

# Appendix C

## Methane Emissions from Gathering Compressor Stations in the U.S.:

### *Major Equipment Emission Factor Details*

#### October 2019 Revision

Daniel Zimmerle<sup>1</sup>, Timothy Vaughn<sup>1</sup>, Benjamin Luck<sup>1</sup>, Terri Lauderdale<sup>2</sup>, Kindal Keen<sup>2</sup>,  
Matthew Harrison<sup>2</sup>, Anthony Marchese<sup>1</sup>, and Laurie Williams<sup>3</sup>

<sup>1</sup>Energy Institute at Colorado State University

<sup>2</sup>AECOM

<sup>3</sup>Fort Lewis College

## C Detailed Data for Major Equipment Emission Factors

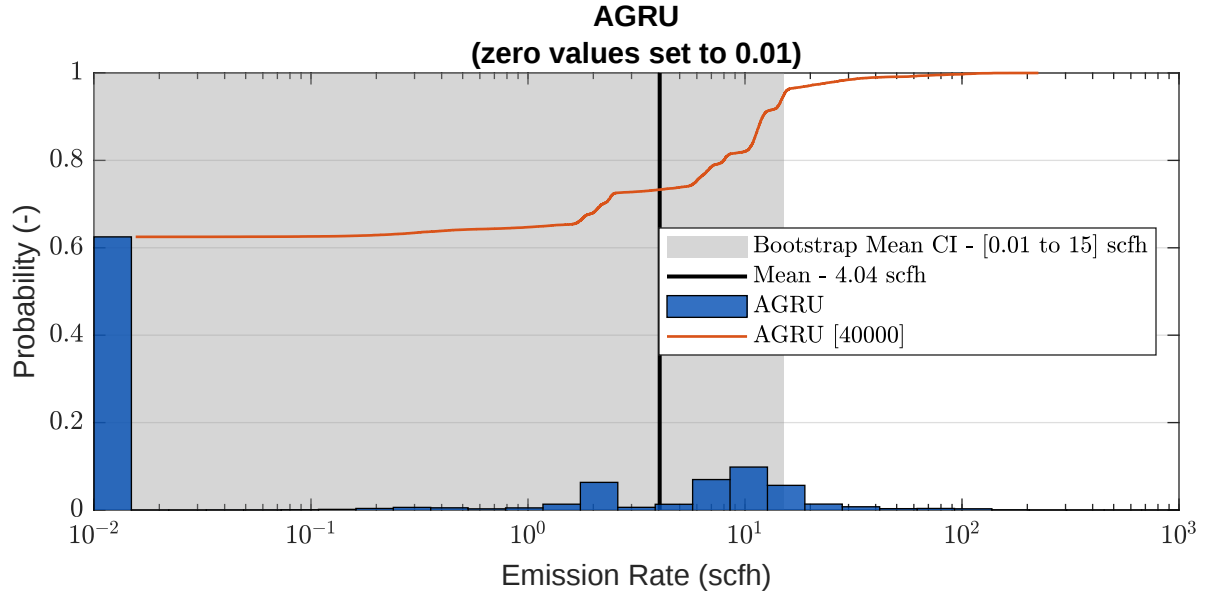
Plots and tables in this appendix provide more detail on recommended emissions factors for major equipment categories. The notes indicate major equipment categories where too few units were encountered during the field campaign to develop high-confidence emission factors. The plot shows the cumulative distribution function for the simulated emissions. Two tables follow:

**Average emission Factor** provides an overview of the emission factor. Columns are:

| Column Header                        | Description                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gas                                  | type of emission factor - whole gas or methane.                                                                                                                                                                                                                                                                                                                                  |
| Population Basis                     | the unit definition (activity basis) and number of units screened (mean population) used to develop the emission factor. Only units where all detected emissions could be estimated are included in the population.                                                                                                                                                              |
| Emission Factor                      | emission factor (mean of per-unit emissions), and upper and lower 95% confidence intervals as absolute values. The emission factor and confidence interval are also shown on the plot.                                                                                                                                                                                           |
| Identified Emission Sources per Unit | mean number of emission sources identified, on a per-unit basis, the fraction of major equipment units in each category with <i>no</i> emissions measured, and the maximum number of emission sources found on one unit. Values are the same for methane and whole gas unless the gas composition was not available to convert measurements between the gas types on some units. |

