Swansea Ambient Air Monitoring Station (SAMS)
Phase I Air Quality Data Report

Prepared for the Colorado Department of Transportation
and the City and County of Denver,
Department of Environmental Health

Montrose Project No. 6203
Report ID: 6203-Year One
Test Dates: June 2017-May 2018
October 15, 2018
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Project Overview

Background
Colorado Department of Transportation (CDOT) and Denver Environmental Health (DEH) entered into an agreement\(^1\) to monitor air quality at Swansea Elementary School in three phases. Phase I monitored air quality for one year prior to startup of a CDOT construction project on Interstate 70 (I-70). Phase II will monitor air quality for three (3) years during the I-70 expansion project; construction may last more than three years. Phase III will monitor air quality for one year after I-70 construction and ground disturbance activities are completed.

The monitoring aspect of Phase I began on April 1, 2017. The monitoring project scope of work, which is an attachment to the agreement, defined the first quarter of a year as beginning on September 1. Therefore, monitoring began in the third quarter of the 2017 project year (Q3 PY2017).

Objectives
Montrose Air Quality Services, LLC (Montrose) was contracted by the City and County of Denver to start up and operate the Swansea Air Monitoring Station (SAMS). During Phase I, SAMS was located at the Swansea Elementary School; faculty parking lot; South East Corner; at 4650 Columbine Street, Denver, Colorado. Because of construction considerations (Swansea Elementary School playground and parking lot areas are swapping), it was necessary to move SAMS approximately 145 feet to the South after Phase I ended. This report represents a summary of monitoring conducted for Phase I. The station monitored the following parameters during Phase I:

- C\(_6\) (6-Carbon) through C\(_{12}\) (12-Carbon) Volatile Organic Compounds (VOC)
- Black Carbon
- Carbon Monoxide (CO)
- Particulate Matter less than 10 Microns (PM\(_{10}\))
- Particulate Matter less than 2.5 Microns (PM\(_{2.5}\))
- Meteorological Measurements
- Nitrogen Oxides (NO\(_x\))

The monitoring was performed to meet the requirements of the agreement between CDOT and DEH. Additionally, the regulations and specifications set forth by the Colorado Department of Public Health and Environment (CDPHE) and the United States Environmental Protection Agency (USEPA), were followed as applicable.

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\(^1\) The agreement between CDOT and DEH became effective on August 12, 2016 and can be obtained from CDOT by referencing routing number 17-HTD-ZH-00167.
Operational Staff and Contacts

The contact information for each of the principal parties is summarized in the table below:

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Address Details</th>
<th>Phone Numbers</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rebecca White</strong></td>
<td>Colorado Department of Transportation</td>
<td>5640 E. Atlantic Place</td>
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<td><a href="mailto:rebecca.white@state.co.us">rebecca.white@state.co.us</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Denver, CO 80222</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Phone: (303) 512-5901</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>E-mail: <a href="mailto:rebecca.white@state.co.us">rebecca.white@state.co.us</a></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>City and County of Denver</td>
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<td>(720) 865-2891</td>
<td><a href="mailto:Michael.Ogletree@denvergov.org">Michael.Ogletree@denvergov.org</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Denver, CO 80204</td>
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<tr>
<td></td>
<td></td>
<td>Phone: (720) 865-2891</td>
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<td></td>
<td></td>
<td>E-mail: <a href="mailto:Michael.Ogletree@denvergov.org">Michael.Ogletree@denvergov.org</a></td>
<td></td>
<td></td>
</tr>
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<td><strong>Patrick Clark, PE, QSTI</strong></td>
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<td>(303) 670-0530</td>
<td><a href="mailto:pclark@montrose-env.com">pclark@montrose-env.com</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Denver, CO 80211</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Phone: (303) 670-0530</td>
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<td></td>
<td>E-mail: <a href="mailto:pclark@montrose-env.com">pclark@montrose-env.com</a></td>
<td></td>
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</tr>
<tr>
<td><strong>Dr. Larry Anderson</strong></td>
<td>University of Colorado Denver</td>
<td>7120 Routt Street</td>
<td>(303) 664-0757</td>
<td><a href="mailto:larry.anderson@ucdenver.edu">larry.anderson@ucdenver.edu</a></td>
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<tr>
<td></td>
<td></td>
<td>Arvada, CO 80004</td>
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<td>Phone: (303) 664-0757</td>
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<td>E-mail: <a href="mailto:larry.anderson@ucdenver.edu">larry.anderson@ucdenver.edu</a></td>
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<tr>
<td><strong>Austin Heitmann</strong></td>
<td>Montrose Air Quality Services, LLC</td>
<td>990 W. 43rd Ave.</td>
<td>(303) 670-0530</td>
<td><a href="mailto:aheitmann@montrose-env.com">aheitmann@montrose-env.com</a></td>
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SAMS Site Description
Region: Denver
AQS ID: 080310023
Latitude: 39.781375
Longitude: -104.955423

Picture 1 – Location of SAMS in the Swansea Elementary School Parking Lot for Phase I

Picture 2 – Interior of SAMS
SAMS Equipment
The list of primary equipment used in this project is shown in the table below. Montrose has supplied and installed the following:

- Glass lined sample probe
- Glass sampling manifold
- Sample blower, fittings, and tubing
- Instrument rack
- Cylinder mounts, calibration gases and regulators
- Security camera

<table>
<thead>
<tr>
<th>Pollutant/Parameter</th>
<th>Sampling Period</th>
<th>Manufacturer</th>
<th>Model</th>
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<tr>
<td>Nitrogen Oxides</td>
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<td>Teledyne</td>
<td>T200U</td>
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<td>Carbon Monoxide</td>
<td>Minute</td>
<td>Thermo Scientific</td>
<td>48i-TLE Trace Level CO</td>
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<td>Dynamic Dilution Calibrator</td>
<td>Periodic</td>
<td>Teledyne</td>
<td>T700U</td>
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<td>PM$<em>{2.5}$ / PM$</em>{10}$</td>
<td>Minute</td>
<td>GRIMM Technologies Inc.</td>
<td>180 EDM</td>
</tr>
<tr>
<td>Meteorological measurements</td>
<td>Minute</td>
<td>GRIMM Technologies Inc.</td>
<td>180 EDM</td>
</tr>
<tr>
<td>Meteorological measurements (wind speed and wind direction)</td>
<td>Minute</td>
<td>RM Young</td>
<td>05305V</td>
</tr>
<tr>
<td>C$<em>6$ through C$</em>{12}$ VOCs</td>
<td>30 Minutes</td>
<td>Chromatotec</td>
<td>Airmo C6-C12 (Model A27022)</td>
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<tr>
<td>Black Carbon</td>
<td>5 Minutes</td>
<td>Magee Scientific</td>
<td>Aethalometer</td>
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<tr>
<td>Data Logger (with remote accessibility)</td>
<td>Multiple</td>
<td>Agilaire</td>
<td>8872</td>
</tr>
</tbody>
</table>

Discussion of Results and Professional Judgment
The reported data is for Phase I, which is considered June 2017 through May 2018. Monitoring was conducted beginning in April 2017. The reason the period June through May is considered Phase I is due to construction project on I-70 not beginning until June 2018. This 12 month period provided base line data that illustrates some of the seasonality and month-to-month variability in these pollutants.

The RM Young meteorological station was installed on 8/15/17, but due to a grounding issue on the signal cable no valid data was collected until 11/3/17, therefore no valid wind
speed or wind direction data was collected during Q3 PY2017 or Q4 PY2017. On 11/3/17 a grounding issue was resolved on the RM Young but after an audit was conducted an 8 degree error in the wind direction was found, invalidating the data collected during November. On 1/22/18 the RM Young successfully passed an audit and valid data was collected since.

The Chromatotec Gas Chromatograph (GC) for C6 through C12 was calibrated daily by running a permeation benzene tube and zero air checks with no unusual results while the GC was in operation. A board malfunction occurred on 4/22/17 and the GC was sent in for repair. The GC was re-installed and re-started operation on 7/17/17. Due to an erroneous factory setting adjustment made during the repair, valid data collection did not occur again until 8/17/17.

The results of NO₂, CO, PM₂.₅, PM₁₀, black carbon and VOC monitoring data and baseline concentrations can be found in Figures 1 through 7 on Pages 7 through 38. The Clean Air Act requires EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The NAAQS guidance table, which defines the pollutant averaging time and limits, can be found the appendix ‘NAAQS Table’. The graphs shown indicate the readings for each month relative to the NAAQS (if applicable). Electronic records of all data and calibrations have been uploaded to the Dropbox data room maintained by DEH.

At 10:35 am on 9/24/17 the power went out at the SAMS and was not restored until 08:29 am on 9/25/17. During this approximately 22 hour outage no data was collected. This report only used the hours of data collected on those days to calculate 24 hour averages for those days.

The PM₂.₅ 24 hour NAAQS of 35 ug/m³ was exceeded on 9/4/17, 11/10/17, 1/8/18, and 2/22/18.

