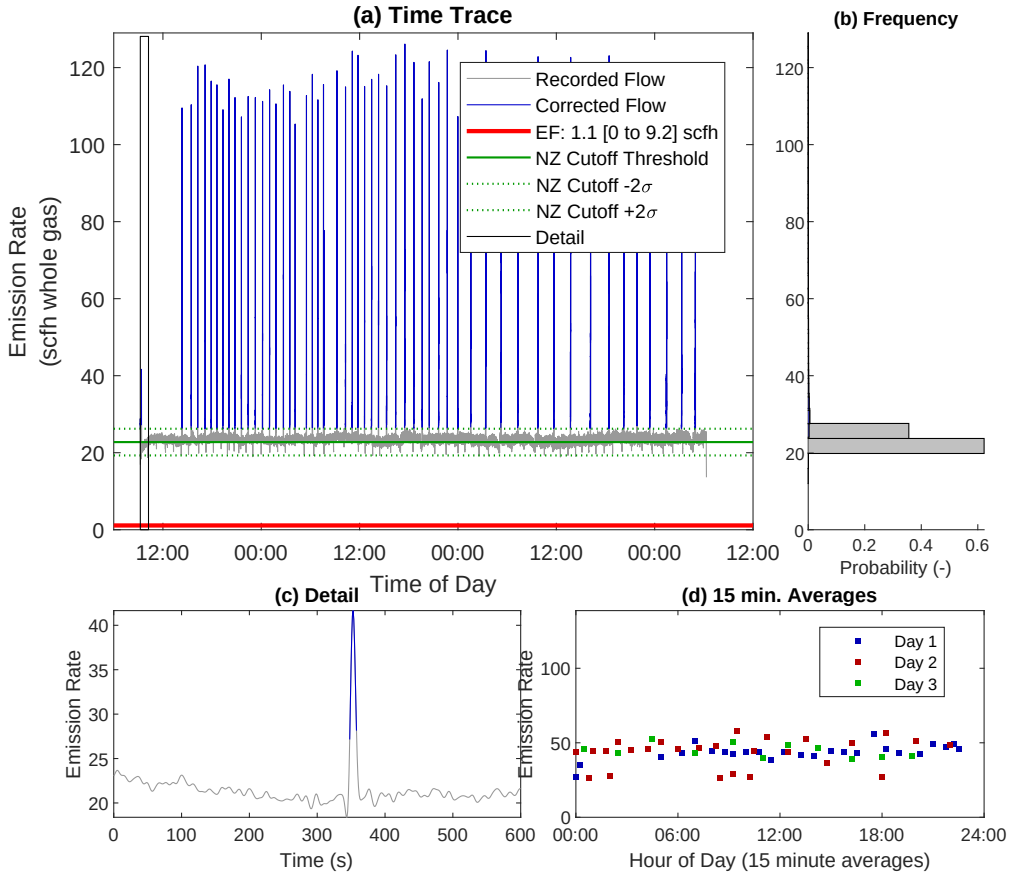

Figure S1-84: Device P-1

Device P-2

Site Class: III	NEMS Region: Gulf Coast
Install Location: Inline	Measurement Duration: 2.87 hrs
Controller Location: Compressor	Avg. Gas Temperature: 46.5 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 68 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 94.5%
EPA Bleed Type: Intermittent	Emission Factor: 1.4 [0 to 8.5]
Non-zero Correction:	NZ Cutoff: 41.8 scfh
Samples Remaining: 1.2%	Emissions Remaining: 4%
Evaluation: Normally Operating	

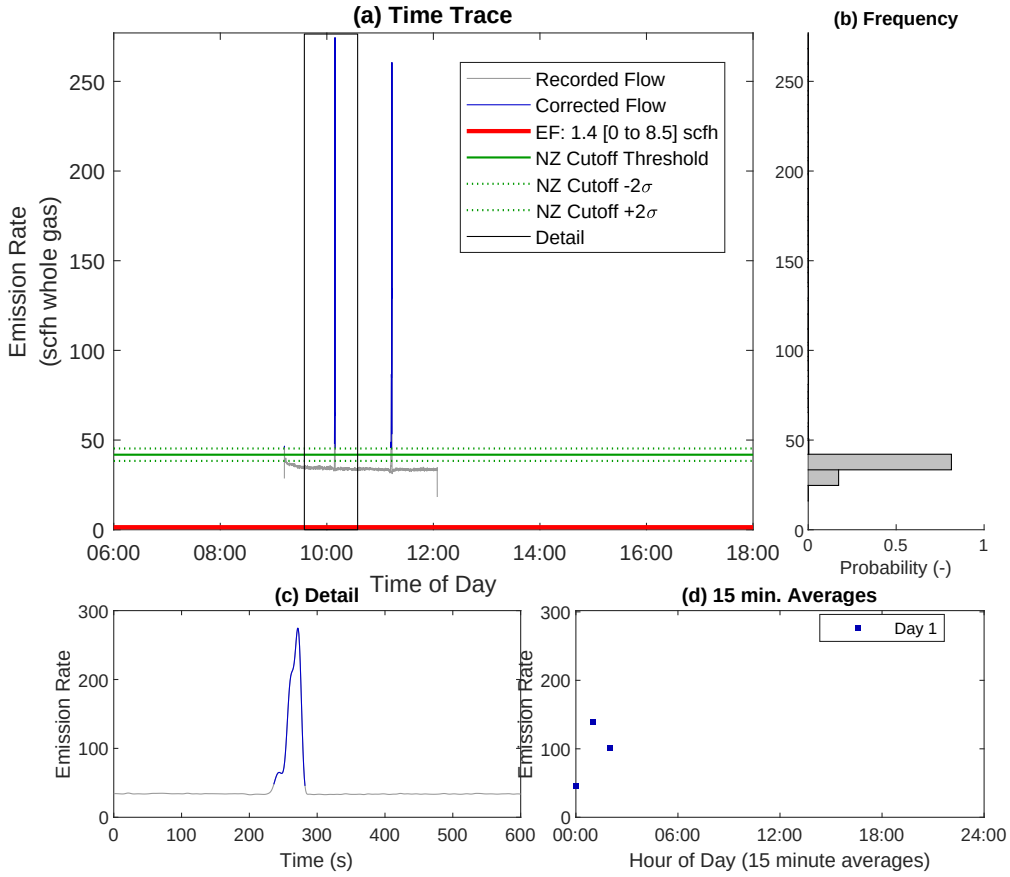

Figure S1-85: Device P-2

Device P-5

Site Class: III	NEMS Region: Gulf Coast
Install Location: Inline	Measurement Duration: 68.8 hrs
Controller Location: Compressor	Avg. Gas Temperature: 48.5 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 39.4 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 94.5%
EPA Bleed Type: Intermittent	Emission Factor: 18 [0 to 50]
Non-zero Correction:	NZ Cutoff: 10.3 scfh
Samples Remaining: 18%	Emissions Remaining: 65%
Evaluation: Abnormally Operating	

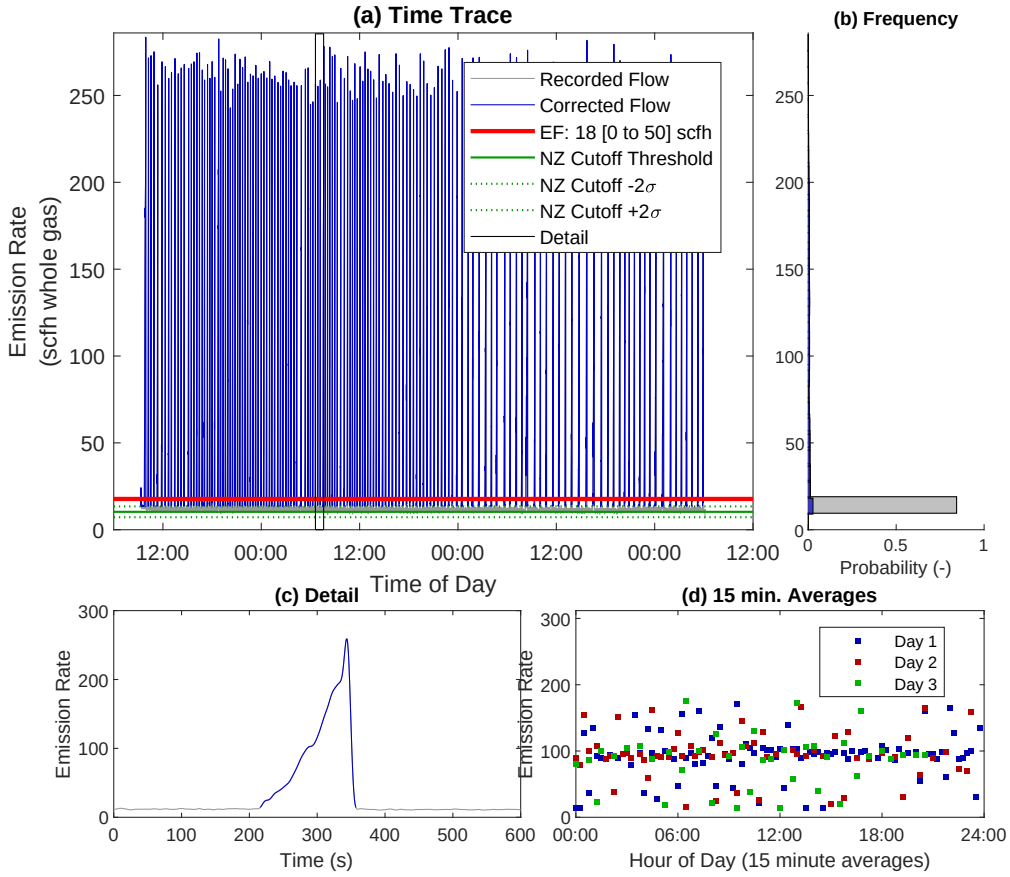

Figure S1-86: Device P-5

Device Q-2

Site Class: III	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 90.4 hrs
Controller Location: Compressor	Avg. Gas Temperature: 73.4 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 35.2 psia
Controller Model: Dynaflo 4000 LBR	Gas Methane Fraction: 80%
EPA Bleed Type: Low Bleed	Emission Factor: 3.6 [0 to 19]
Non-zero Correction:	NZ Cutoff: 6.46 scfh
Samples Remaining: 24%	Emissions Remaining: 48%
Evaluation: Normally Operating	