**Unmeasured / Simulated Sources** indicates the type of measurements utilized to develop the emission factor, including direct measurements and measurements approximated from other data. Columns are:

| Column Header                         | Description                                                                                                                                                                                                                                                                                       |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Measurement Quality Indicator         | the quality indicator for each detected emission, see description in main report.                                                                                                                                                                                                                 |
| Count of Emission Sources             | the number of detected emissions in each quality indicator.                                                                                                                                                                                                                                       |
| Total Emissions & Confidence Interval | total emissions simulated for each quality indicator, with 95% confidence interval.                                                                                                                                                                                                               |
| Mean Fraction of Total Emissions      | the mean estimate of emissions attributable to each quality indicator. For example, a value of 10% with a quality indicator of <i>Inaccessible</i> , indicates that one tenth of the emission factor estimate is due to the detected emissions which were inaccessible and could not be measured. |



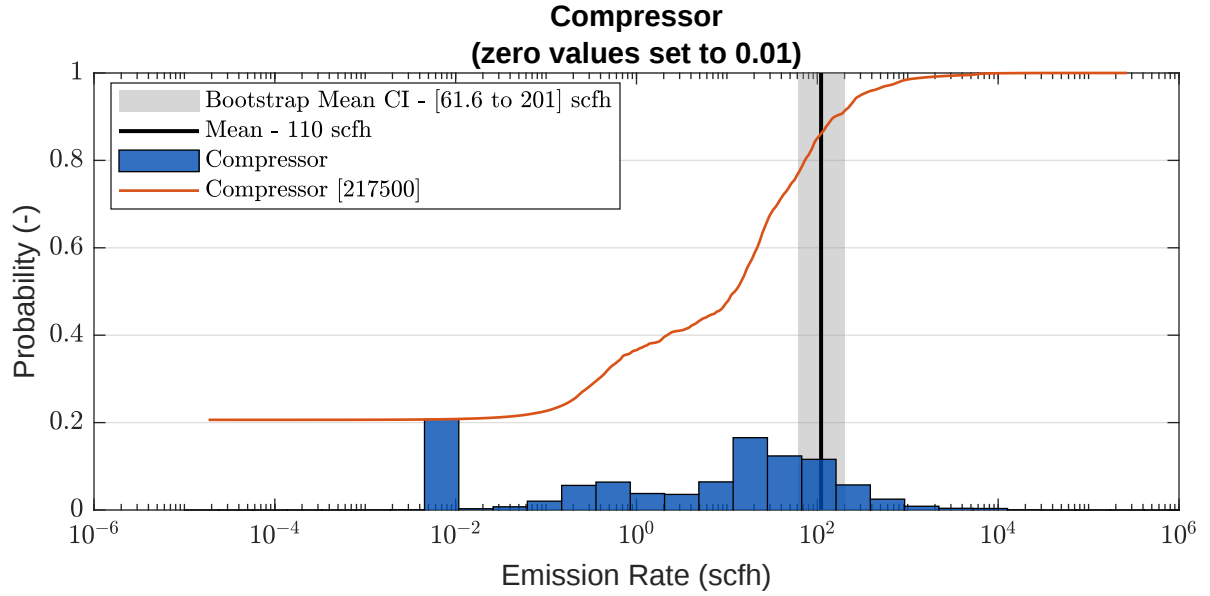
**Figure C1:** AGRU

**Table C1:** Average Emission Factor for AGRU

| Gas                           | Population Basis |                 | Emission Factor (scfh) |                     | Identified Emission Sources |                       |                          |
|-------------------------------|------------------|-----------------|------------------------|---------------------|-----------------------------|-----------------------|--------------------------|