- The 9/4/17 PM₂.₅ 24 hour NAAQS exceedance of 51.2 ug/ m³ was attributed to very dense smoke plumes from wild fires in western Montana, Northern Idaho, Washington, and Northern California. The elevated levels in PM₂.₅ in the days before and after 9/4/17 are also due to the wild fires in the Northeast.
- The 11/10/17 PM₂.₅ 24 hour NAAQS exceedance of 38.3 ug/ m³ was due to a very strong surface temperature inversion. This causes stagnant air, trapped by the temperature inversion, to sit over Denver all day. Winds around the SAMS were remained below 6 mph all day, also pointing to local stagnation. Without other contradictory data, this spike in PM₂.₅ was local Denver emissions trapped by stagnate meteorology. PM₂.₅ was elevated at most (but not at Chatfield and National Jewish) of the Denver area PM₂.₅ stations for most of the middle of the day.
- The 1/8/18 PM₂.₅ 24 hour NAAQS exceedance of 42.7 ug/ m³ was also due to a very strong surface temperature inversion for the same reasons as stated above for
the 11/10/17 exceedance with winds at or below 3 mph all day. Additionally, PM$_{2.5}$ was elevated at most of the Denver area PM$_{2.5}$ stations from the late morning through the end of the day.

- 2/22/18 PM$_{2.5}$ 24 hour NAAQS exceedance of 36.0 ug/ m$^3$ was also due to a very strong surface temperature inversion for the same reasons as stated above for the 11/10/17 exceedance with winds at or below 6 mph all day.

An exceptional event is any unusual or naturally occurring event that can affect air quality but cannot not be reasonably controlled using techniques that agencies may implement in order to attain and maintain the NAAQS. All exceptional events are documented by CDPHE. As of 9/27/18 CDPHE has not declared the above events as exceptional events.

The CO and NO$_X$ analyzers were calibrated daily by diluting an EPA Protocol 1 calibration. No maintenance issues were observed during the sampling period. Unusual calibration results were observed as follows: The CO monitor was regularly exceeding the 10% precision requirement when analyzing the one (1) ppm calibration mixture. These exceedances fell between an 11 to 15% error. Considering the ambient levels of CO were found to be well below the 1-hour and 8-hour NAAQSs we consider the ramifications for the exceedances to be negligible. The CO analyzer precision level calibration mixture was increased to 1.5 ppm on 1/3/18 to increase the acceptable range of error, which should increase the passing rate of the precision level calibration. The NO$_2$ monitor was regularly exceeding the 10% precision requirement when analyzing the seventy (70) ppb calibration mixture. These exceedances fell between an 11 to 18% error. The Gas Phase Titration (GPT) used to produce the NO$_2$ gas by mixing O$_3$ and NO gas is created with the Dynamic Gas Dilution Calibrator. The Gas Phase Titration Pre-Set (GPTPS) is run to calibrate the ozone generator to improve the accuracy of the O$_3$ concentration. A GPTPS began running weekly 1/5/18. This increased the passing rate of the precision level calibration from 64% in Q2 PY2018 to 89% in Q3 PY2018.
Pollutant Data Collected

Figure 1a – Quarterly PM$_{10}$ Data

The graph below is shown for June 2017 through August 2017 and is the plot of the 24 hour averages. The orange line represents the 150 ug/m$^3$ 24 hour ambient PM$_{10}$ NAAQS.
Figure 1b – Quarterly PM$_{10}$ Data

The graph below is shown for September 2017 through November 2017 and is the plot of the 24 hour averages. The orange line represents the 150 ug/m$^3$ 24 hour ambient PM$_{10}$ NAAQS.
Figure 1c – Quarterly PM$_{10}$ Data

The graph below is shown for December 2017 through February 2018 and is the plot of the 24 hour averages. The orange line represents the 150 ug/m$^3$ 24 hour ambient PM$_{10}$ NAAQS.
Figure 1d – Quarterly PM$_{10}$ Data

The graph below is shown for March 2018 through May 2018 and is the plot of the 24 hour averages. The orange line represents the 150 micrograms per cubic meter (ug/m$^3$) 24 hour ambient PM$_{10}$ NAAQS.
Figure 2a – Quarterly PM$_{2.5}$ Data

The graph below is shown for June 2017 through August 2017 and is a plot of the 24 hour averages. The orange line represents the 35 ug/m$^3$ 24 hour ambient PM$_{2.5}$ NAAQS and the yellow line represents the 12 ug/m$^3$ one (1) year mean ambient PM$_{2.5}$ NAAQS. Please note that the 24 hour average values cannot be directly compared to the annual mean NAAQS.
Figure 2b – Quarterly PM$_{2.5}$ Data

The graph below is shown for September 2017 through November 2017 and is a plot of the 24 hour averages. The orange line represents the 35 ug/m$^3$ 24 hour ambient PM$_{2.5}$ NAAQS and the yellow line represents the 12 ug/m$^3$ one (1) year mean ambient PM$_{2.5}$ NAAQS. Please note that the 24 hour average values cannot be directly compared to the annual mean NAAQS.

![Graph showing PM$_{2.5}$ data for September '17 - November '17 Denver-Swansea](image-url)
Figure 2c – Quarterly PM\textsubscript{2.5} Data

The graph below is shown for December 2017 through February 2018 and is a plot of the 24 hour averages. The orange line represents the 35 ug/m\textsuperscript{3} 24 hour ambient PM\textsubscript{2.5} NAAQS and the yellow line represents the 12 ug/m\textsuperscript{3} one (1) year mean ambient PM\textsubscript{2.5} NAAQS. Please note that the 24 hour average values cannot be directly compared to the annual mean NAAQS.
Figure 2d – Quarterly PM$_{2.5}$ Data

The graph below is shown for March 2018 through May 2018 and is a plot of the 24 hour averages. The orange line represents the 35 ug/m$^3$ 24 hour ambient PM$_{2.5}$ NAAQS and the yellow line represents the 12 ug/m$^3$ one (1) year mean ambient PM$_{2.5}$ NAAQS. Please note that the 24 hour average values cannot be directly compared to the annual mean NAAQS.
The graph below is shown for June 2017 through August 2017 is a plot of the one (1) hour averages. The orange line represents the 100 parts per billion (ppb) one (1) hour ambient NO$_2$ NAAQS and the yellow line represents the 53 ppb one (1) year mean ambient NO$_2$ NAAQS. Please note that the 1 hour average values cannot be directly compared to the annual mean NAAQS.
Figure 3b – Quarterly NO₂ Data

The graph below is shown for September 2017 through November 2017 and is a plot of the one (1) hour averages. The orange line represents the 100 ppb one (1) hour ambient NO₂ NAAQS and the yellow line represents the 53 ppb one (1) year mean ambient NO₂ NAAQS. Please note that the 1 hour average values cannot be directly compared to the annual mean NAAQS.
Figure 3c – Quarterly NO₂ Data

The graph below is shown for December 2017 through February 2018 is a plot of the one (1) hour averages. The orange line represents the 100 ppb one (1) hour ambient NO₂ NAAQS and the yellow line represents the 53 ppb one (1) year mean ambient NO₂ NAAQS. Please note that the 1 hour average values cannot be directly compared to the annual mean NAAQS.
Figure 3d – Quarterly NO₂ Data

The graph below is shown for March 2018 through May 2018 is a plot of the one (1) hour averages. The orange line represents the 100 parts per billion (ppb) one (1) hour ambient NO₂ NAAQS and the yellow line represents the 53 ppb one (1) year mean ambient NO₂ NAAQS. Please note that the 1 hour average values cannot be directly compared to the annual mean NAAQS.
Figure 4a – Quarterly CO Data

The graph below is shown for June 2017 through August 2017 and is a plot of the one (1) hour averages. The orange line represents the nine (9) ppm eight (8) hour ambient CO NAAQS and the yellow line represents the 35 ppm one (1) hour ambient CO NAAQS.