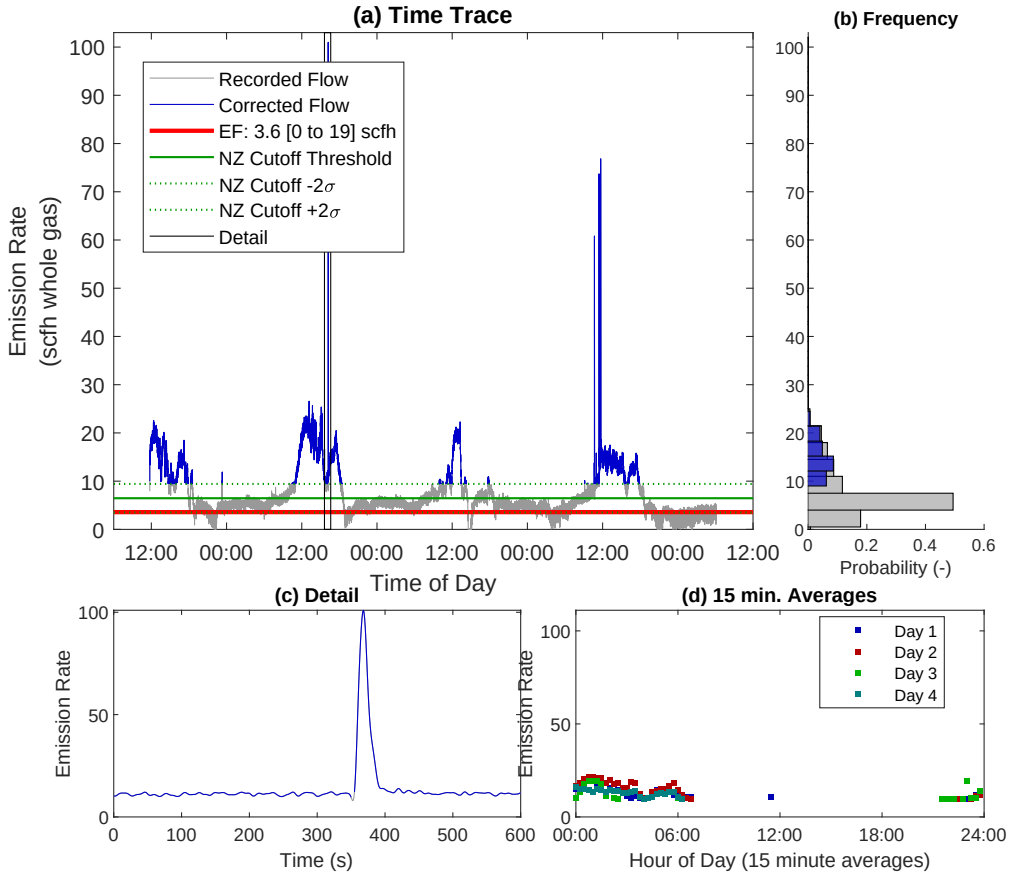

Figure S1-87: Device Q-2

Device Q-5

Site Class: III	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 92.6 hrs
Controller Location: Glycol Dehydrator	Avg. Gas Temperature: 64.5 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 37.4 psia
Controller Model: Mallard 3201	Gas Methane Fraction: 80%
EPA Bleed Type: Intermittent	Emission Factor: 1.8 [0 to 9.7]
Non-zero Correction:	NZ Cutoff: 8.45 scfh
Samples Remaining: 5.5%	Emissions Remaining: 20%
Evaluation: Normally Operating	

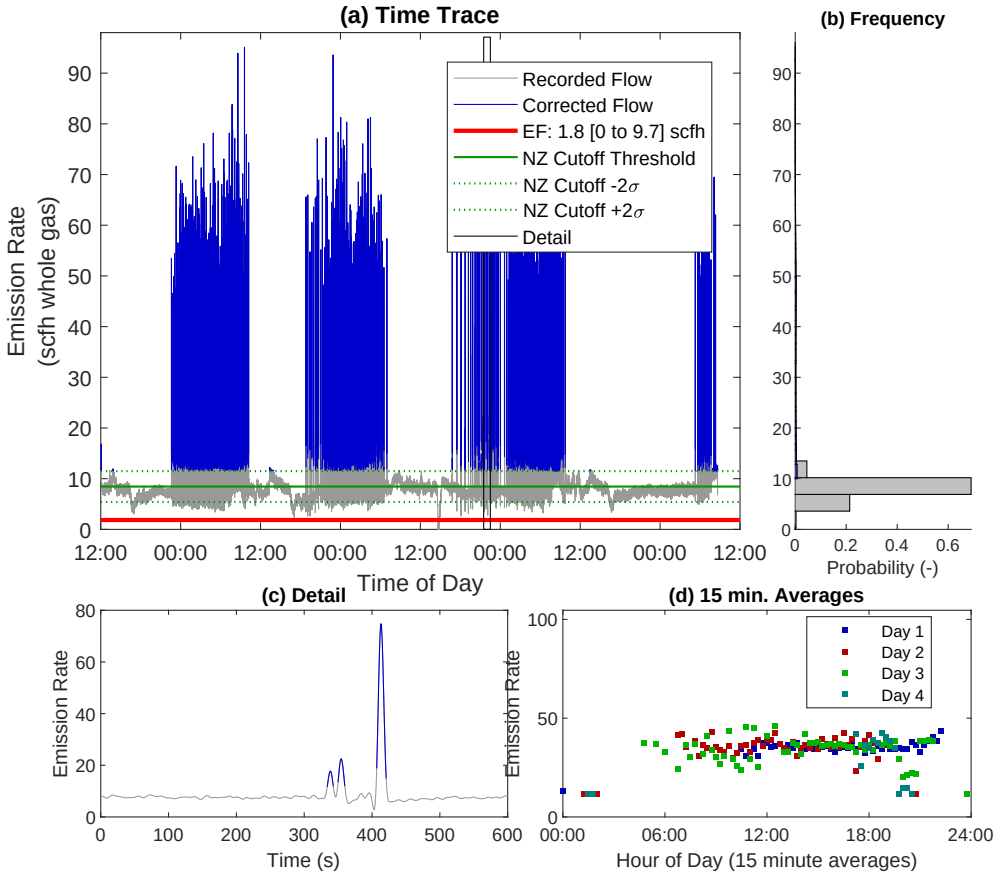

Figure S1-88: Device Q-5

Device S-1

Site Class: I	NEMS Region: Midcontinent
Install Location: Inline	Measurement Duration: 87.8 hrs
Controller Location: Glycol Dehydrator	Avg. Gas Temperature: 47.6 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 34.9 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 96.8%
EPA Bleed Type: Intermittent	Emission Factor: 0.00062 [0 to 0]
Non-zero Correction:	NZ Cutoff: 1.07 scfh
Samples Remaining: 0.013%	Emissions Remaining: 0.25%
Evaluation: Normally Operating	

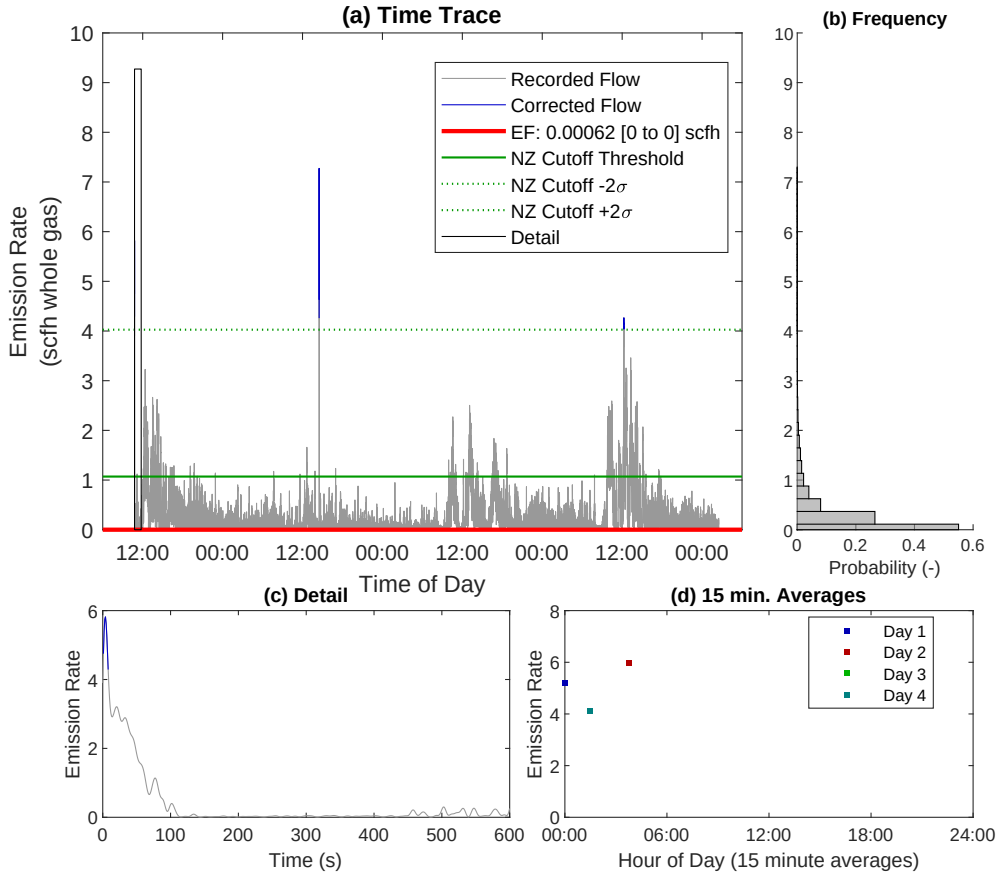

Figure S1-89: Device S-1

Device S-5

Site Class: I	NEMS Region: Midcontinent
Install Location: Inline	Measurement Duration: 92.4 hrs
Controller Location: Glycol Dehydrator	Avg. Gas Temperature: 53.8 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 42.7 psia
Controller Model: Mallard, 3100-P1	Gas Methane Fraction: 96.8%
EPA Bleed Type: Intermittent	Emission Factor: 0.0048 [0 to 0]
Non-zero Correction:	NZ Cutoff: 13.5 scfh
Samples Remaining: 0.018%	Emissions Remaining: 0.053%
Evaluation: Normally Operating	

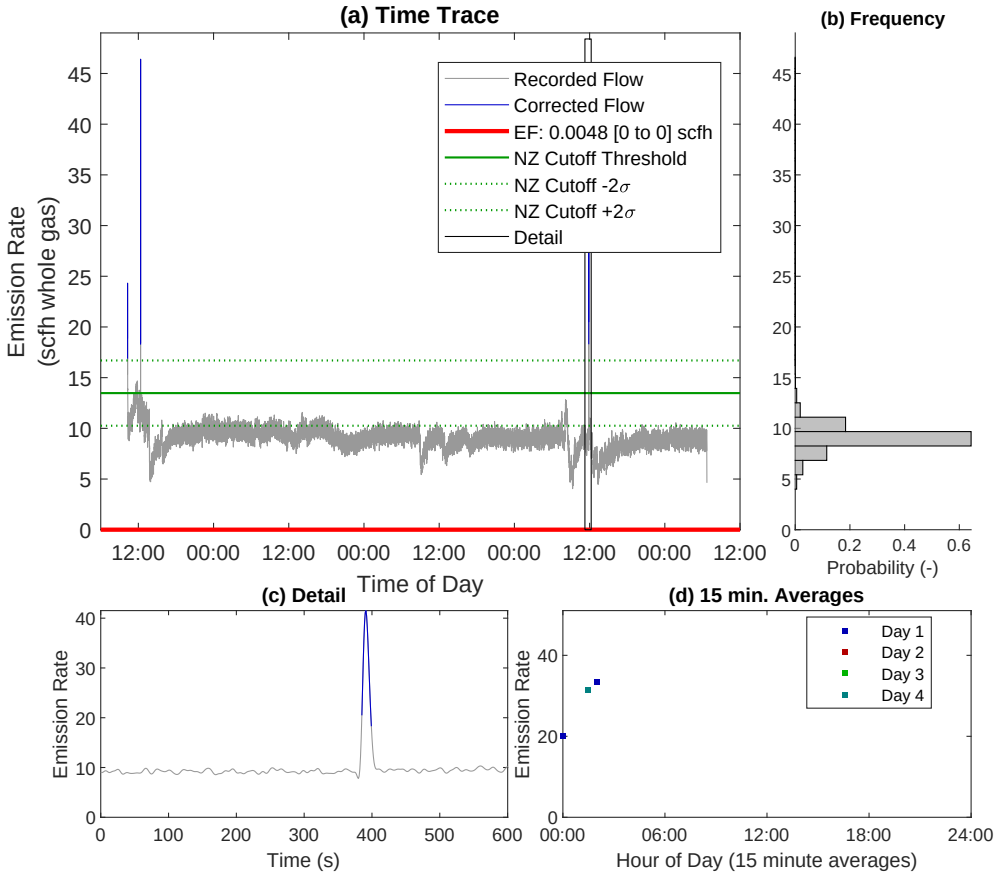

Figure S1-90: Device S-5

Device T-5

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 70.4 hrs
Controller Location: Compressor	Avg. Gas Temperature: 30.2 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 36.4 psia
Controller Model: Mallard 3200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 1.9 [0 to 30]
Non-zero Correction:	NZ Cutoff: 7.48 scfh
Samples Remaining: 4.1%	Emissions Remaining: 26%
Evaluation: Abnormally Operating	