|                               | Activity Basis   | Mean Population | Mean                   | Confidence Interval | Mean Sources Per Unit       | Units with No Sources | Maximum Sources per Unit |
| <i>Whole Gas</i> <sup>1</sup> | Unit             | 8               | 4.04                   | [0 to 15.1]         | 0.5                         | 63%                   | 2                        |
| <i>Methane</i> <sup>1</sup>   | Unit             | 8               | 3.61                   | [0.0269 to 13.7]    | 0.5                         | 63%                   | 2                        |

<sup>1</sup> Emission factor is based upon few measurements and is unlikely to be robust.

| Unmeasured / Simulated Sources |                           |                        |                     |                                  |
|--------------------------------|---------------------------|------------------------|---------------------|----------------------------------|
| Measurement Quality Indicator  | Count of Emission Sources | Total Emissions (scfh) | Confidence Interval | Mean Fraction of Total Emissions |
| Measured                       | 2                         | 17                     | [12.5 to 22.9]      | 53%                              |
| Other                          | 2                         | 15.4                   | [0.18 to 95.5]      | 47%                              |

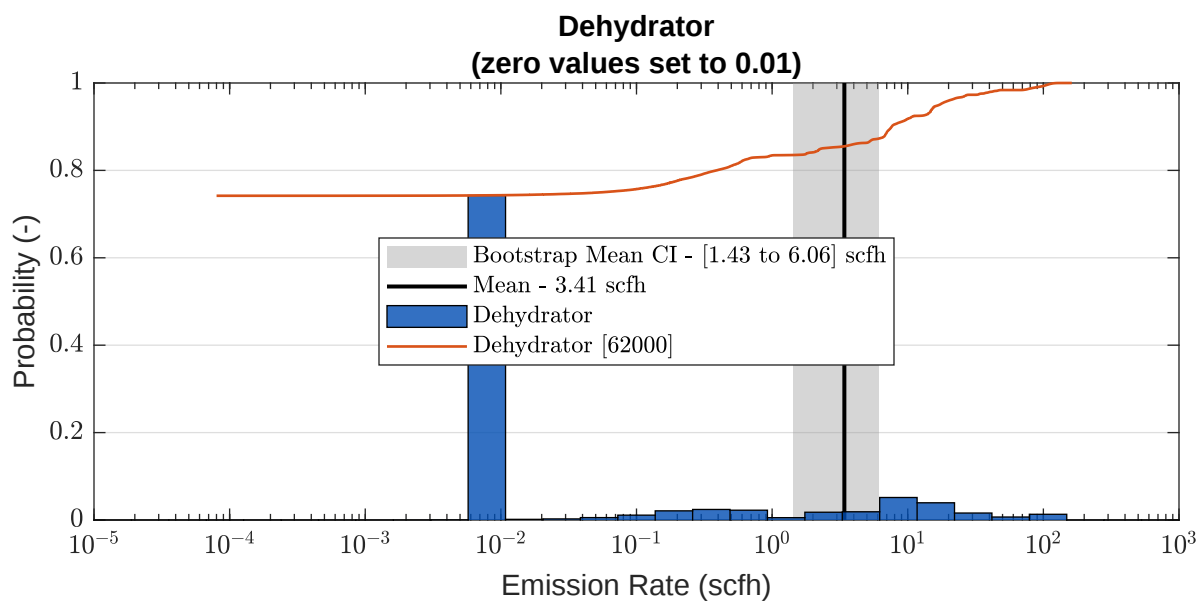


**Figure C2:** Compressor

**Table C2:** Average Emission Factor for Compressor

| Gas       | Population Basis |                 | Emission Factor (scfh) |                     | Identified Emission Sources |                       |                          |
|-----------|------------------|-----------------|------------------------|---------------------|-----------------------------|-----------------------|--------------------------|
|           | Activity Basis   | Mean Population | Mean                   | Confidence Interval | Mean Sources Per Unit       | Units with No Sources | Maximum Sources per Unit |
| Whole Gas | Unit             | 435             | 110                    | [61.3 to 191]       | 2.69                        | 20%                   | 18                       |
| Methane   | Unit             | 435             | 94.4                   | [52.2 to 167]       | 2.69                        | 20%                   | 18                       |