June '17 - August '17 Denver-Swansea

- CO 1 Hour Average
- 8 Hour Standard (9 ppm)
- 1 Hour Standard (35 ppm)
Figure 4b – Quarterly CO Data

The graph below is shown for September 2017 through November 2017 and is a plot of the one (1) hour averages. The orange line represents the nine (9) ppm eight (8) hour ambient CO NAAQS and the yellow line represents the 35 ppm one (1) hour ambient CO NAAQS.
Figure 4c – Quarterly CO Data

The graph below is shown for December 2017 through February 2018 and is a plot of the one (1) hour averages. The orange line represents the nine (9) ppm eight (8) hour ambient CO NAAQS and the yellow line represents the 35 ppm one (1) hour ambient CO NAAQS.
The graph below is shown for March 2018 through May 2018 and is a plot of the one (1) hour averages. The orange line represents the nine (9) ppm eight (8) hour ambient CO NAAQS and the yellow line represents the 35 ppm one (1) hour ambient CO NAAQS.
Figure 5a – Quarterly Black Carbon Data

The graph below is shown for June 2017 through August 2017 and plots the 24 hour averages. Black Carbon does not have a NAAQS.
Figure 5b – Quarterly Black Carbon Data

The graph below is shown for September 2017 through November 2017 and plots the 24 hour averages. Black Carbon does not have a NAAQS.
Figure 5c – Quarterly Black Carbon Data

The graph below is shown for December 2017 through February 2018 and plots the 24 hour averages. Black Carbon does not have a NAAQS.
Figure 5d – Quarterly Black Carbon Data

The graph below is shown for March 2018 through May 2018 and plots the 24 hour averages. Black Carbon does not have a NAAQS.
The results of the selected VOC compounds are shown in the table below. Electronic records of all VOC compounds have been uploaded to the Dropbox data room maintained by DEH. When calculating the average, the following rules were applied:

- If an individual result was above the reporting limit (RL), the result was used in calculating the average
- If an individual result was below the RL or not detected, one half the RL was used in calculating the average.

**Figure 6a – Yearly N-Hexane Data**

The graph below is shown for June 2017 through May 2018 and plots the 1 month averages. N-Hexane does not have a NAAQS.
Figure 6b – Yearly N-Heptane Data

The graph below is shown for June 2017 through May 2018 and plots the 1 month averages. N-Heptane does not have a NAAQS.
Figure 6c – Yearly N-Octane Data

The graph below is shown for June 2017 through May 2018 and plots the 1 month averages. N-Octane does not have a NAAQS.
Figure 6d – Yearly Benzene Data

The graph below is shown for June 2017 through May 2018 and plots the 1 month averages. Benzene does not have a NAAQS.
Figure 6e – Yearly Toluene Data

The graph below is shown for June 2017 through May 2018 and plots the 1 month averages. Toluene does not have a NAAQS.
Figure 6f – Yearly Ethylbenzene Data

The graph below is shown for June 2017 through May 2018 and plots the 1 month averages. Ethylbenzene does not have a NAAQS.
Figure 6g – Yearly m,p-Xylene Data

The graph below is shown for June 2017 through May 2018 and plots the 1 month averages. M,P-Xylene does not have a NAAQS.
Figure 6h – Yearly o-Xylene Data

The graph below is shown for June 2017 through May 2018 and plots the 1 month averages. O-Xylene does not have a NAAQS.

![o-Xylene Denver-Swansea graph]

Table 1 – Reporting and Quantification Limits for Selected VOC Compounds

The RLs and QLs for the selected compounds is shown in the table below:

<table>
<thead>
<tr>
<th>Compound</th>
<th>Reporting Limit (ppb)</th>
<th>Quantification Limit (ppb)</th>
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<tbody>
<tr>
<td>N-Hexane</td>
<td>0.1</td>
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</tr>
<tr>
<td>N-Heptane</td>
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<td>0.2</td>
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<td>N-Octane</td>
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<td>0.2</td>
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<td>Benzene</td>
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<td>o-Xylene</td>
<td>0.2</td>
<td>0.35</td>
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Figure 7a – Baseline PM$_{10}$ Data

The graph below is shown for Phase I and is a plot of the monthly maximum 24 hour averages. The blue line represents the 150 $\mu$g/m$^3$ 24 hour ambient PM$_{10}$ NAAQS.
Figure 7b – Baseline PM$_{2.5}$ Data

The graph below is shown for Phase I and is a plot of the monthly maximum 24 hour averages. The blue line represents the 35 µg/m$^3$ 24 hour ambient PM$_{2.5}$ NAAQS. Please note that the 24 hour average values cannot be directly compared to the annual mean NAAQS.
Figure 7c – Baseline NO₂ Data

The graph below is shown for Phase I and is a plot of the NO₂ monthly maximum 1 hour averages. The blue line represents the 100 ppb 1 hour ambient NO₂ NAAQS. Please note that the 1 hour average values cannot be directly compared to the annual mean NAAQS.
The graphs below are shown for Phase I. The first plot of the CO monthly maximum 1 hour averages, the blue line represents the 35 ppm 1 hour ambient CO NAAQS. The second plot of the CO monthly maximum 8 hour averages, the blue line represents the 9 ppm 8 hour ambient CO NAAQS.
**Data Quality Assurance/Quality Control**

**Quality Assurance/Quality Control**

Quality assurance is a general term for the procedures used to ensure that a particular measurement meets the quality requirements for its intended use. Quality control of continuous analyzers consists of precision and span checks or flow verifications. Quality objectives were assessed via laboratory and site system audits.

All work being done on this project followed the operating procedures described in the “Swansea Air Monitoring Station Quality Assurance Project Plan” (QAPP) dated 7/1/17. The QAPP can be provided by Michael Ogletree upon request. Mr. Ogletree’s contact information can be found in the “Operational Staff and Contacts” section of this report.

To ensure the collection of high-quality data, the following Quality Assurance/Quality Control procedures were implemented:

**NO\textsubscript{X} and CO Analyzers - Span Test**

A span test was conducted every other day. The NO\textsubscript{X} span test started at 21:46 and lasted for approximately 50 minutes. The CO span test started at 22:46 and lasted for approximately 20 minutes.

A CO span test was conducted by first analyzing a span gas of CO which was introduced to the sampling manifold at the back of the analyzer. After a stable reading was reached and recorded, a zero gas was introduced to the sampling manifold at the back of the analyzer. The CO gas was generated by diluting an EPA Protocol 1 calibration gas using the Teledyne Dynamic Dilution Calibrator.

An NO/NO\textsubscript{2} span test was conducted by first analyzing a zero gas that was introduced to the sampling manifold at the back of the analyzer. After a stable reading was reached and recorded, a span gas of NO was introduced to the sampling manifold at the back of the analyzer. The NO gas was also generated by diluting an EPA Protocol 1 calibration gas using the Teledyne Dynamic Dilution Calibrator. After a stable reading was reached and recorded, a span gas of NO\textsubscript{2} was generated by diluting an EPA Protocol 1 calibration gas and combing the diluted gas with a known quantity of ozone (O\textsubscript{3}) using the Teledyne Dynamic Dilution Calibrator. After a stable reading was reached and recorded, a zero gas was introduced to the sampling manifold at the back of the analyzer.

Each calibration gas was certified according to EPA Protocol 1 procedures. The generated gases were approximately, five (5) ppm of CO, 400 ppb of NO and 300 ppb of NO\textsubscript{2}. In all cases the measured responses were then compared to the generated gas value to determine the analyzer drift. The EPA requirement for span is 10 percent. The span check results are summarized in the table below:
A precision test was conducted every other day. The NO\textsubscript{x} precision test started at 21:46 and lasted for approximately 50 minutes. The CO precision test started at 22:46 and lasted for approximately 20 minutes.

A CO precision test was conducted by first analyzing a precision gas of CO which was introduced to the sampling manifold at the back of the analyzer. After a stable reading was reached and recorded, a zero gas was introduced to the sampling manifold at the back of the analyzer. The CO gas was generated by diluting an EPA Protocol 1 calibration gas using the Teledyne Dynamic Dilution Calibrator.

An NO/NO\textsubscript{2} precision test was conducted by first analyzing a zero gas that was introduced to the sampling manifold at the back of the analyzer. After a stable reading was reached and recorded, a precision gas of NO was introduced to the sampling manifold at the back of the analyzer. The NO gas was also generated by diluting an EPA Protocol 1 calibration gas using the Teledyne Dynamic Dilution Calibrator. After a stable reading was reached and recorded, a precision gas of NO\textsubscript{2} was generated by diluting an EPA Protocol 1 calibration gas and combining the diluted gas with a known quantity of ozone (O\textsubscript{3}) using the Teledyne Dynamic Dilution Calibrator. After a stable reading was reached and recorded, a zero gas was introduced to the sampling manifold at the back of the analyzer.

Each calibration gas was certified according to EPA Protocol 1 procedures. The generated gases were approximately, 1 or 1.5 ppm of CO, 100 ppb of NO and 70 ppb of NO\textsubscript{2}. In all cases the measured responses were then compared to the generated gas value to determine the analyzer drift. The EPA requirement for span is 10 percent. The span check results are summarized in the table below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Span Count</th>
<th>Span Passed</th>
<th>Span Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen Oxide</td>
<td>181</td>
<td>172</td>
<td>94</td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>183</td>
<td>137</td>
<td>75</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>183</td>
<td>140</td>
<td>77</td>
</tr>
</tbody>
</table>

\textsuperscript{2} Due to a power outage from the morning of 9/24/17 to the morning of 9/25/17 a Span Test was inadvertently skipped.
**PM$_{2.5}$/PM$_{10}$ Analyzer**

A zero check was conducted on the GRIMM analyzer every two (2) weeks. The zero check was conducted by placing a particulate filter inline and observing the response of the analyzer. If anything other than a zero reading was observed, corrective action was taken. Additionally, a flow check was conducted on the analyzer by using a NIST traceable standard to measure the flow rate through the GRIMM. The NIST standard was a MesaLabs DCL-MH DryCal flowmeter. The calibration certification can be found in the Appendix of this report. The flow test was considered acceptable if the flow rate was between 1.15 and 1.25 liters per minute (lpm). On a weekly basis the met station ambient temperature, relative humidity, and pressure was checked by comparing the measured values to that of a reference standard. The results were considered acceptable if the temperature, relative humidity, and pressure was within 2°C, 5%, and 10 mmHg, respectively. A summary of the weekly and biweekly checks is summarized below.