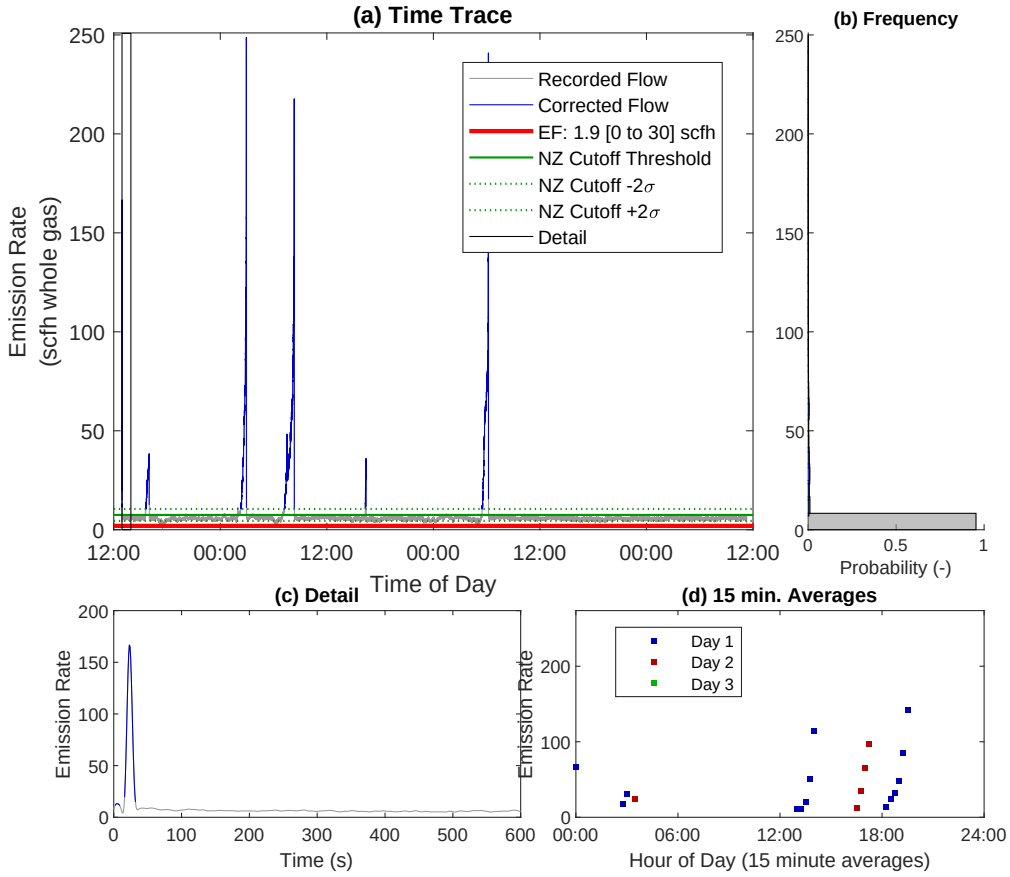

Figure S1-91: Device T-5

Device T-6

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 70.2 hrs
Controller Location: Compressor	Avg. Gas Temperature: 30.8 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 40.7 psia
Controller Model: Mallard 3200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 12 [0 to 1.5e+02]
Non-zero Correction:	NZ Cutoff: 11.7 scfh
Samples Remaining: 12%	Emissions Remaining: 58%
Evaluation: Abnormally Operating	

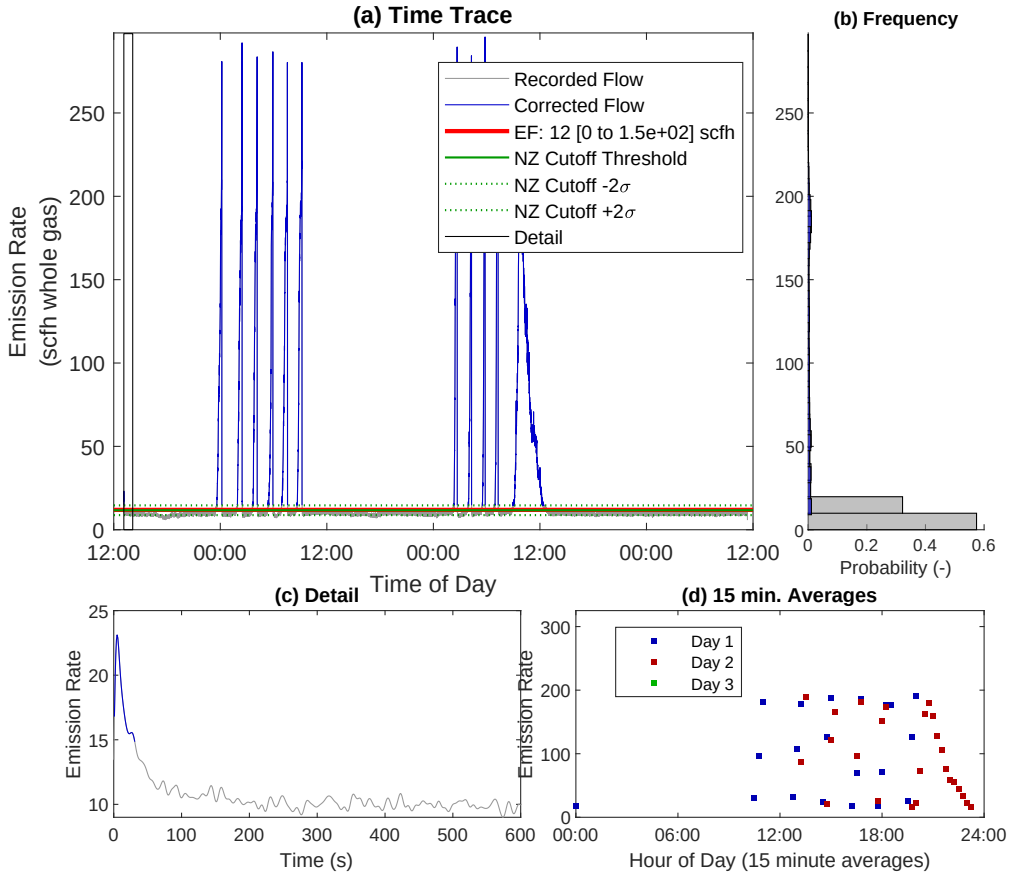

Figure S1-92: Device T-6

Device U-6

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 76.7 hrs
Controller Location: Compressor	Avg. Gas Temperature: 46.4 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 37.2 psia
Controller Model: Mallard 3200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 1.4 [0 to 16]
Non-zero Correction:	NZ Cutoff: 6.89 scfh
Samples Remaining: 8.3%	Emissions Remaining: 24%
Evaluation: Abnormally Operating	

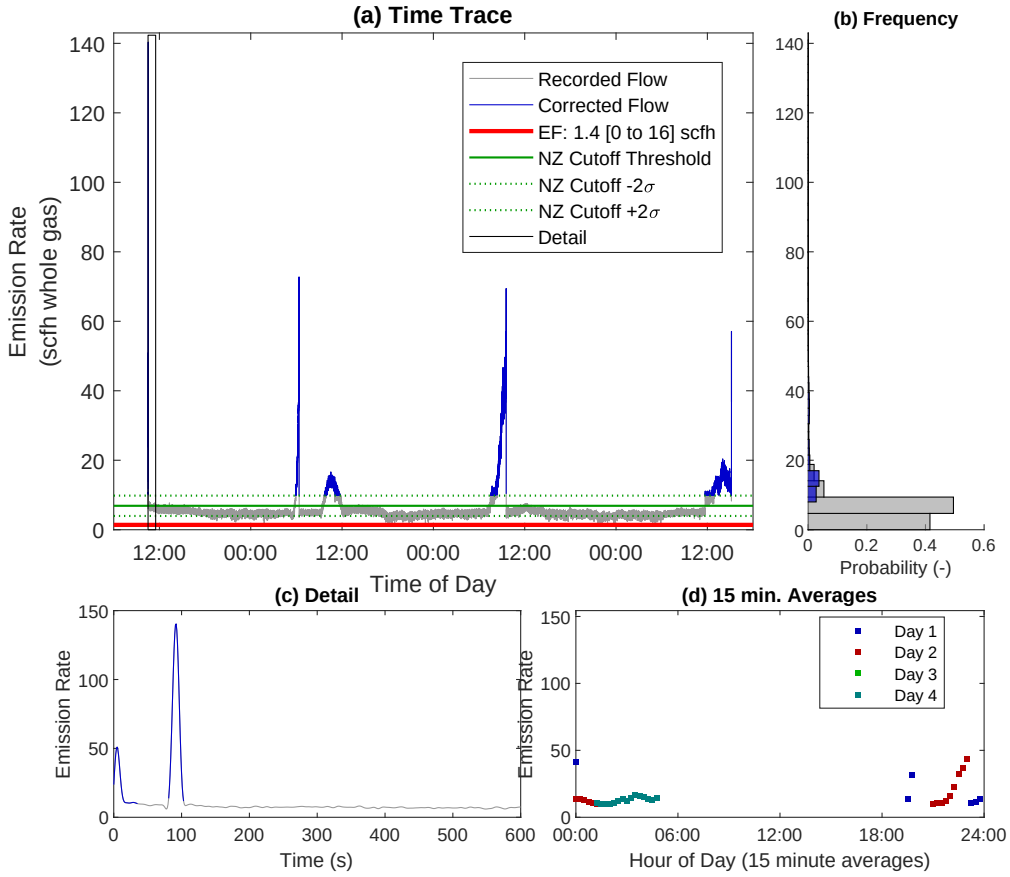

Figure S1-93: Device U-6

Device V-2

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 76.1 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 23.3 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 84.9 psia
Controller Model: Murphy, LS200N	Gas Methane Fraction: 75%
EPA Bleed Type: Intermittent	Emission Factor: 29 [0 to 1.2e+02]
Non-zero Correction:	NZ Cutoff: 60 scfh
Samples Remaining: 29%	Emissions Remaining: 46%
Evaluation: Abnormally Operating	