| Measurement<br>Quality Indicator | Unmeasured / Simulated Sources  |                              |                                       | Mean Fraction<br>of Total<br>Emissions |
|----------------------------------|---------------------------------|------------------------------|---------------------------------------|----------------------------------------|
|                                  | Count of<br>Emission<br>Sources | Total<br>Emissions<br>(scfh) | Confidence<br>Interval                |                                        |
| Measured                         | 753                             | $22.2 \times 10^3$           | $[20.9 \text{ to } 23.7] \times 10^3$ | 47%                                    |
| Cannot Measure                   | 21                              | 536                          | $[197 \text{ to } 1.37 \times 10^3]$  | 1.1%                                   |
| Exceeded Capacity                | 12                              | $19.2 \times 10^3$           | $[6.06 \text{ to } 50.9] \times 10^3$ | 40%                                    |
| Inaccessible                     | 33                              | $1.95 \times 10^3$           | $[403 \text{ to } 7.25 \times 10^3]$  | 4.1%                                   |
| Incomplete Capture               | 16                              | $2.9 \times 10^3$            | $[1.84 \text{ to } 5.46] \times 10^3$ | 6.1%                                   |
| OGI Non-detect                   | 310                             | 42.2                         | [39.5 to 44.9]                        | 0.089%                                 |
| Other                            | 19                              | 550                          | $[178 \text{ to } 1.3 \times 10^3]$   | 1.2%                                   |
| Safety                           | 4                               | 90                           | [7.43 to 452]                         | 0.19%                                  |