<table>
<thead>
<tr>
<th>Test</th>
<th>Count</th>
<th>Passed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Check</td>
<td>28</td>
<td>28</td>
<td>100%</td>
</tr>
<tr>
<td>Flow Check</td>
<td>28</td>
<td>28</td>
<td>100%</td>
</tr>
<tr>
<td>Temperature Check</td>
<td>45</td>
<td>45</td>
<td>100%</td>
</tr>
<tr>
<td>Pressure Check</td>
<td>45</td>
<td>45</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Aethalometer**

On a monthly basis the aethalometer cyclone was cleaned and inspected. A flow check was conducted using a NIST traceable standard to measure the flow rate through the aethalometer. The NIST standard was a MesaLabs DCL-MH DryCal flowmeter. The calibration certification can be found in the Appendix of this report. The flow test was considered acceptable if the flow rate was within seven (7) percent of the measured value. Additionally, a leak check was conducted by capping the sample probe and observing the measured flow through the instrument. The leak check was considered valid if the measured flow rate was less than 2.5 liters per minute (lpm). A summary of the monthly checks and is summarized below:

<table>
<thead>
<tr>
<th>Test</th>
<th>Count</th>
<th>Passed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Check</td>
<td>12</td>
<td>12</td>
<td>100%</td>
</tr>
<tr>
<td>Leak Check</td>
<td>12</td>
<td>12</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Wind Speed and Wind Direction**

The wind speed was calibrated via an anemometer drive that provided a convenient and accurate way to rotate the anemometer shaft at a known rate. The known rate that the drive rotates was then compared to the wind speed reading on the data logger.
The wind direction was calibrated with a vane angle bench stand. The monitor was placed on the stand which has a base with markings of 0 to 360 degrees. The tail of the monitor was stabilized so that as the monitor was rotated the wind direction readings are stable on the data logger.

<table>
<thead>
<tr>
<th>Test</th>
<th>Count³</th>
<th>Passed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed Check</td>
<td>5</td>
<td>5</td>
<td>100%</td>
</tr>
<tr>
<td>Wind Direction Check</td>
<td>5</td>
<td>5</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Gas Chromatograph**

The GC was calibrated prior to installation using a gas standard containing a known concentration of the Photochemical Assessment Monitoring Station (PAMS) list of compounds. A copy of the calibration certification can be found in the Appendix of this report. Two (2) additional concentrations were prepared and analyzed by diluting the cylinder gases using zero air and a Thermo Model 146i Multi-Gas Calibrator.

A multipoint calibration of the GC was conducted before monitoring commenced. The calibration also identifies 35 compounds (or pairs of compounds that coelute). An example of the calibration for one of these compounds, benzene, is shown in the following figure. This calibration spans the concentration range from about 1 to 17 ppb. Similar calibrations were done for the other PAMS compounds identified by the GC.

³ Wind sensor calibrations began in January 2018
An issue with the calibration of the mass flow controller in the gas dilution system used to generated these PAMS gas mixtures resulted in the values of the actual concentrations being too high.
The PAMS calibration data collected on 9/28/2017 was prior to recalibration of the mass flow controller used for dilution of the PAMS gas mixture. This led to an inaccurate calibration. Additional PAMS calibration data was collected on 10/31/2017, after recalibration of the flow controller. Four repeated samples were collected at a single concentration with a measured response of about 93% of actual.
Two PAMS calibrations were done during Q2 PY2018. The results of these calibrations were quite consistent with each other. The benzene concentration measured in these two calibrations was about 85% of the expected value, but since the PAMS gas mixture was about gone, this agreement was judged to be acceptable. When a new PAMS gas mixture is used, there may be sufficient justification for additional changes in the base sensitivity for the instrument. No new PAMS gas mixture was used during Phase I, but a new PAMS gas mixture will be used during Phase II.

The detection limit for the GC technique was determined from data collected during repeated measurements of a low concentration PAMS standard mixture. The detection limit was three (3) times the standard deviation of low concentration measurements for the individual compounds. Because some peaks were close together, there was a greater uncertainty for partially overlapping peaks and small retention time shifts. A reporting limit was used, as the smallest concentration where there was confidence that the compound is present. The smallest reporting limit was set at 0.1 ppb and was greater than or equal to three times the standard deviation for each of the compounds.

Compounds present at concentrations equal to the detection limit (or reporting limit, in this case) were believed to be present, but concentrations near this limit were highly uncertain. Data to be used quantitatively should exceed the quantitation limit. This limit was used to identify when the concentration that was measured for the compound
was known with a reasonable degree of confidence. The quantitation limit is defined as 10 times the standard deviation of low concentration measurements for individual compounds. Concentrations below the quantitation limit and above the reporting limit really indicated that the compound was present, but the concentration was too uncertain to be of value.

The GC technique used in this work used a sorbent tube to collect C₆ through C₁₂ hydrocarbons, then thermally desorbed these compounds onto the GC column for separation. The larger compounds were not completely desorbed under the conditions used in this analysis, so that could place additional limitations on the quantitative determination of the concentrations of some of these compounds, since some of the compound collected during one time period would not be desorbed until the following sample is analyzed. This carryover of sample to a subsequent period was estimated by looking at data for a zero sample following a PAMS calibration sample. This data allows one to estimate the percent carryover of compounds to a subsequent period. The data for both undecane and dodecane suggested that the carryover was more than 50% so concentrations were not reported for these compounds. The following table shows the reporting limits, quantitation limits and estimated percent carryover for each of the compounds identified in this work.
<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Reporting Limit</th>
<th>Quantitation Limit</th>
<th>Approximate % carryover</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,2-Dimethylbutane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>2</td>
<td>n-Hexane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>3</td>
<td>Methylcyclopentane &amp; 2,4-dimethylpentane⁴</td>
<td>0.1 ppbv</td>
<td>0.25 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>4</td>
<td>Benzene</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>5</td>
<td>Cyclohexane</td>
<td>0.25 ppbv</td>
<td>0.75 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>6</td>
<td>2-Methylhexane &amp; 2,3-dimethylpentane</td>
<td>0.2 ppbv</td>
<td>0.5 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>7</td>
<td>3-Methylhexane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>8</td>
<td>2,2,4-Trimethylpentane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>9</td>
<td>n-Heptane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>10</td>
<td>Methylcyclohexane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>11</td>
<td>2,3,4-Trimethylpentane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>12</td>
<td>Toluene</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>13</td>
<td>2-Methylheptane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>14</td>
<td>3-Methylheptane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>15</td>
<td>n-Octane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>5%</td>
</tr>
<tr>
<td>16</td>
<td>Ethylbenzene</td>
<td>0.1 ppbv</td>
<td>0.25 ppbv</td>
<td>10%</td>
</tr>
<tr>
<td>17</td>
<td>m &amp; p-Xylene</td>
<td>0.15 ppbv</td>
<td>0.35 ppbv</td>
<td>10%</td>
</tr>
<tr>
<td>18</td>
<td>Styrene</td>
<td>0.2 ppbv</td>
<td>0.5</td>
<td>15%</td>
</tr>
<tr>
<td>19</td>
<td>o-Xylene</td>
<td>0.2 ppbv</td>
<td>0.35</td>
<td>10%</td>
</tr>
<tr>
<td>20</td>
<td>n-Nonane</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>10%</td>
</tr>
<tr>
<td>21</td>
<td>Isopropylbenzene</td>
<td>0.1 ppbv</td>
<td>0.2 ppbv</td>
<td>10%</td>
</tr>
<tr>
<td>22</td>
<td>a-Pinene</td>
<td>0.2 ppbv</td>
<td>0.4</td>
<td>nd</td>
</tr>
<tr>
<td>23</td>
<td>n-Propylbenzene</td>
<td>0.15 ppbv</td>
<td>0.35</td>
<td>15%</td>
</tr>
<tr>
<td>24</td>
<td>m-Ethyltoluene</td>
<td>0.3 ppbv</td>
<td>1</td>
<td>15%</td>
</tr>
<tr>
<td>25</td>
<td>p-Ethyltoluene</td>
<td>0.2 ppbv</td>
<td>0.65</td>
<td>15%</td>
</tr>
<tr>
<td>26</td>
<td>1,3,5-Trimethylbenzene</td>
<td>0.2 ppbv</td>
<td>0.5</td>
<td>15%</td>
</tr>
<tr>
<td>27</td>
<td>o-Ethyltoluene</td>
<td>0.2 ppbv</td>
<td>0.5</td>
<td>15%</td>
</tr>
<tr>
<td>28</td>
<td>1,2,4-Trimethylbenzene</td>
<td>0.25 ppbv</td>
<td>0.75</td>
<td>20%</td>
</tr>
<tr>
<td>29</td>
<td>n-Decane</td>
<td>0.3 ppbv</td>
<td>0.85</td>
<td>20%</td>
</tr>
<tr>
<td>30</td>
<td>1,2,3-Trimethylbenzene</td>
<td>0.3 ppbv</td>
<td>0.85</td>
<td>20%</td>
</tr>
<tr>
<td>31</td>
<td>m-Diethylbenzene</td>
<td>0.3 ppbv</td>
<td>0.9</td>
<td>20%</td>
</tr>
<tr>
<td>32</td>
<td>p-Diethylbenzene</td>
<td>0.4 ppbv</td>
<td>1.3</td>
<td>25%</td>
</tr>
<tr>
<td>33</td>
<td>n-Undecane</td>
<td></td>
<td></td>
<td>45%</td>
</tr>
<tr>
<td>34</td>
<td>n-Dodecane</td>
<td></td>
<td></td>
<td>45%</td>
</tr>
</tbody>
</table>