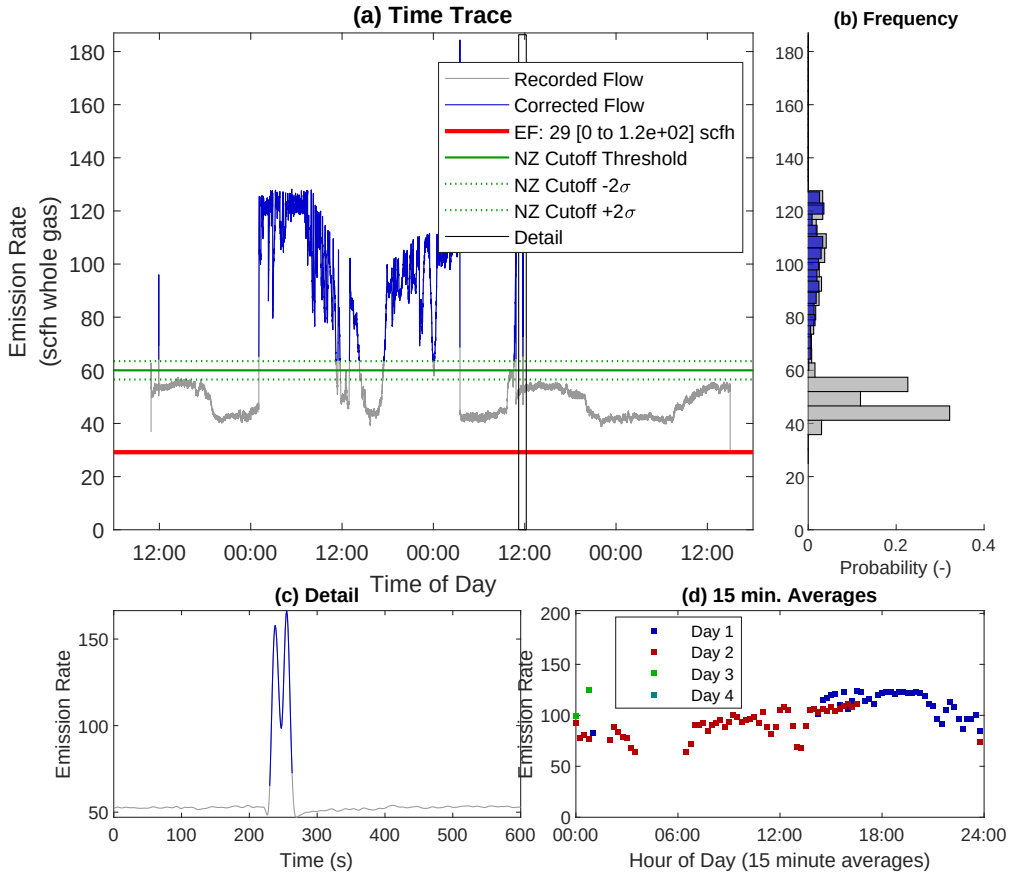

Figure S1-94: Device V-2

Device V-3

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 78.1 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 21.1 $^{\circ}F$
Process Controlled: Pressure	Avg. Supply Pressure: 48.1 psia
Controller Model: Fisher C1	Gas Methane Fraction: 75%
EPA Bleed Type: Low Bleed	Emission Factor: 1.1 [0 to 20]
Non-zero Correction:	NZ Cutoff: 16.7 scfh
Samples Remaining: 4.7%	Emissions Remaining: 6.5%
Evaluation: Normally Operating	

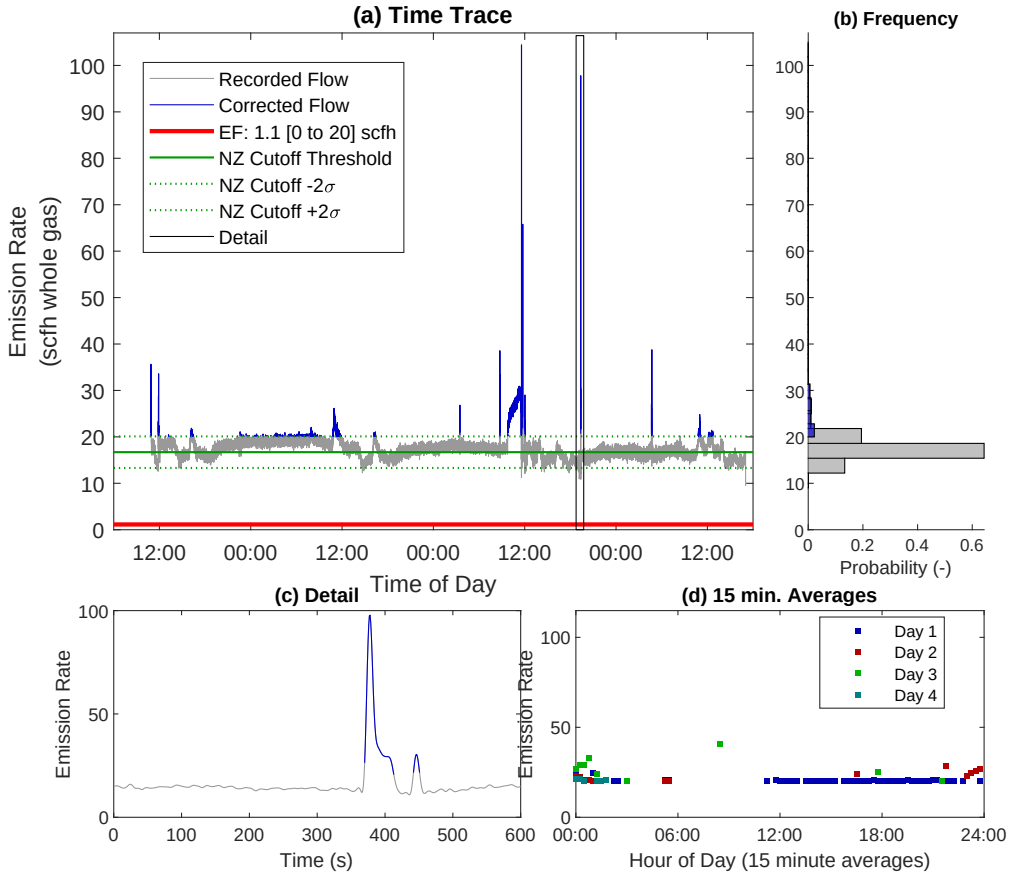

Figure S1-95: Device V-3

Device V-5

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 78.3 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 16.6 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 37.3 psia
Controller Model: Fisher C1	Gas Methane Fraction: 75%
EPA Bleed Type: Low Bleed	Emission Factor: 0.71 [0 to 13]
Non-zero Correction:	NZ Cutoff: 8.27 scfh
Samples Remaining: 5.5%	Emissions Remaining: 16%
Evaluation: Normally Operating	

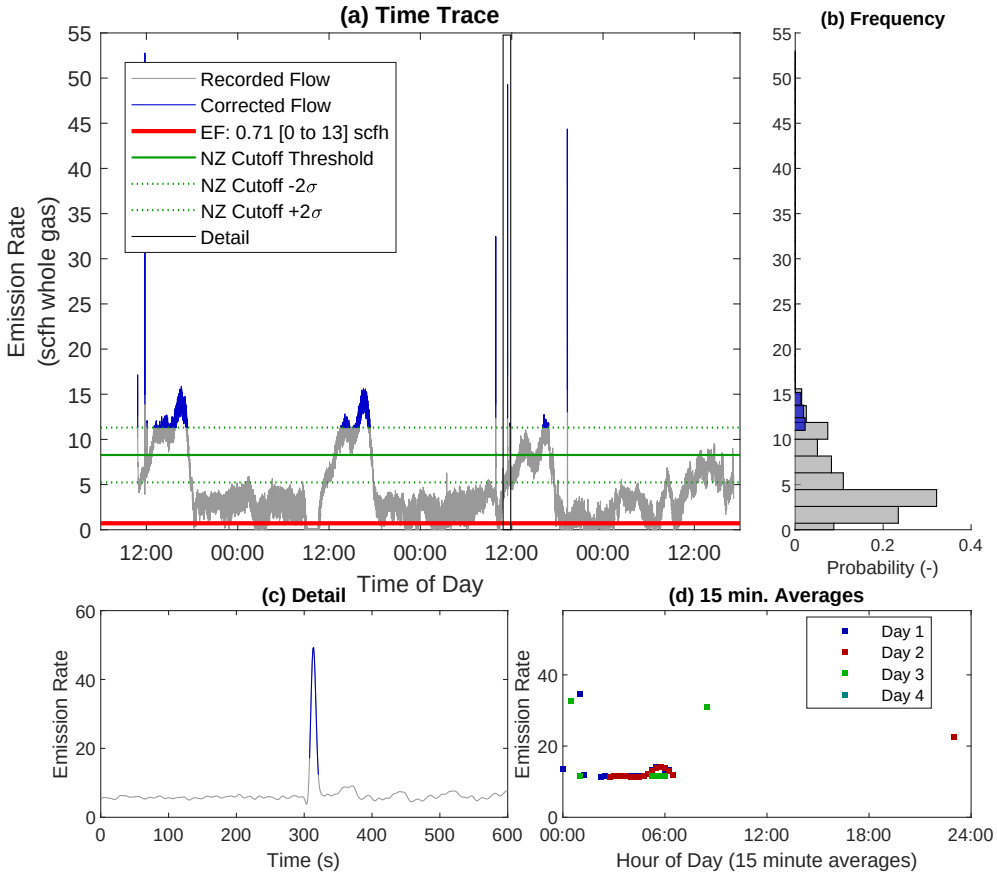

Figure S1-96: Device V-5

S1-7.4 Discarded

This section contains recordings that were effectively zeroed after applying the NZ correction. Because the recordings in this section do not contain measurements that are distinguishable from the NZ meter error, they will not be used for any further analysis.