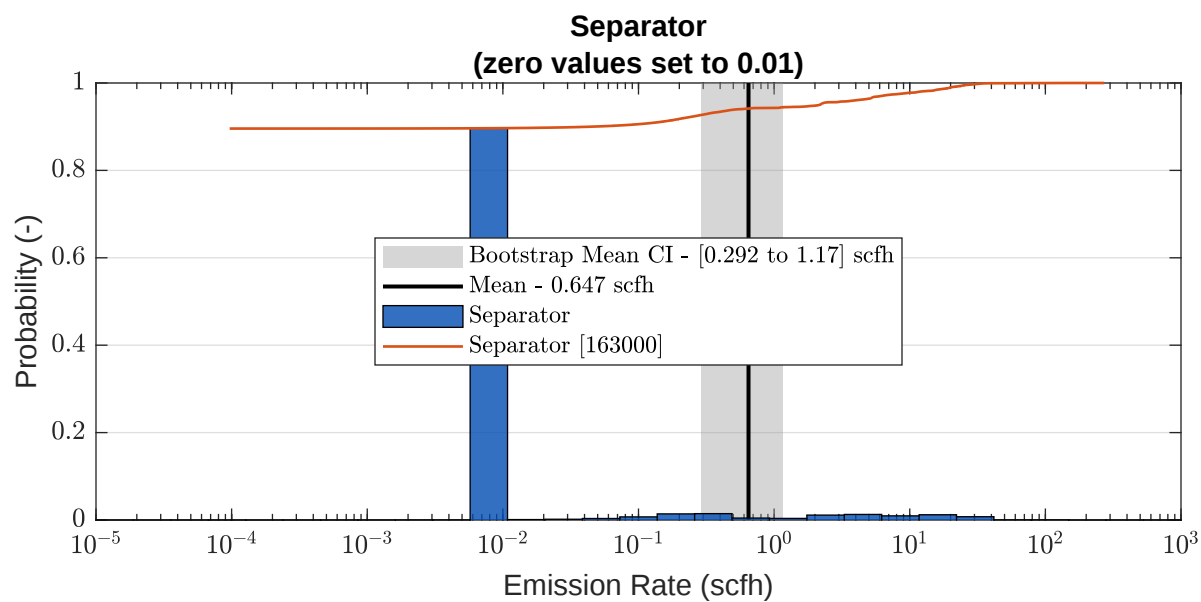


**Figure C3:** Dehydrator

**Table C3:** Average Emission Factor for Dehydrator

| Gas       | Population Basis |                 | Emission Factor (scfh) |                     | Identified Emission Sources |                       |                          |
|-----------|------------------|-----------------|------------------------|---------------------|-----------------------------|-----------------------|--------------------------|
|           | Activity Basis   | Mean Population | Mean                   | Confidence Interval | Mean Sources Per Unit       | Units with No Sources | Maximum Sources per Unit |
| Whole Gas | Unit             | 124             | 3.41                   | [1.44 to 5.97]      | 0.532                       | 74%                   | 6                        |
| Methane   | Unit             | 124             | 2.95                   | [1.23 to 5.14]      | 0.532                       | 74%                   | 6                        |

| Unmeasured / Simulated Sources |                           |                        |                     |                                  |
|--------------------------------|---------------------------|------------------------|---------------------|----------------------------------|
| Measurement Quality Indicator  | Count of Emission Sources | Total Emissions (scfh) | Confidence Interval | Mean Fraction of Total Emissions |
| Measured                       | 48                        | 409                    | [385 to 434]        | 97%                              |
| OGI Non-detect                 | 16                        | 2.15                   | [1.55 to 2.76]      | 0.51%                            |
| Other                          | 1                         | 5.5                    | [0.0253 to 34.7]    | 1.3%                             |
| Safety                         | 1                         | 5.68                   | [0.0251 to 34.7]    | 1.3%                             |