⁴ Due to Methylcyclopentane & 2,4-dimethylpentane co-eluting the concentrations of the individual compounds became unavailable, therefore the compound concentrations must be reported as a sum of both compounds
To verify the stability of the GC, a span check was normally done at a 25-hour interval. The span check used a benzene permeation tube that emits benzene at a rate of 101 nanograms per minute and was diluted to generate a gas concentration of approximately 39 ppb from startup through 10/25/17, 55 ppb from 10/26/17 to 11/10/17, 18 ppb from 11/11/17 through 11/30/17, 22 ppb from 12/1/17 to 12/31/17, and 30 ppb beginning 1/1/18. Changes to the permeation tube span check concentration can be attributed to changes in dilution flow rates and a permeation tube change on 11/16/17. The span check was followed by a zero check to minimize carryover of the high benzene concentration of benzene from the span check to the next ambient sample and to verify the desorption efficiency and check for contamination of the GC.

If the results of the span check varied by more than ±15% from the average response that has been observed previously for more than two (2) consecutive days, a system retention time and response test was scheduled as soon as possible. Appropriate remedial action was taken if a problem was observed. A control chart showing the results of the span check for Year One is shown below.

For the zero checks, the benzene carryover from a preceding calibration or span check should have been less than 1% of the concentration of the benzene in the span gas. If this zero check limit was exceeded on more than two (2) consecutive days, a system retention time and response test was scheduled as soon as possible. Appropriate remedial action was taken if a problem was observed. A control chart showing the results of the zero check for Phase I is shown as follows.
The zero and span checks are summarized below:

<table>
<thead>
<tr>
<th>Test</th>
<th>Count</th>
<th>Passed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span Check</td>
<td>285</td>
<td>283</td>
<td>99%</td>
</tr>
<tr>
<td>Zero Check</td>
<td>292</td>
<td>292</td>
<td>100%</td>
</tr>
</tbody>
</table>
Signature Page
Prepared and reviewed by:

Patrick Clark, PE
Montrose Air Quality Services, LLC

Austin Heitmann
Montrose Air Quality Services, LLC

Additionally reviewed by:

Michael Ogletree
City and County of Denver
Appendix

Quality Assurance Logs
# Weekly SAMS QA/QC

All SOPs are stored in folder on Agliare desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>5/13/17</th>
<th>5/14/17</th>
<th>5/15/17</th>
<th>5/16/17</th>
<th>5/17/17</th>
<th>5/18/17</th>
<th>5/19/17</th>
<th>5/20/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>8:13</td>
<td>10:00</td>
<td>13:00</td>
<td>12:30</td>
<td>13:00</td>
<td>13:30</td>
<td>8:30</td>
<td>8:45</td>
</tr>
<tr>
<td>Technician</td>
<td>A04</td>
<td>A04</td>
<td>A1K</td>
<td>A1K</td>
<td>A1K</td>
<td>A1K</td>
<td>A04</td>
<td>A04</td>
</tr>
</tbody>
</table>

### NOx
- Zero Checks Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Span/Bias Check Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Screen Warnings? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Verify Test Functions ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### CO
- Zero Checks Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Span/Bias Check Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Screen Warnings? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### Gas Diluter
- Any Screen Warnings? Mention in Comments × ✓ ✓ ✓ ✓ ✓ ✓
- CO Gas Cylinder above 500psi? 1800 1550 1430 1420 1310 1100 1600
- NOx Gas Cylinder above 500psi? 3000 3800 3800 3000 3000
- Verify Test Functions ✓ ✓ ✓ ✓ ✓ ✓ ✓

### Aethalometer
- Date/Time within 1 minute? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Error Lights/Messages? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow Rate 4.7-5.3 SLPM? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow rate within 5% from last week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Check Message File ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Tape remaining >10%? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Collected Data from flash disk (Do within first 3 min of 5 min cycles) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### GRIMM
- Zero Check (Every 2 weeks) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow Check 1.15-1.25 LPM? (Every 2 weeks) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Temp within 2 degrees C ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Pressure within 10 mmHg ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### GC
- H2 Gas Cylinder above 500psi? Outlet 30psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Temperature of Permeation ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Check zero and span files ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Column Head Pressure (hPa) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Sampling Pressure (hPa) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Critical Sampling Pressure (hPa) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Chromatogram look ok? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### Zero Air Generator
- Is pressure gauge set to 50 psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

**Comments:**

5/13-15 UC in Ohio for training
5/15 Flow meter for Griffin is out for calibration
5/18-20 data from Aethalometer
5/15-17 MFC flow was coming to low, flow was adjusted, no issues reported
5/17-18 all equipment is working properly
5/19-20 all equipment is working properly
5/20-21 all equipment is working properly
**Weekly SAMS QA/QC**

All SOPs are stored in folder on Agilaire desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>7/5/17</th>
<th>7/6/17</th>
<th>7/13/17</th>
<th>7/14/17</th>
<th>7/15/17</th>
<th>7/16/17</th>
<th>7/17/17</th>
<th>8/1/17</th>
<th>8/2/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>AM 7:00</td>
<td>AM 7:00</td>
<td>AM 7:00</td>
<td>AM 7:00</td>
<td>AM 7:00</td>
<td>AM 7:00</td>
<td>AM 7:00</td>
<td>AM 7:00</td>
<td>AM 7:00</td>
</tr>
<tr>
<td>Technician</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
</tr>
</tbody>
</table>

### NOx
- Zero Checks Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Span/Bias Check Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Screen Warnings? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Verify Test Functions ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### CO
- Zero Checks Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Span/Bias Check Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Screen Warnings? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### Gas Diluter
- Any Screen Warnings? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- CO Gas Cylinder above 500psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- NOx Gas Cylinder above 500psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Verify Test Functions ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### Aethalometer
- Date/Time within 1 minute? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Error Lights/Messages? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow Rate 4.7-5.3 SLPM? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow rate within 5% from last week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Check Message File ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Tape remaining >10%? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Collected Data from flash disk (Do within first 3 min of 5 min cycles) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### GRIMM
- Zero Check (Every 2 weeks) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow Check 1.15-1.25 LPM? (Every 2 weeks) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Temp within 2 degrees C ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Pressure within 10 mmHg ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### GC
- H2 Gas Cylinder above 500psi? Outlet 30psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Temperature of Permeation ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Check zero and span files ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Column Head Pressure (hPa) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Sampling Pressure (hPa) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Critical Sampling Pressure (hPa) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Chromatogram looks ok? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Status Lights ok? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### Zero Air Generator
- Is pressure gauge set to 50 psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

**Comments:**

7/5/17 - New filter, check filters, cleaned filters.
7/6/17 - New filter, check filters, cleaned filters.