Device A-5

Site Class: II	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 69 hrs
Controller Location: Compressor	Avg. Gas Temperature: 51.1 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 35.1 psia
Controller Model: Murphy LS200N	Gas Methane Fraction: 92%
EPA Bleed Type: Intermittent	Emission Factor: 0.93 [0 to 11]
Non-zero Correction:	NZ Cutoff: 6.17 scfh
Samples Remaining: 9.1%	Emissions Remaining: 14%
Evaluation: -	

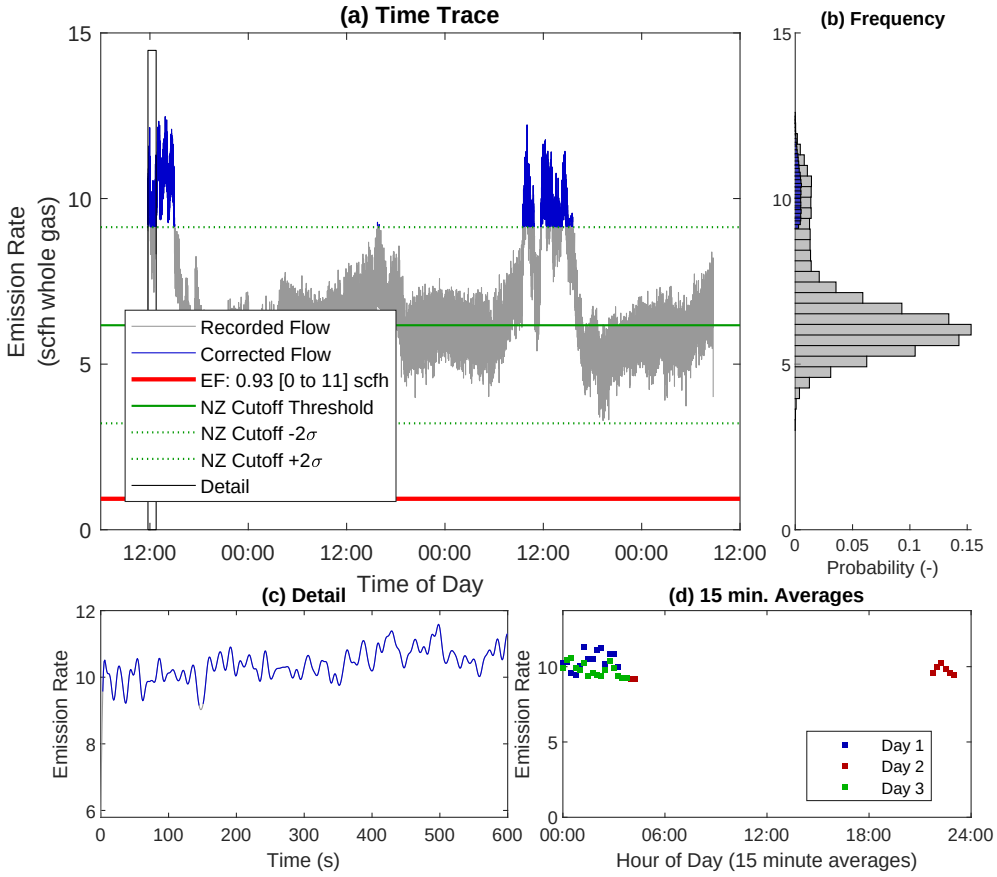

Figure S1-97: Device A-5

Device D-5

Site Class: I	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 91.1 hrs
Controller Location: Compressor	Avg. Gas Temperature: 42.9 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 32.8 psia
Controller Model: Mallard, 3100-P1	Gas Methane Fraction: 99.2%
EPA Bleed Type: Intermittent	Emission Factor: 0.0013 [0 to 0]
Non-zero Correction:	NZ Cutoff: 4.06 scfh
Samples Remaining: 0.018%	Emissions Remaining: 0.038%
Evaluation: -	

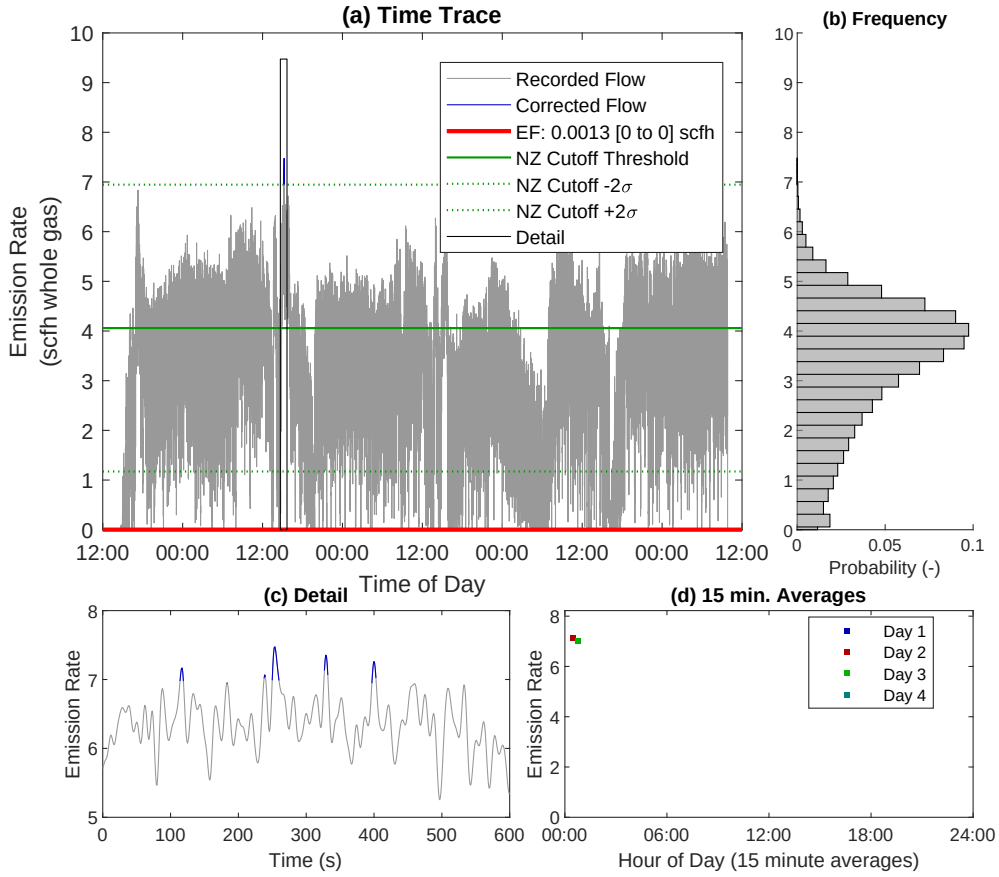

Figure S1-98: Device D-5

Device H-2

Site Class: I	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 88 hrs
Controller Location: Compressor	Avg. Gas Temperature: 67.7 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 39.9 psia
Controller Model: ABB, Type 22/06	Gas Methane Fraction: 70%
EPA Bleed Type: Low Bleed	Emission Factor: 0 [0 to 0]
Non-zero Correction:	NZ Cutoff: 11.5 scfh
Samples Remaining: 0%	Emissions Remaining: 0%
Evaluation: -	

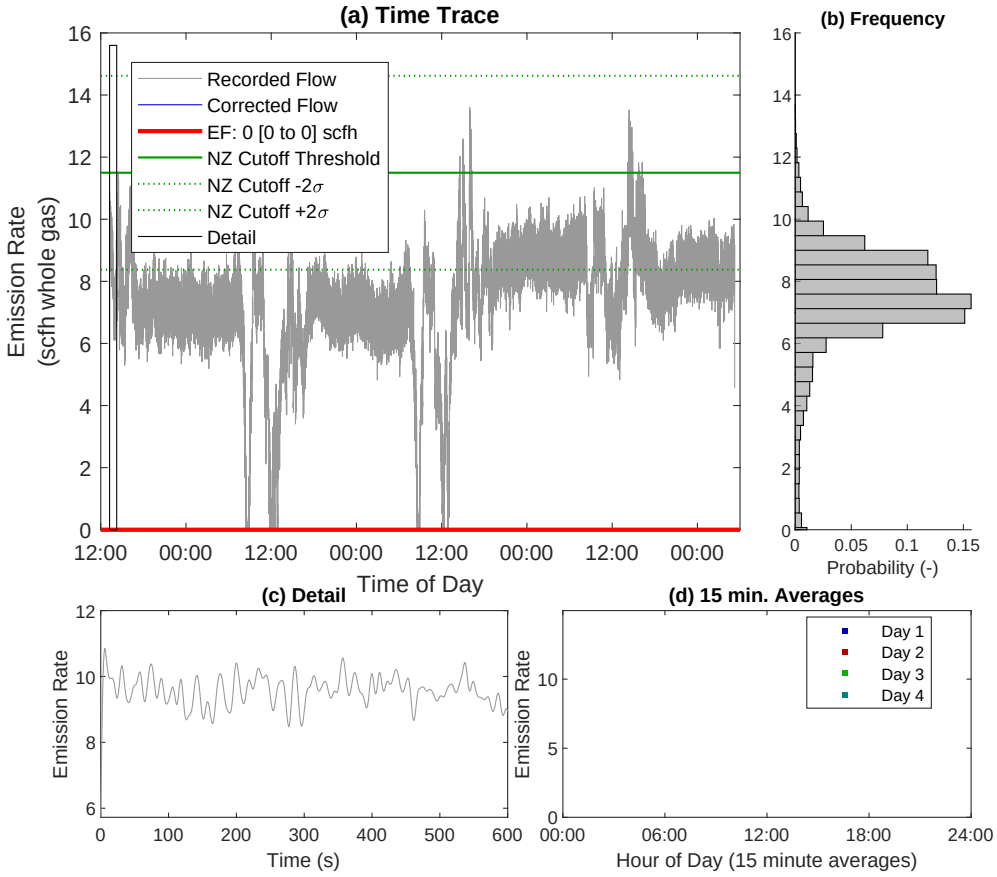

Figure S1-99: Device H-2

Device H-3

Site Class: I	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 89.9 hrs
Controller Location: Compressor	Avg. Gas Temperature: 71.5 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 37.7 psia
Controller Model: Ronan X55-600 I/P	Gas Methane Fraction: 70%
EPA Bleed Type: Low Bleed	Emission Factor: 1.1 [0 to 9.9]
Non-zero Correction:	NZ Cutoff: 4.25 scfh
Samples Remaining: 13%	Emissions Remaining: 20%
Evaluation: -	

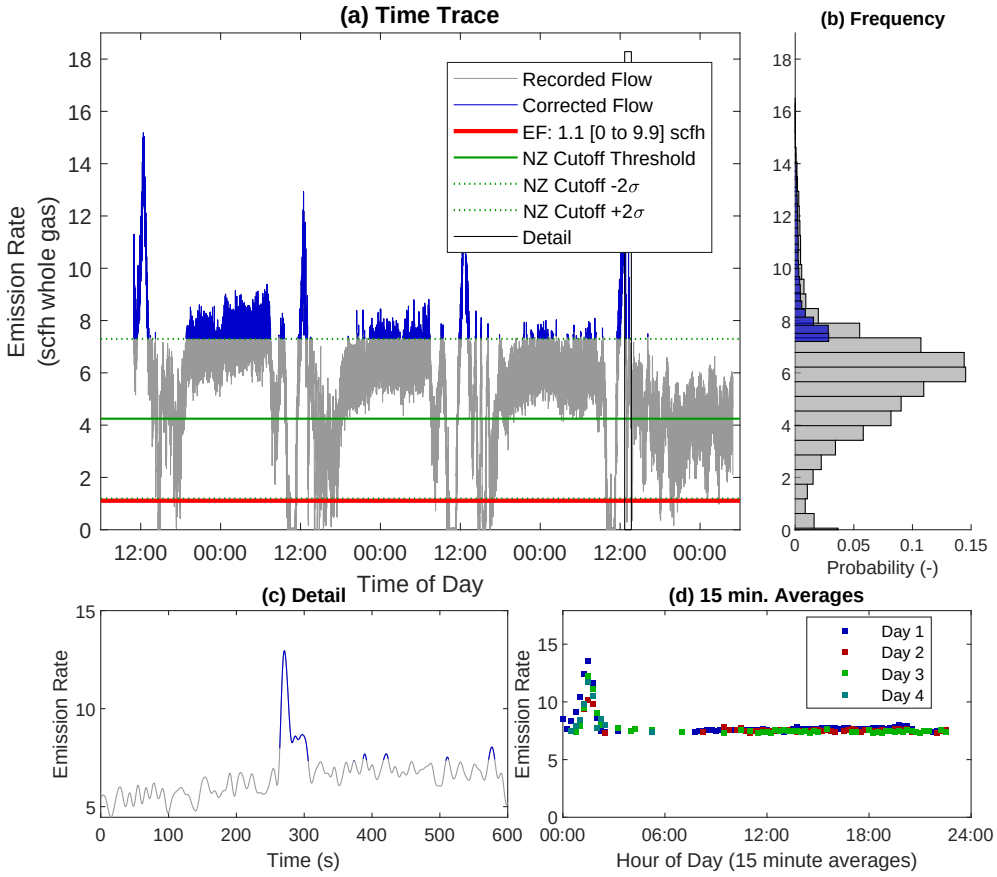

Figure S1-100: Device H-3

Device H-5

Site Class: I	NEMS Region: Southwest
Install Location: Inline	Measurement Duration: 91.8 hrs
Controller Location: Compressor	Avg. Gas Temperature: 67.9 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 47.8 psia
Controller Model: Solenoid Operated	Gas Methane Fraction: 70%
EPA Bleed Type: Low Bleed	Emission Factor: 0.0015 [0 to 0]
Non-zero Correction:	NZ Cutoff: 18.3 scfh
Samples Remaining: 0.0067%	Emissions Remaining: 0.017%
Evaluation: -	