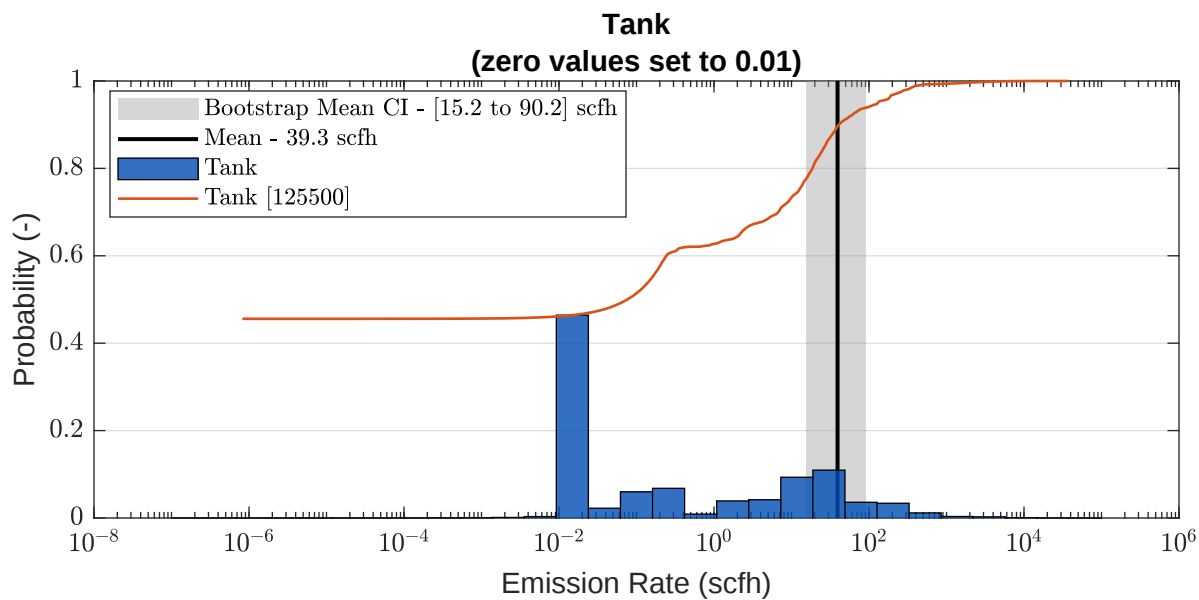
**Figure C4:** Separator

**Table C4:** Average Emission Factor for Separator

| Gas       | Population Basis |                 | Emission Factor (scfh) |                     | Identified Emission Sources |                       |                          |
|-----------|------------------|-----------------|------------------------|---------------------|-----------------------------|-----------------------|--------------------------|
|           | Activity Basis   | Mean Population | Mean                   | Confidence Interval | Mean Sources Per Unit       | Units with No Sources | Maximum Sources per Unit |
| Whole Gas | Unit             | 326             | 0.647                  | [0.291 to 1.13]     | 0.153                       | 90%                   | 6                        |
| Methane   | Unit             | 326             | 0.545                  | [0.257 to 0.983]    | 0.153                       | 90%                   | 6                        |

**Unmeasured / Simulated Sources**

| Measurement Quality Indicator | Count of Emission Sources | Total Emissions (scfh) | Confidence Interval | Mean Fraction of Total Emissions |
|-------------------------------|---------------------------|------------------------|---------------------|----------------------------------|
| Measured                      | 34                        | 170                    | [157 to 182]        | 80%                              |
| OGI Non-detect                | 11                        | 1.49                   | [0.974 to 2]        | 0.71%                            |
| Other                         | 5                         | 39.6                   | [2.82 to 141]       | 19%                              |