...
Weekly SAMS QA/QC

All SOPs are stored in folder on Agilare desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>8/13/17</th>
<th>9/13/17</th>
<th>9/20/17</th>
<th>9/26/17</th>
<th>10/18/17</th>
<th>10/25/17</th>
<th>11/1/17</th>
</tr>
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<tbody>
<tr>
<td>Time</td>
<td>1:00</td>
<td>1:30</td>
<td>1:30</td>
<td>2:00</td>
<td>2:27</td>
<td>1:30</td>
<td>1:30</td>
</tr>
<tr>
<td>Technician</td>
<td>M. H.</td>
<td>M. H.</td>
<td>Z. H.</td>
<td>T. H.</td>
<td>K. H.</td>
<td>R. H.</td>
<td>R. H.</td>
</tr>
</tbody>
</table>

**NOx**
- Zero Checks Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Span/Bias Check Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Screen Warnings? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Verify Test Functions ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

**CO**
- Zero Checks Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Span/Bias Check Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Screen Warnings? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

**Gas Diluter**
- Any Screen Warnings? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- CO Gas Cylinder above 500psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- NOx Gas Cylinder above 500psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Verify Test Functions ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

**Aethalometer**
- Data/Time within 1 minute? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Error Lights/Messages? Mention in Comments ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow Rate 4.7-5.3 SLPM? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow rate within 5% from last week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Check Message File ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Tape remaining >10%? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Collected Data from flash disk (Do within first 3 min of 5 min cycles) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

**GRIMM**
- Zero Check (Every 2 weeks) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow Check 1.15-1.25 LPM (Every 2 weeks) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Temp within 2 degrees C ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Pressure within 10 mmHg ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

**GC**
- H2 Gas Cylinder above 500psi? Outlet 30psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Temperature of Permeation ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Check zero and span files ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Column Head Pressure (hPa) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Sampling Pressure (hPa) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Critical Sampling Pressure (hPa) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Chromatogram look ok? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Status Lights ok? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

**Zero Air Generator**
- Is pressure gauge set to 50 psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

Comments:

- Power failure at 8/23/17 8:45 am
- Power failure at 9/23/17 8:27 am
- 9/23/17 8:40 am - No power in lab due to lack of power
- 9/23/17 8:45 am - Power back on
- 9/23/17 9:00 am - No power in lab due to lack of power
- 9/23/17 9:45 am - Power back on
- 9/23/17 10:00 am - No power in lab due to lack of power
- 9/23/17 10:45 am - Power back on

- 10/25/17 7:00 am - Power failure in lab due to lack of power
- 10/25/17 7:45 am - Power back on
- 10/25/17 8:00 am - No power in lab due to lack of power
- 10/25/17 8:45 am - Power back on
- 10/25/17 9:00 am - No power in lab due to lack of power
- 10/25/17 9:45 am - Power back on
- 10/25/17 10:00 am - No power in lab due to lack of power
- 10/25/17 10:45 am - Power back on

- Power failure in lab due to lack of power
- Power back on
- Power failure in lab due to lack of power
- Power back on
- Power failure in lab due to lack of power
- Power back on
- Power failure in lab due to lack of power
- Power back on
### Weekly SAMS QA/QC

All SOPs are stored in folder on Agilaire desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>1/11/17</th>
<th>1/12/17</th>
<th>1/17/17</th>
<th>1/18/17</th>
<th>1/19/17</th>
<th>1/23/17</th>
<th>1/24/17</th>
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<tbody>
<tr>
<td>Time</td>
<td>10:48</td>
<td>10:38</td>
<td>8:30</td>
<td>11:40</td>
<td>11:05</td>
<td>9:16</td>
<td>11:07</td>
</tr>
<tr>
<td>Technician</td>
<td>4H - 8H</td>
<td>8H - 4H</td>
<td>4H - 8H</td>
<td>8H - 4H</td>
<td>4H - 8H</td>
<td>8H - 4H</td>
<td>4H - 8H</td>
</tr>
</tbody>
</table>

### NOx

- **Zero Checks Came in for Week?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Span/Bias Check Came in for Week?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Any Screen Warnings? Mention in Comments**
  - ✓
  - x
  - ✓
  - ✓
  - x
  - x
  - ✓
  - ✓

- **Verify Test Functions**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

### CO

- **Zero Checks Came in for Week?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Span/Bias Check Came in for Week?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Any Screen Warnings? Mention in Comments**
  - x
  - x
  - x
  - x
  - x
  - ✓
  - ✓
  - ✓

### Gas Diluter

- **Any Screen Warnings? Mention in Comments**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **CO Gas Cylinder above 500psi?**
  - 1300
  - 1300
  - 1300
  - 1300
  - 1300
  - 1300
  - 1200

- **NOx Gas Cylinder above 500psi?**
  - 1060
  - 1060
  - 1060
  - 1060
  - 1060
  - 1060
  - 1200

- **Verify Test Functions**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

### Aethalometer

- **Date/Time within 1 minute?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Any Error Lights/Messages? Mention in Comments**
  - x
  - x
  - x
  - x
  - x
  - x
  - x
  - x

- **Flow Rate 4.7-5.3 SLPM?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Flow rate within 5% from last week?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Check Message File**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Tape remaining >10%?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Collected Data from flash disk (Do within first 3 min of 5 min cycles)**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

### Grimm

- **Zero Check (Every 2 weeks)**
  - ✓
  - ✓

- **Flow Check 1.15-1.25 LPM? (Every 2 weeks)**
  - ✓
  - ✓

- **Ambient Temp within 2 degrees C**
  - ✓
  - ✓

- **Ambient Pressure within 10 mmHg**
  - ✓
  - ✓

### GC

- **H2 Gas Cylinder above 500psi? Outlet 30psi?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Temperature of Permeation**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Check zero and span files**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Column Head Pressure (hPa)**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Ambient Sampling Pressure (hPa)**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Critical Sampling Pressure (hPa)**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Chromatogram look ok?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

- **Status Lights ok?**
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓
  - ✓

### Zero Air Generator

- **Is pressure gauge set to 50 psi?**
  - ✓
  - ✓
  - ✓
  - ✓

### Comments:

- Every morning: Begin permeation testing at c.c. flow settings.
- 1st week: New 3rd cylinder.
- 2nd week: Completed permeation tests in duplicate files.

Signatures:

__________________________

__________________________

__________________________

__________________________
<table>
<thead>
<tr>
<th>Date</th>
<th>12/5/17</th>
<th>12/11/17</th>
<th>12/18/17</th>
<th>1/5/18</th>
<th>1/12/18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>9:55</td>
<td>9:12</td>
<td>10:30</td>
<td>15:20</td>
<td></td>
</tr>
<tr>
<td>Technician</td>
<td>A1/A1</td>
<td>A1/A1</td>
<td>A1/A1</td>
<td>A1/A1</td>
<td></td>
</tr>
</tbody>
</table>

**NOx**
- Zero Checks Came in for Week?  
  - Yes
- Span/Bias Check Came in for Week?  
  - Yes
- Any Screen Warnings? Mention in Comments  
  - Yes
- Verify Test Functions  
  - Yes

**CO**
- Zero Checks Came in for Week?  
  - Yes
- Span/Bias Check Came in for Week?  
  - Yes
- Any Screen Warnings? Mention in Comments  
  - Yes

**Gas Diluter**
- Any Screen Warnings? Mention in Comments  
  - Yes
- CO Gas Cylinder above 500psi?  
  - Yes 11.40  
  - Yes 12.50  
  - Yes 12.50  
  - Yes 11.10
- NOx Gas Cylinder above 500psi?  
  - Yes 2.30  
  - Yes 2.00  
  - Yes 3.00  
  - Yes 2.90  
- Verify Test Functions  
  - Yes

**Aethalometer**
- Date/Time within 1 minute?  
  - Yes
- Any Error Lights/Messages? Mention in Comments  
  - Yes
- Flow Rate 4.7-5.3 LPM?  
  - Yes 5.0  
  - Yes 5.0  
  - Yes 5.0  
  - Yes 5.0
- Flow rate within 5% from last week?  
  - Yes
- Check Message File  
  - Yes
- Tape remaining >10%?  
  - Yes 89%  
  - Yes 22%  
  - Yes 18%  
  - Yes 11%
- Collected Data from flash disk (Do within first 3 min of 5 min cycles)  
  - Yes

**GRIMM**
- Zero Check (Every 2 weeks)  
  - Yes
- Flow Check 1.15-1.25 LPM? (Every 2 weeks)  
  - Yes
- Ambient Temp within 2 degrees C  
  - Yes
- Ambient Pressure within 10 mmHg  
  - Yes

**GC**
- H2 Gas Cylinder above 500psi? Outlet 30psi?  
  - 210/30  
  - 750/30  
  - 1700/30  
  - 1650/30
- Temperature of Permeation (C)  
  - 50  
  - 50  
  - 50  
  - 50
- Check zero and span files  
  - Yes
- Column Head Pressure (hPa)  
  - 410  
  - 410  
  - 410
- Ambient Sampling Pressure (hPa)  
  - 2.95  
  - 2.95  
  - 2.95
- Critical Sampling Pressure (hPa)  
  - 2.38  
  - 2.38  
  - 2.38
- Chromatogram look ok?  
  - Yes
- Status Lights ok?  
  - Yes

**Zero Air Generator**
- Is pressure gauge set to 50 psi?  
  - Yes

**Comments:**
- 12/5/17 - N2 gas coming in at 56 psi instead of 60 psi  
  - After adjusting valve, readjusted to 60 psi.  
  - Gas reading was still high, ran for additional sample adjustment, still high.
- 12/11/17 - Running Aethalometer equipment  
  - No issues reported.
- 12/18/17 - N2 check available  
  - 1/11/18 - Ran GTPs on N2, wide pressure span
### Weekly SAMS QA/QC