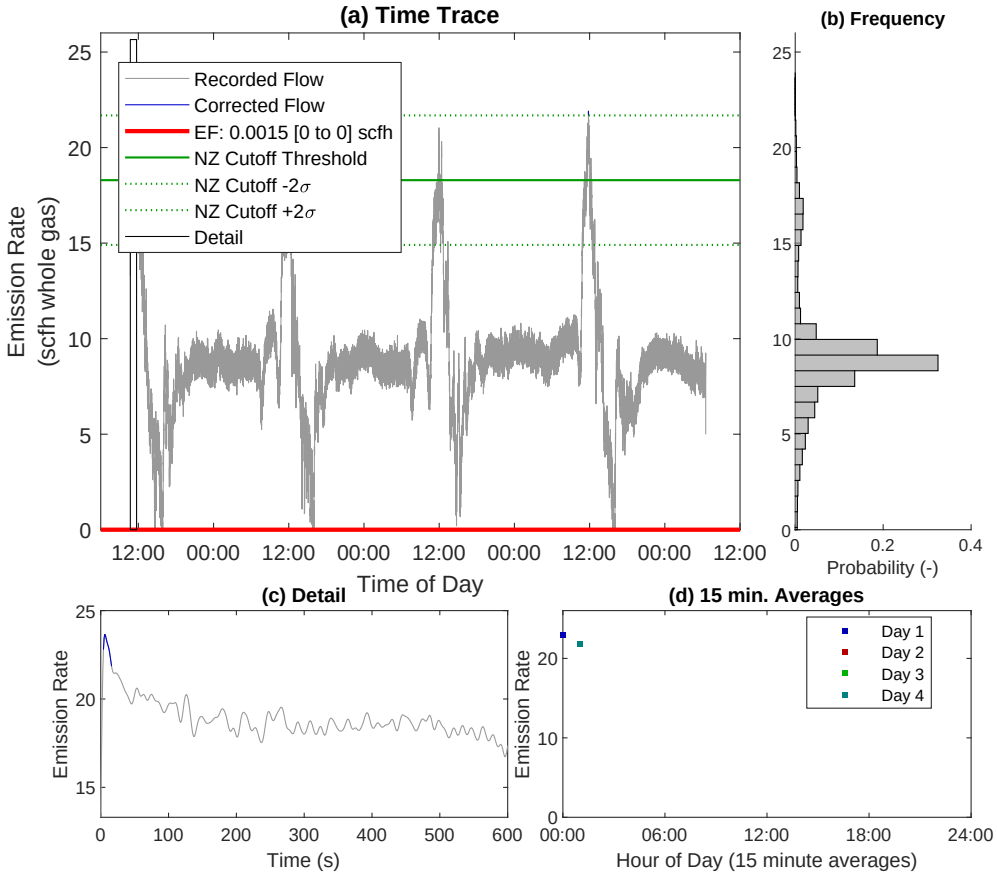

Figure S1-101: Device H-5

Device L-5

Site Class: III	NEMS Region: Gulf Coast
Install Location: Inline	Measurement Duration: 90.2 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 24.2 $°F$
Process Controlled: Pressure	Avg. Supply Pressure: 46.6 psia
Controller Model: Fisher 546	Gas Methane Fraction: 94.5%
EPA Bleed Type: High Bleed	Emission Factor: 0.21 [0 to 1.2]
Non-zero Correction:	NZ Cutoff: 17.1 scfh
Samples Remaining: 1%	Emissions Remaining: 1.2%
Evaluation: -	

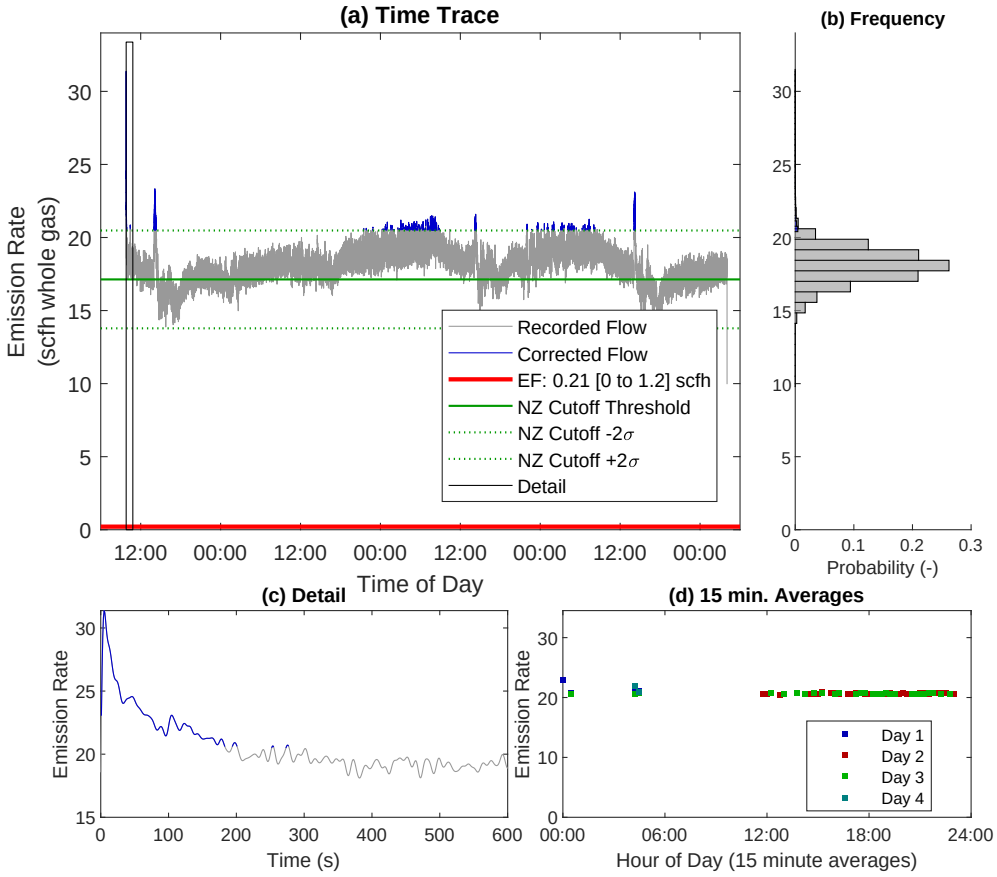

Figure S1-102: Device L-5

Device L-6

Site Class: III	NEMS Region: Gulf Coast
Install Location: Inline	Measurement Duration: 89.9 hrs
Controller Location: Yard Piping	Avg. Gas Temperature: 32.6 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 46.4 psia
Controller Model: Mallard 3100P1	Gas Methane Fraction: 94.5%
EPA Bleed Type: Intermittent	Emission Factor: 0.00035 [0 to 0]
Non-zero Correction:	NZ Cutoff: 19 scfh
Samples Remaining: 0.0015%	Emissions Remaining: 0.0026%
Evaluation: -	

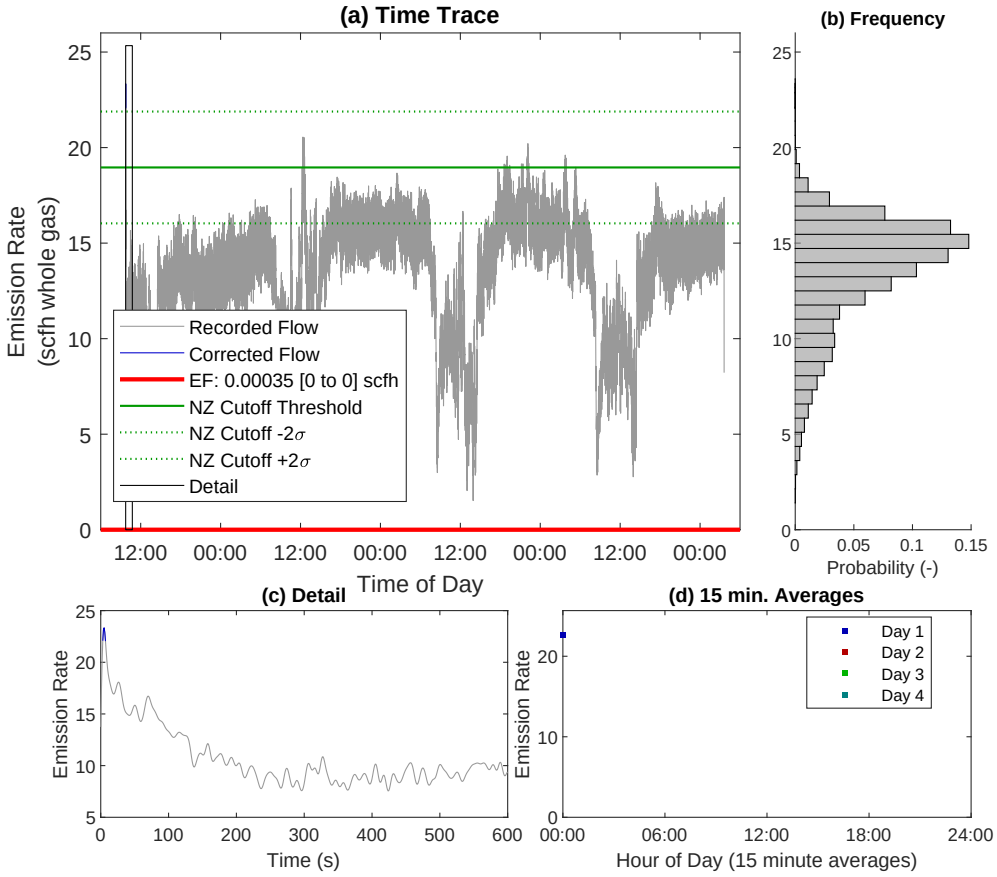

Figure S1-103: Device L-6

Device O-4

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 73.5 hrs
Controller Location: Compressor	Avg. Gas Temperature: 71.6 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 37.4 psia
Controller Model: Mallard 3200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 0.28 [0 to 2.7]
Non-zero Correction:	NZ Cutoff: 3.66 scfh
Samples Remaining: 4%	Emissions Remaining: 4.9%
Evaluation: -	