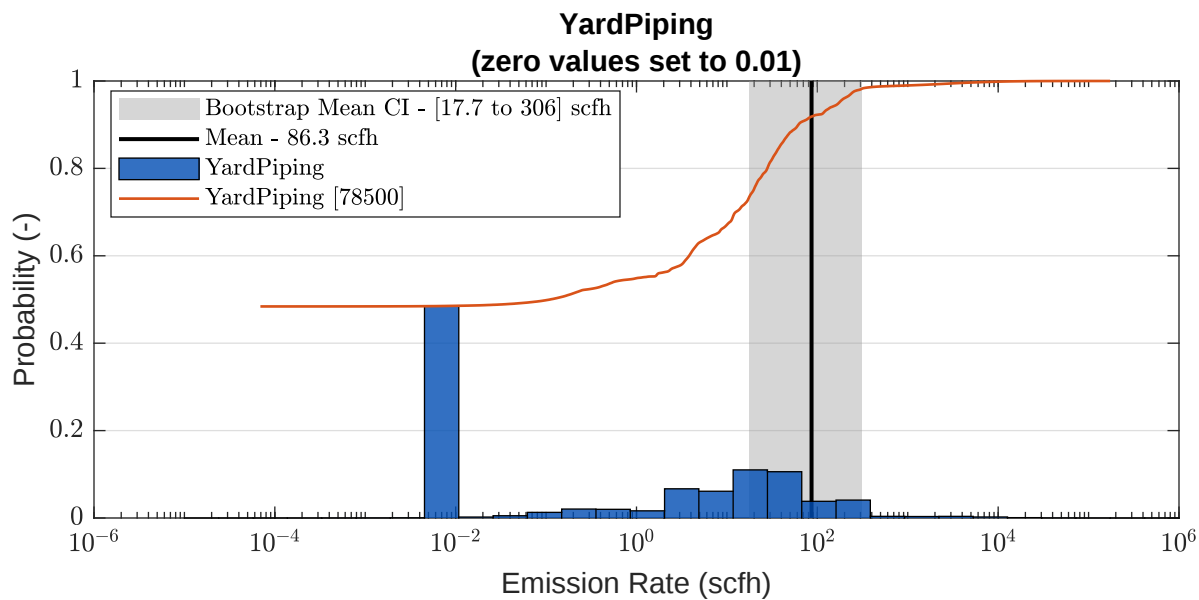


**Figure C5:** Tank

**Table C5:** Average Emission Factor for Tank

| Gas       | Population Basis |                 | Emission Factor (scfh) |                     | Identified Emission Sources |                       |                          |
|-----------|------------------|-----------------|------------------------|---------------------|-----------------------------|-----------------------|--------------------------|
|           | Activity Basis   | Mean Population | Mean                   | Confidence Interval | Mean Sources Per Unit       | Units with No Sources | Maximum Sources per Unit |
| Whole Gas | Tank             | 251             | 39.3                   | [15.4 to 95.3]      | 0.793                       | 44%                   | 4                        |
| Methane   | Tank             | 251             | 33.6                   | [13.1 to 74.4]      | 0.793                       | 44%                   | 4                        |

| Unmeasured / Simulated Sources |                           |                        |                                       |                                  |
|--------------------------------|---------------------------|------------------------|---------------------------------------|----------------------------------|
| Measurement Quality Indicator  | Count of Emission Sources | Total Emissions (scfh) | Confidence Interval                   | Mean Fraction of Total Emissions |
| Measured                       | 138                       | $4.59 \times 10^3$     | $[3.78 \text{ to } 5.51] \times 10^3$ | 47%                              |
| Cannot Measure                 | 1                         | 47.3                   | [0.0402 to 357]                       | 0.48%                            |
| Exceeded Capacity              | 2                         | $4.86 \times 10^3$     | $[1.15 \text{ to } 13.8] \times 10^3$ | 49%                              |
| Incomplete Capture             | 1                         | 199                    | [59 to 508]                           | 2%                               |
| OGI Non-detect                 | 55                        | 6.71                   | [5.64 to 7.76]                        | 0.068%                           |
| Safety                         | 2                         | 115                    | [0 to 690]                            | 1.2%                             |



**Figure C6:** YardPiping

**Table C6:** Average Emission Factor for YardPiping

| Gas       | Population Basis |                 | Emission Factor (scfh) |                     | Identified Emission Sources |                       |                          |
|-----------|------------------|-----------------|------------------------|---------------------|-----------------------------|-----------------------|--------------------------|
|           | Activity Basis   | Mean Population | Mean                   | Confidence Interval | Mean Sources Per Unit       | Units with No Sources | Maximum Sources per Unit |
| Whole Gas | Station          | 157             | 86.3                   | [18 to 310]         | 1.9                         | 48%                   | 17                       |
| Methane   | Station          | 157             | 74.4                   | [14.8 to 259]       | 1.9                         | 48%                   | 17                       |

| Unmeasured / Simulated Sources |                           |                        |                                       |                                  |
|--------------------------------|---------------------------|------------------------|---------------------------------------|----------------------------------|
| Measurement Quality Indicator  | Count of Emission Sources | Total Emissions (scfh) | Confidence Interval                   | Mean Fraction of Total Emissions |
| Measured                       | 238                       | $2.44 \times 10^3$     | $[2.2 \text{ to } 2.67] \times 10^3$  | 18%                              |
| Exceeded Capacity              | 2                         | $9.87 \times 10^3$     | $[1.21 \text{ to } 40.4] \times 10^3$ | 74%                              |
| Inaccessible                   | 6                         | 132                    | [8.17 to 429]                         | 0.99%                            |
| Incomplete Capture             | 4                         | 493                    | [291 to 868]                          | 3.7%                             |
| OGI Non-detect                 | 31                        | 4.34                   | [3.45 to 5.26]                        | 0.032%                           |
| Other                          | 12                        | 322                    | [75.5 to 752]                         | 2.4%                             |
| Safety                         | 4                         | 80.1                   | [11.9 to 311]                         | 0.6%                             |
| Weather                        | 1                         | 7.9                    | [0.0461 to 30.9]                      | 0.059%                           |