API Field Measurement Study: Pneumatic Controllers

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Paul Tupper
Study Overview

➢ Goals
  ▪ Inventory pneumatic controllers at a range of site types
  ▪ Correctly classify pneumatic controllers and measure emissions
  ▪ Understand the frequency of malfunctioning pneumatic controllers and their emissions

➢ 72 sites operated by 8 companies selected for study in 4 AAPG basins
  ▪ Anadarko (# 360), San Juan (# 580), Gulf Coast (# 220) and Permian (# 430)

➢ Variety of site types in the production and gathering & boosting segments

➢ Variety of production/formation types; conventional gas, unconventional gas and oil

➢ Study conducted from June to December 2015
A broad range of site types were represented in the study.

<table>
<thead>
<tr>
<th>Site Type and Category</th>
<th>San Juan</th>
<th>Anadarko</th>
<th>Permian*</th>
<th>Gulf Coast</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas Sites</td>
<td>12</td>
<td>25</td>
<td>0</td>
<td>11</td>
<td>48</td>
</tr>
<tr>
<td>Well Site</td>
<td>6</td>
<td>8</td>
<td>0</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Well Production</td>
<td>2</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Central Production</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Boosting and Gathering</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td><strong>Oil Sites</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well Site</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Well Production</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Central Production</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Boosting and Gathering</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>12</td>
<td>26</td>
<td>18</td>
<td>16</td>
<td>72</td>
</tr>
</tbody>
</table>

*3 Permian Basin natural gas sites, initially selected for study, were not included since they were EOR sites handling primarily CO₂
Pneumatic Controllers – Inventory

➢ Of 72 sites, controllers were inventoried at 67
  ▪ 19 (26%) sites - no pneumatic controllers.
  ▪ 40 (55%) sites – At least one natural gas powered pneumatic controller; with 32 sites exclusively natural gas
  ▪ 8 (11%) sites - pneumatic controllers were exclusively air or primarily CO₂

➢ At 45 sites with detailed inventory
  ▪ 420 non-mechanical controllers counted
  ▪ 370 (88%) Operated by natural gas
  ▪ 39 (9%) Operated by air or primarily CO₂
  ▪ 7 (2%) Electric operated
  ▪ 4 (1%) Out of service or energy type unknown
Pneumatic Controller Measurement Overview

- Measured exhaust emissions from 308 controllers at 39 sites with nat. gas controllers
  - Most time series at 2 second sampling rate (0.5 Hz) for minimum of approx. 15 min
  - Daily calibration, and QA/QC used to ensure instrument performance.

![Bar chart showing controllers measured by basin and type]

- Intermittent: 85.4%
- High Bleed: 6.5%
- Low Bleed: 8.1%
Pneumatic Controller Measurement Averages

- Study averages were dominated by Gulf Coast measurements.
- Intermittent vent type controller average was dominated by malfunctioning controllers.

Note: 0.13 scf/hr minimum emissions was used when instrument readings were below 0.13 scf/hr.
## Study Measurement Averages and Cumulative Emissions

### Average Measured Emissions – SCFH Whole Gas

<table>
<thead>
<tr>
<th></th>
<th>Study Overall</th>
<th>Gulf Coast</th>
<th>Permian</th>
<th>San Juan</th>
<th>Anadarko</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Emissions – All</td>
<td>9.2</td>
<td>15.4</td>
<td>1.6</td>
<td>3.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Average Emissions - High Bleed</td>
<td>16.4</td>
<td>17.4</td>
<td>15.7</td>
<td>12.6</td>
<td></td>
</tr>
<tr>
<td>Average Emissions - Low Bleed</td>
<td>2.6</td>
<td>2.7</td>
<td>2.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Emissions - Intermittent</td>
<td>9.2</td>
<td>16.2</td>
<td>1.6</td>
<td>3.8</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Note that average values may change slightly as analysis is completed.

### Cumulative Measured Emissions – SCF Whole Gas

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>Study Cumulative Measured SCF</th>
<th>% of Study Measured Controller Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Bleed</td>
<td>20</td>
<td>327</td>
<td>11.6%</td>
</tr>
<tr>
<td>Low Bleed</td>
<td>25</td>
<td>65.8</td>
<td>2.3%</td>
</tr>
<tr>
<td>Properly Functioning Intermittent</td>
<td>164</td>
<td>42.3</td>
<td>1.5%</td>
</tr>
<tr>
<td>Malfunctioning Intermittent</td>
<td>99</td>
<td>2,387</td>
<td>84.6%</td>
</tr>
</tbody>
</table>

Note that category counts and cumulative measurements may change slightly as analysis is completed.
Intermittent PC Data Fitting

- Cumulative distribution fitting with Weibull distribution function
  - Dominated by number of Gulf Coast measurements
  - Minimally emitting controllers excluded from Weibull distribution but included in cumulative distribution

<table>
<thead>
<tr>
<th></th>
<th>Weibull scale parameter</th>
<th>Weibull shape parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Properly functioning</td>
<td>0.2735</td>
<td>0.5463</td>
</tr>
<tr>
<td>Malfunctioning</td>
<td>17.4266</td>
<td>0.6294</td>
</tr>
</tbody>
</table>

Red Line – Malfunctioning
Black Line – Properly Functioning
Green Line – Subpart W EF
Instruments and Measurement Approach

➢ Controller exhaust was measured with high volume samplers
➢ Most measurements were made with the GHD recording high volume sampler with about 0.5 Hz recording
➢ 8 measurements were made with the Indaco high volume sampler and 1 with the Bacharach high volume sampler. All 9 were either zero measured emissions or had constant emissions
➢ The effective resolution of the GHD sampler was empirically determined to be 0.26 scf/hr
➢ To conservatively account for minimal emissions (seepage) 0.13 scf/hr (1/2 the effective resolution) was used as the minimum rate for intermittent vent controller measurements below this value
➢ Instrument response factors were developed for each instrument using the gas composition at each site with measurements
Conclusions

➢ Comparison to Subpart W Emissions Factors
   - Subpart W High bleed is higher than study (37.3 vs. 16.4)
   - Subpart W Low bleed is lower than study (1.39 vs. 2.6)
   - Consider new tiered approach for Subpart W Intermittent
     o Properly Functioning Intermittent Controller >> 0.3 scfh
     o Malfunctioning Intermittent Controller >> 24.1 scfh
   - Tiered approach supported by skewed emission distribution in this and other studies
   - Tiered approach would enable collection of more accurate GHGRP emission data
Questions?