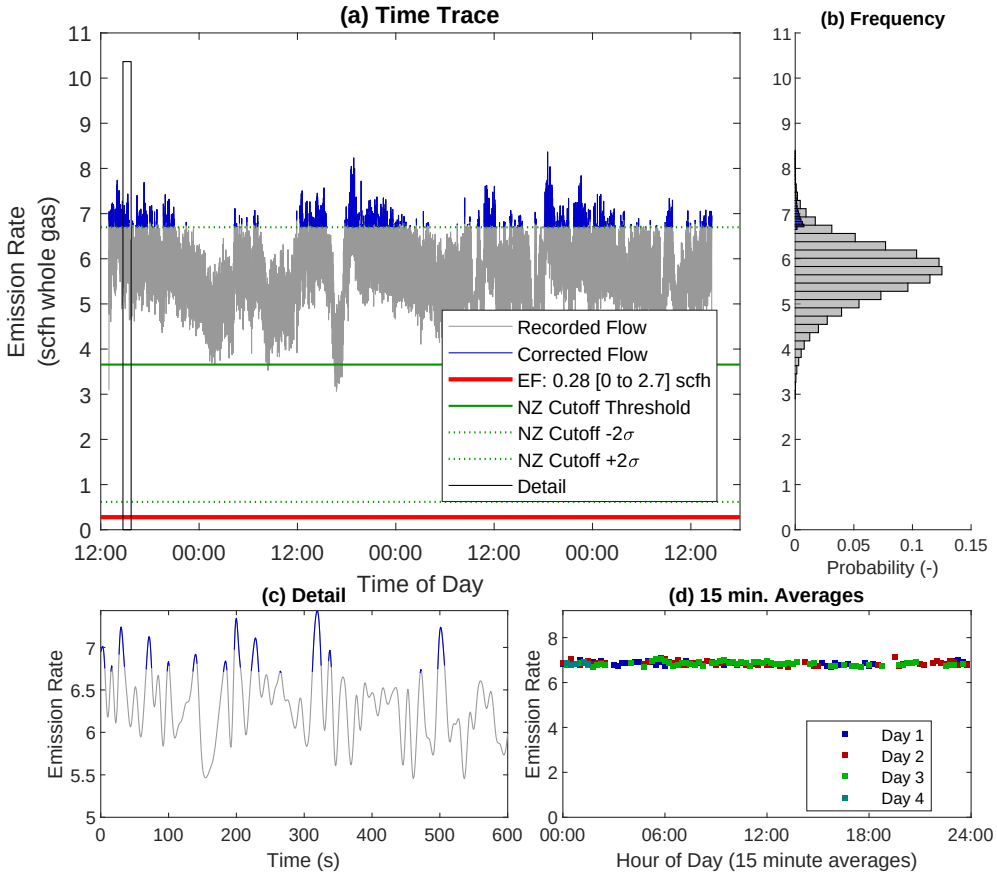

Figure S1-104: Device O-4

Device O-5

Site Class: II	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 28.8 hrs
Controller Location: Compressor	Avg. Gas Temperature: 57.1 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 41.9 psia
Controller Model: Mallard 3200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 0 [0 to 0]
Non-zero Correction:	NZ Cutoff: 12.7 scfh
Samples Remaining: 0%	Emissions Remaining: 0%
Evaluation: -	

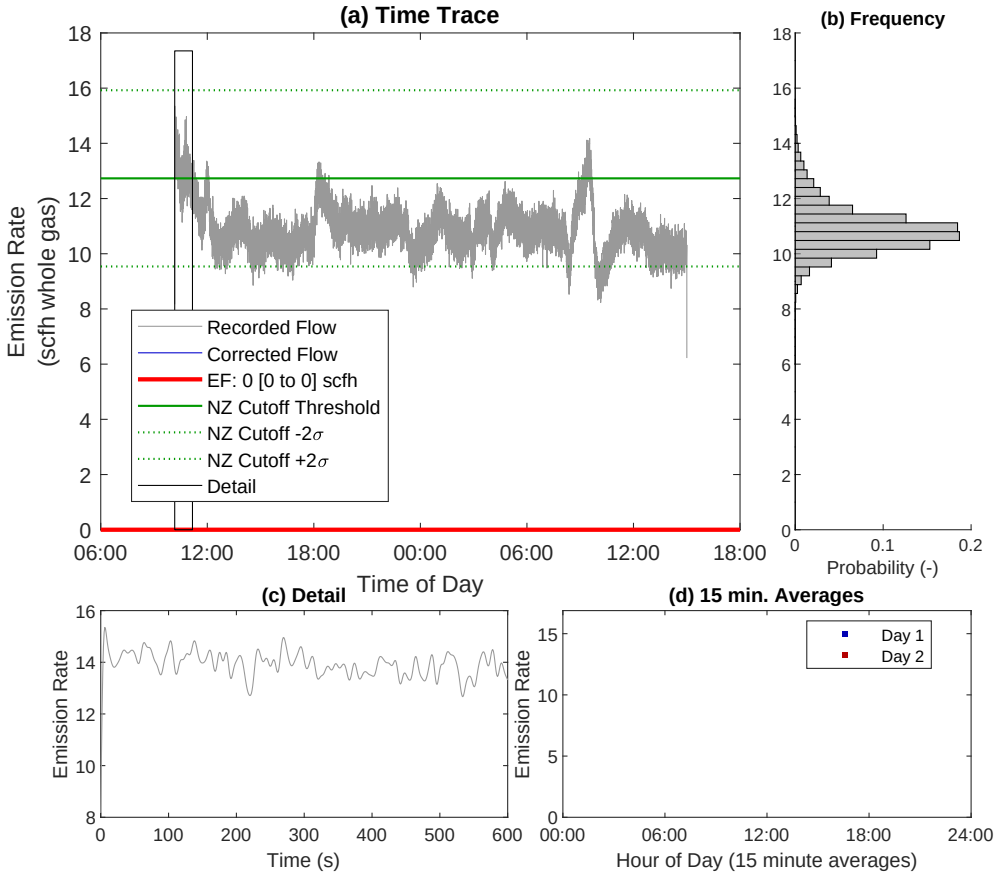

Figure S1-105: Device O-5

Device P-3

Site Class: III	NEMS Region: Gulf Coast
Install Location: Inline	Measurement Duration: 68.6 hrs
Controller Location: Compressor	Avg. Gas Temperature: 49.7 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 39.5 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 94.5%
EPA Bleed Type: Intermittent	Emission Factor: 0.00048 [0 to 0]
Non-zero Correction:	NZ Cutoff: 6.37 scfh
Samples Remaining: 0.0049%	Emissions Remaining: 0.007%
Evaluation: -	

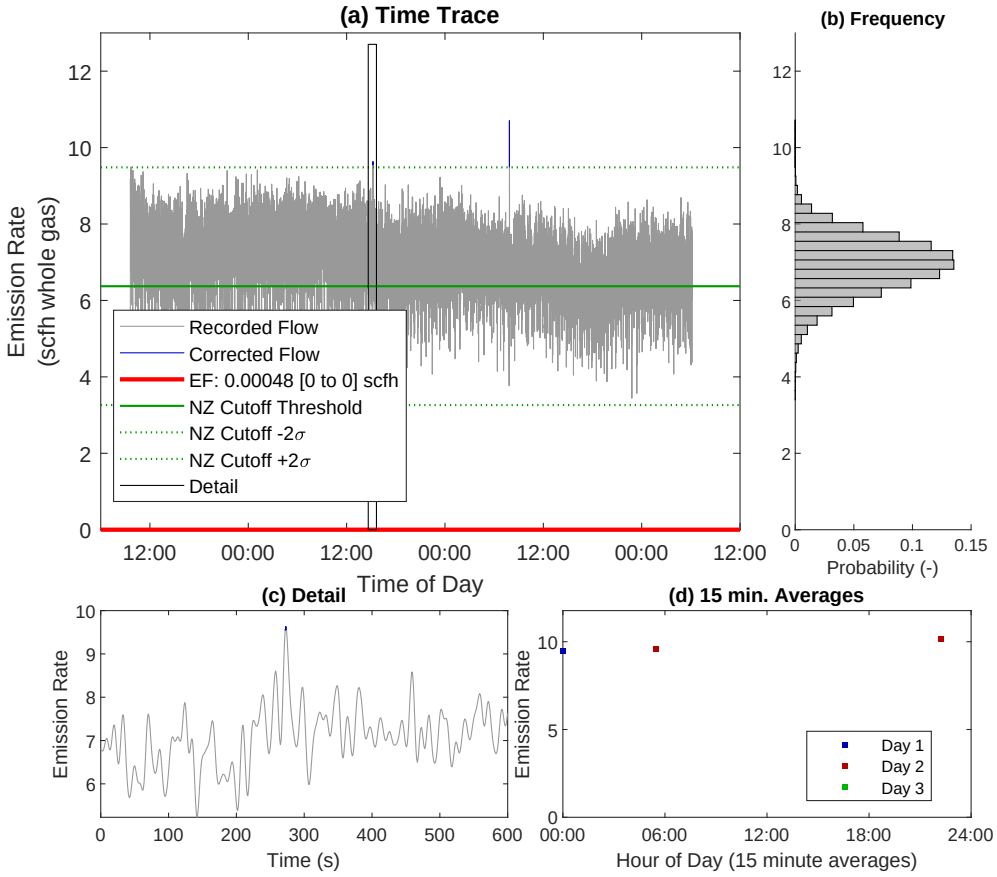

Figure S1-106: Device P-3

Device P-4

Site Class: III	NEMS Region: Gulf Coast
Install Location: Inline	Measurement Duration: 68.7 hrs
Controller Location: Compressor	Avg. Gas Temperature: 45.9 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 68.5 psia
Controller Model: Norriseal 1001A	Gas Methane Fraction: 94.5%
EPA Bleed Type: Intermittent	Emission Factor: 0 [0 to 0]
Non-zero Correction:	NZ Cutoff: 25.8 scfh
Samples Remaining: 0%	Emissions Remaining: 0%
Evaluation: -	