All SOPs are stored in folder on Agilaire desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>11/6/18</th>
<th>11/12/18</th>
<th>11/14/18</th>
<th>11/15/18</th>
<th>11/16/18</th>
<th>11/17/18</th>
<th>11/19/18</th>
<th>11/18/18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>14:10</td>
<td>12:10</td>
<td>12:10</td>
<td>10:54</td>
<td>10:45</td>
<td>13:54</td>
<td>15:45</td>
<td>16:14</td>
</tr>
<tr>
<td>Technician</td>
<td>Av H</td>
<td>Av H</td>
<td>Av H</td>
<td>Av H</td>
<td>Av H</td>
<td>Av H</td>
<td>Av H</td>
<td>Av H</td>
</tr>
</tbody>
</table>

#### NOx

| Zero Checks Came in for Week? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Span/Bias Check Came in for Week? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Any Screen Warnings? Mention in Comments | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Verify Test Functions | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

#### CO

| Zero Checks Came in for Week? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Span/Bias Check Came in for Week? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Any Screen Warnings? Mention in Comments | X | X | X | X | X | X | X | X |

#### Gas Diluter

| Any Screen Warnings? Mention in Comments | X | X | X | X | X | X | X | X |
| CO Gas Cylinder above 500psi? | 12:10 | 12:10 | 12:00 | 12:00 | 12:00 | 12:00 | 12:00 | 12:00 |
| NOx Gas Cylinder above 500psi? | 2.50 | 2.04 | 1.400 | 1.800 | 1.800 | 1.800 | 1.800 | 1.800 |
| Run GPTPS (NO 400 O3 300 LPM 4, 100 O3 70 LPM 11) | NO | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Verify Test Functions | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

#### Aethelometer

| Date/Time within 1 minute? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Any Error Lights/Messages? Mention in Comments | X | X | X | X | X | X | X | X |
| Flow Rate 4.7-5.3 SLPM? | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Flow rate within 5% from last week? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Check Message File | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Tape remaining >10%? | 15.4 | 17.0 | 12.4 | 12.4 | 11.4 | 14.0 | 5.0 |
| Collected Data from flash disk (Do within first 3 min of 5 min cycles) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

#### GRIMM

| Zero Check (Every 2 weeks) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Flow Check 1.15-1.25 LPM? (Every 2 weeks) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Ambient Temp within 2 degrees C | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Ambient Pressure within 10 mHg | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

#### GC

| H2 Gas Cylinder above 500psi? Outlet 30psi? | 13/5/18 | 13/5/18 | 13/5/18 | 13/5/18 | 13/5/18 | 13/5/18 | 13/5/18 | 13/5/18 |
| Temperature of Permeation | 50˚C | 50˚C | 50˚C | 50˚C | 50˚C | 50˚C | 50˚C | 50˚C |
| Check zero and span files | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Column Head Pressure (hPa) | 40.2 | 91.1 | 91.1 | 91.1 | 91.1 | 91.1 | 91.1 | 91.1 |
| Ambient Sampling Pressure (hPa) | 697.4 | 387.8 | 441.4 | 338.8 | 338.8 | 338.8 | 338.8 | 338.8 |
| Critical Sampling Pressure (hPa) | 337.4 | 314.3 | 314.3 | 314.3 | 314.3 | 314.3 | 314.3 | 314.3 |
| Chromatogram lock ok? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Status Lights ok? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

#### Zero Air Generator

| Is pressure gauge set to 50 psi? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Comments: 11/29/18 - New NOx cylinder installed (22157209)
- Week of 12/19/18 was Extension was available to check GC
- 11/26/18 - Aethelometer tape replaced
<table>
<thead>
<tr>
<th>Date</th>
<th>6/11/17</th>
<th>6/18/17</th>
<th>6/25/17</th>
<th>7/2/17</th>
<th>7/9/17</th>
<th>7/16/17</th>
<th>7/23/17</th>
<th>7/30/17</th>
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<td>07:15</td>
<td>12:00</td>
<td>6:00</td>
<td>9:00</td>
<td>12:00</td>
<td>6:00</td>
<td>9:00</td>
</tr>
<tr>
<td>Technician</td>
<td>NaH</td>
<td>NaH</td>
<td>NaH</td>
<td>3:00</td>
<td>NaH</td>
<td>NaH</td>
<td>NaH</td>
<td>NaH</td>
</tr>
</tbody>
</table>

### NOx
- Zero Checks Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Span/Bias Check Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Screen Warnings? Mention in Comments X X X X X X
- Verify Test Functions ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### CO
- Zero Checks Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Span/Bias Check Came in for Week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Screen Warnings? Mention in Comments X X X X X X
- Verify Test Functions ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### Gas Diluter
- Any Screen Warnings? Mention in Comments X X X X X X
- CO Gas Cylinder above 500psi? 1200 1200 1200 1200 1200 1200 1200 1200
- NOx Gas Cylinder above 500psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Run GPTPS (NO 400 O3 300 LPM 4, 100 O3 70 LPM 11) NO ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Verify Test Functions ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### Aethalometer
- Date/Time within 1 minute? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Any Error Lights/Messages? Mention in Comments X X X X X X
- Flow Rate 4.7-5.3 SLPM? 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0
- Flow rate within 5% from last week? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Check Message File ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Tape remaining >10%? 93% 94% 96% 95% 94% 93% 92% 92%
- Collected Data from flash disk (Do within first 3 min of 5 min cycles) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### GRIMM
- Zero Check (Every 2 weeks) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Flow Check 1.15-1.25 LPM (Every 2 weeks) ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Temp within 2 degrees C ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Ambient Pressure within 10 mmHg ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### GC
- H2 Gas Cylinder above 500psi? Outlet 30psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Temperature of Permeation (°C) 30 30 30 30 30 30 30 30
- Check zero and span files ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Column Head Pressure (psi) 90 100 140 90 100 140 90 100
- Ambient Sampling Pressure (psi) 870 870 870 870 870 870 870 870
- Critical Sampling Pressure (psi) 870 870 870 870 870 870 870 870
- Chromatogram look ok? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓
- Status Lights ok? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

### Zero Air Generator
- Is pressure gauge set to 50 psi? ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

**Comments:**
- No technicians available 6/11/17 & 6/18/17. Data was checked correctly to save quality.
- 6/18: GRIMM monitor detained change to pickle during high winds warning. Check flow, temp and pressure. Flow was checked with local electron. Flow next yield a 1.782 (LPM average flow)
- 6/30: Bed GPTPS on 6/30 gave bad result. Corrected through 06/30 GPTPS run correctly. Data is valid for this month.
- Due to 4000 NO, other GPTPS may not be valid.
- Further investigation is possible.
- 7/6 pm: quick back flush straight passed QARIC
**Weekly SAMS QA/QC**

All SOPs are stored in folder on Agilare desktop

| Date       | &lt;1/24/18 1/31/18 | | | |
| Time       | 12:00 12:03 | | | |
| Technician | A+H A+H | | | |

### NOx
- Zero Checks Came in for Week? ✅ ✅
- Span/Bias Check Came in for Week? | | |
- Any Screen Warnings? Mention in Comments ✗ ✗
- Verify Test Functions | | |

### CO
- Zero Checks Came in for Week? ✅ ✅
- Span/Bias Check Came in for Week? | | |
- Any Screen Warnings? Mention in Comments ✗ ✗

### Gas Diluter
- Any Screen Warnings? Mention in Comments ✗ ✗
- CO Gas Cylinder above 500psi? 1.5 1.5
- Nox Gas Cylinder above 500psi? 4 6
- Run GPTPS (NO 400 O3 300 LPM 4, 100 O3 70 LPM 11) ✅ ✅
- Verify Test Functions | | |

### Aethalometer
- Date/Time within 1 minute? ✅ ✅
- Any Error Lights/Messages? Mention in Comments ✅ ✅
- Flow Rate 4.7-5.3 SLPM? 5.0 5.0
- Flow rate within 5% from last week? | | |
- Check Message File ✅ ✅
- Tape remaining >10%? 411 417
- Collected Data from flash disk (Do within first 3 min of 5 min cycles) ✅ ✅

### GRIMM
- Zero Check (Every 2 weeks) ✗ —
- Flow Check 1.15-1.25 LPM? (Every 2 weeks) ✗ ✗
- Ambient Temp within 2 degrees C | | |
- Ambient Pressure within 10 mmHg ✅ ✅

### GC
- H2 Gas Cylinder above 500psi? Outlet 30psi? 7.0/5.0 2.5/0.5
- Temperature of Permeation 58 58
- Check zero and span files ✅ ✅
- Column Head Pressure (hPa) 912 412
- Ambient Sampling Pressure (hPa) 820.5 820.7
- Critical Sampling Pressure (hPa) 820.5 820.4
- Chromatogram look ok? ✅ ✅
- Status Lights ok? ✅ ✅