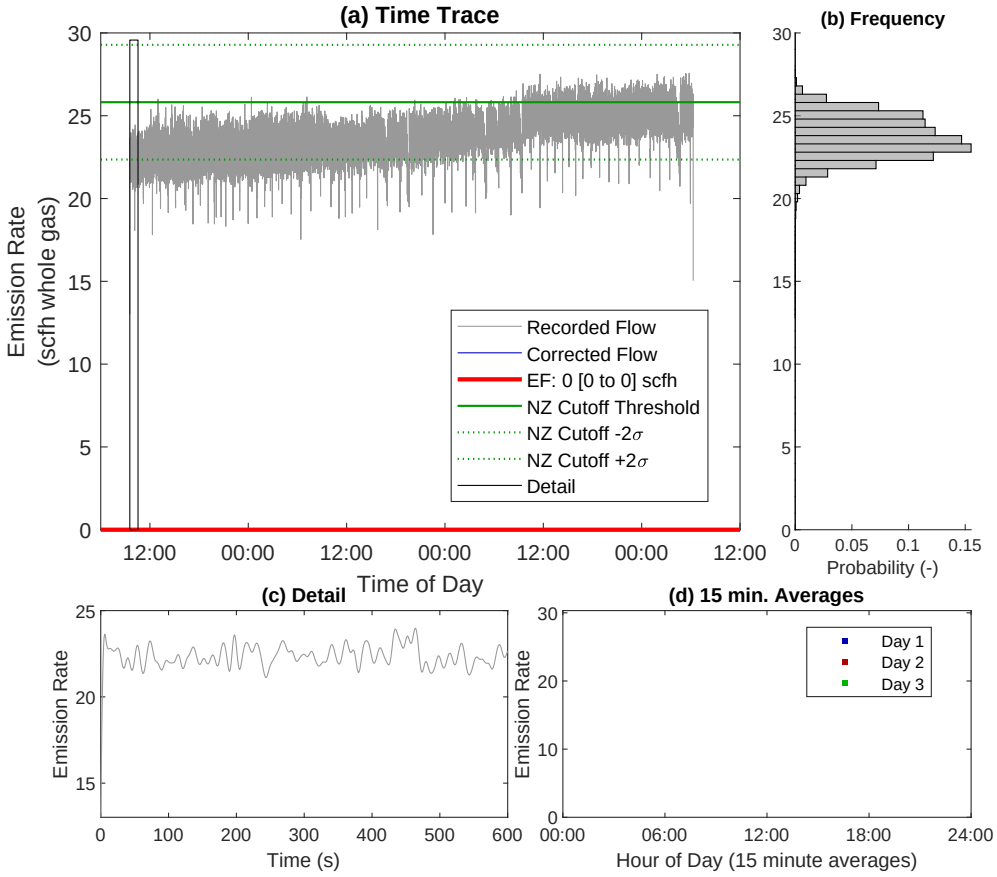

Figure S1-107: Device P-4

Device T-1

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 69.4 hrs
Controller Location: Separator	Avg. Gas Temperature: 4.89 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 35.8 psia
Controller Model: Solenoid Operated	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 0.0085 [0 to 0.009]
Non-zero Correction:	NZ Cutoff: 1.66 scfh
Samples Remaining: 0.18%	Emissions Remaining: 0.53%
Evaluation: -	

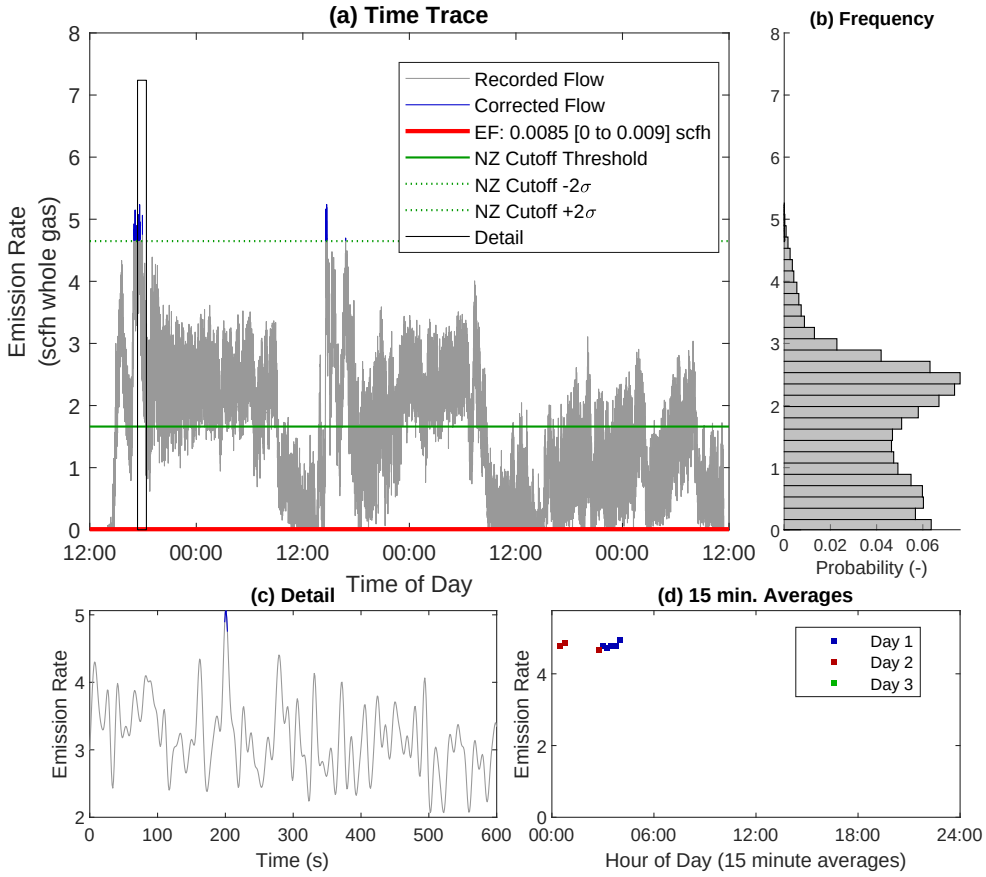

Figure S1-108: Device T-1

Device U-1

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 76.3 hrs
Controller Location: Separator	Avg. Gas Temperature: 16 $^{\circ}F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 50.6 psia
Controller Model: Unknown	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 0 [0 to 0]
Non-zero Correction:	NZ Cutoff: 11.4 scfh
Samples Remaining: 0%	Emissions Remaining: 0%
Evaluation: -	

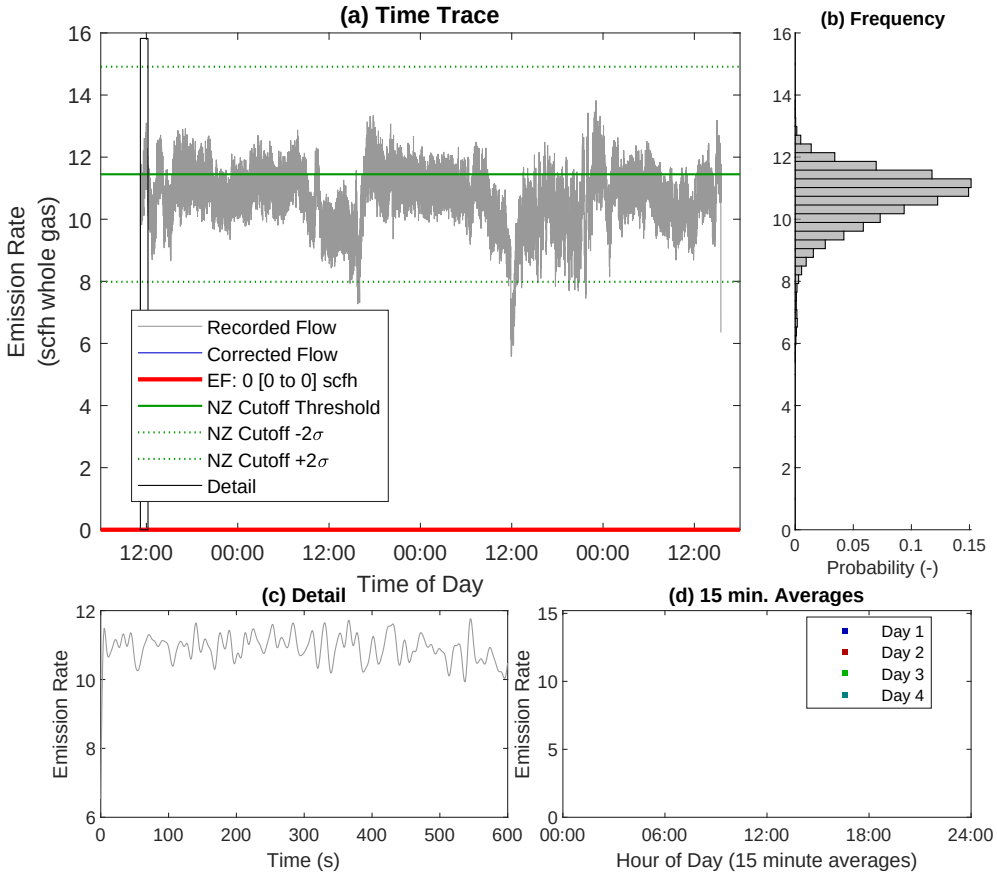

Figure S1-109: Device U-1

Device U-4

Site Class: III	NEMS Region: Rocky Mountain
Install Location: Inline	Measurement Duration: 76.8 hrs
Controller Location: Compressor	Avg. Gas Temperature: 54.2 $°F$
Process Controlled: Liquid Level	Avg. Supply Pressure: 44.8 psia
Controller Model: Mallard 3200	Gas Methane Fraction: 89.5%
EPA Bleed Type: Intermittent	Emission Factor: 0 [0 to 0]
Non-zero Correction:	NZ Cutoff: 8.89 scfh
Samples Remaining: 0%	Emissions Remaining: 0%
Evaluation: -	

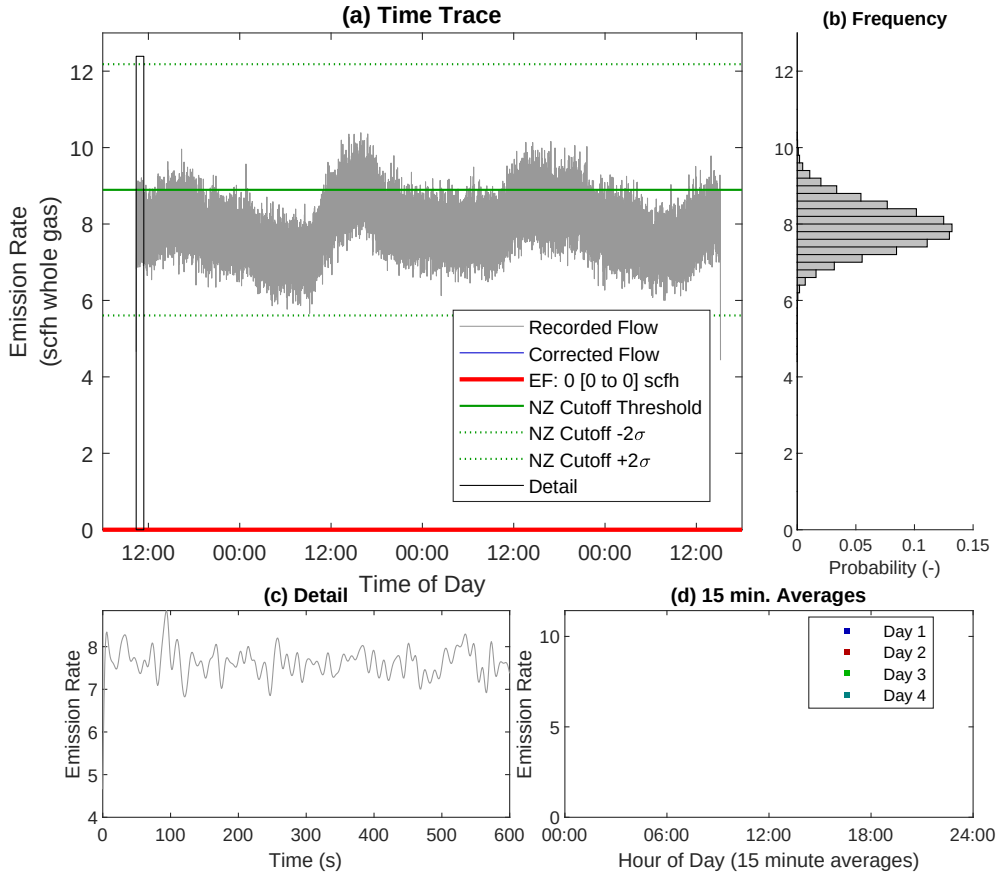

Figure S1-110: Device U-4