### Zero Air Generator
- Is pressure gauge set to 50 psi? ✅ ✅

**Comments:**

*Note tech available for 5/24/18*

*3/21/18 - Replaced H2 cylinder for GC*
## Monthly SAMS QA/QC

All SOPs are stored in folder on Agilaire desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>3/4/17</th>
<th>5/1/17</th>
<th>6/15/17</th>
<th>7/2/17</th>
<th>7/6/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>1:00</td>
<td>12:00</td>
<td>12:00</td>
<td>12:00</td>
<td>11:30</td>
</tr>
<tr>
<td>Technician</td>
<td>AvH</td>
<td>AvH</td>
<td>AvH</td>
<td>AvH</td>
<td>AvH</td>
</tr>
</tbody>
</table>

### Aethalometer

<table>
<thead>
<tr>
<th></th>
<th>3/4/17</th>
<th>5/1/17</th>
<th>6/15/17</th>
<th>7/2/17</th>
<th>7/6/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Cyclone</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>External Flow Check (SLPM)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Flow check % error &lt;7%?</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Leak check (less then 2.5 LPM?)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

### GC

<table>
<thead>
<tr>
<th></th>
<th>3/4/17</th>
<th>5/1/17</th>
<th>6/15/17</th>
<th>7/2/17</th>
<th>7/6/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check for Leaks</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Retention Time Check with BTEX</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Run Zero Check after BTEX</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

### Comments:

- 
- 
- 
- 
- 

Calibration
## Monthly SAMS QA/QC

All SOPs are stored in folder on Agilaire desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>9/16/17</th>
<th>9/21/17</th>
<th>9/27/17</th>
<th>10/5/17</th>
<th>11/2/17</th>
<th>11/9/17</th>
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</thead>
<tbody>
<tr>
<td>Time</td>
<td>1:30</td>
<td>1:30</td>
<td>13:16</td>
<td>8:15</td>
<td>10:50</td>
<td>10:45</td>
</tr>
<tr>
<td>Technician</td>
<td>Apr</td>
<td>Nov</td>
<td>Nov</td>
<td>Nov</td>
<td>Nov</td>
<td>Nov</td>
</tr>
</tbody>
</table>

### Aethalometer

| Clean Cyclone | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| External Flow Check (SLPM) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Flow check % error <7%? | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Leak check (less than 2.5 LPM?) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

### GC

| Check for Leaks | ✓ | x | shift | ✓ | ✓ | ✓ |
| Retention Time Check with BTEX | ✓ | x | Running | PAM | ✓ | ✓ |
| Run Zero Check after BTEX | x | x | Coals | ✓ | ✓ | ✓ |

Comments:
- 9/16/17 - GC is busy, coded
- 9/21/17 - run is at PAM, call will skip BTEX check
- Run is now ready
# Monthly SAMS QA/QC

All SOPs are stored in folder on Agilaire desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>2/11/18</th>
<th>3/5/18</th>
<th>4/19/18</th>
<th>5/15/18</th>
<th>6/1/18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>10:30</td>
<td>10:30</td>
<td>15:00</td>
<td>11:00</td>
<td>13:00</td>
</tr>
<tr>
<td>Technician</td>
<td>A.H.</td>
<td>A.H.</td>
<td>A.H.</td>
<td>A.H.</td>
<td>A.H.</td>
</tr>
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</table>

### Aethalometer

<table>
<thead>
<tr>
<th>Clean Cyclone</th>
<th>✓</th>
<th>✓</th>
<th>✓</th>
<th>✓</th>
<th>✓</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Flow Check (SLPM)</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Flow check % error &lt;7%?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Leak check (less than 2.5 LPM?)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

### GC

<table>
<thead>
<tr>
<th>Check for Leaks</th>
<th>✓</th>
<th>✓</th>
<th>✓</th>
<th>✓</th>
<th>✓</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention Time Check with BTEX</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Run Zero Check after BTEX</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Comments: - PAMS cal on GC on 4/6/18
# Quarterly SAMS QA/QC

All SOPs are stored in folder on Agilaire desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>3/3/17</th>
<th>7/3/17</th>
<th>10/2/17</th>
<th>1/3/18</th>
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<tr>
<td>Technician</td>
<td>ALH</td>
<td>ALH</td>
<td>ALH</td>
<td>ALH</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Aethalometer</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated Self Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Optical Test, Balance = 0.9-1.1?</td>
<td>1.03</td>
<td>1.02</td>
<td>1.04</td>
<td>1.03</td>
</tr>
<tr>
<td>Dynamic Zero Test, within 0.4 µg/m3 of 0?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GC</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3-point cal with PAMS gas</td>
<td>✓</td>
<td>0</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Run Zero Check after PAMS</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zero Air Generator</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Check CO Scrubber, replace if necessary</td>
<td>X</td>
<td>checked</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Check HC Scrubber, replace if necessary</td>
<td>X</td>
<td>checked</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Comments: 4/17/17 - ran 3pt PAMS cal

---

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---

---
<table>
<thead>
<tr>
<th>Date</th>
<th>4/9/18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>15:30</td>
</tr>
<tr>
<td>Technician</td>
<td>AuH</td>
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</table>

<table>
<thead>
<tr>
<th>Aethalometer</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated Self Test</td>
<td>✓</td>
</tr>
<tr>
<td>Optical Test, Balance = 0.9-1.1?</td>
<td>✓</td>
</tr>
<tr>
<td>Dynamic Zero Test, within 0.4 ug/m3 of 0?</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GC</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3-point cal with PAMS gas</td>
<td></td>
</tr>
<tr>
<td>Run Zero Check after PAMS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zero Air Generator</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Check CO Scrubber, replace if necessary</td>
<td></td>
</tr>
<tr>
<td>Check HC Scrubber, replace if necessary</td>
<td></td>
</tr>
</tbody>
</table>

Comments: PAMS cal 2/6/18
### Annual SAMS QA/QC

All SOPs are stored in folder on Agilaire desktop

<table>
<thead>
<tr>
<th>Date</th>
<th>5/17/17</th>
<th>5/18/18</th>
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</thead>
<tbody>
<tr>
<td>Time</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Technician</td>
<td>Art H</td>
<td>No 19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GC</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Service by CAS or equivalent</td>
<td>✔️</td>
<td>Do-Not-Apply</td>
</tr>
<tr>
<td>5-point cal with PAMS gas</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Run Zero Check after PAMS</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zero Air Generator</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace Charcoal Scrubber</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Replace NO-NO2 Scrubber</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Replace Particulate Filter</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>

Comments:

_____________________________
_____________________________
_____________________________
_____________________________
Calibration Certification Sheets
CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number: E02NI99E15A0367  Reference Number: 153-124573895-1
Cylinder Number: CC476211  Cylinder Volume: 144.3 CF
Laboratory: 124 - Tooele (SAP) - UT  Cylinder Pressure: 2015 PSIG
PGVP Number: B72018  Valve Outlet: 660
Gas Code: NO, NOX, BALN  Certification Date: Sep 07, 2016

Expiration Date: Sep 07, 2019

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

<table>
<thead>
<tr>
<th>Component</th>
<th>Requested Concentration</th>
<th>Actual Concentration</th>
<th>Protocol Method</th>
<th>Total Relative Uncertainty</th>
<th>Assay Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOX</td>
<td>10.00 PPM</td>
<td>10.08 PPM</td>
<td>G1</td>
<td>+/- 1.1% NIST Traceable</td>
<td>09/29/2016, 09/07/2016</td>
</tr>
<tr>
<td>NITRIC OXIDE</td>
<td>10.00 PPM</td>
<td>10.08 PPM</td>
<td>G1</td>
<td>+/- 1.0% NIST Traceable</td>
<td>09/29/2016, 09/07/2016</td>
</tr>
<tr>
<td>NITROGEN</td>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CALIBRATION STANDARDS

<table>
<thead>
<tr>
<th>Type</th>
<th>Lot ID</th>
<th>Cylinder No</th>
<th>Concentration</th>
<th>Uncertainty</th>
<th>Expiration Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTRM</td>
<td>13061112</td>
<td>CC403791</td>
<td>10.14 PPM NITRIC OXIDE/NITROGEN</td>
<td>1%</td>
<td>Feb 07, 2017</td>
</tr>
<tr>
<td>NTRM</td>
<td>13061112</td>
<td>CC403791-NOX</td>
<td>10.14 PPM NOx/NITROGEN</td>
<td>1%</td>
<td>Feb 07, 2017</td>
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</tbody>
</table>

ANALYTICAL EQUIPMENT

<table>
<thead>
<tr>
<th>Instrument/Make/Model</th>
<th>Analytical Principle</th>
<th>Last Multipoint Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermo 42-LS 1123749327 NO</td>
<td>Chemiluminescence (Mason)</td>
<td>Aug 25, 2016</td>
</tr>
<tr>
<td>Thermo 42-LS 1123749327 NOx</td>
<td>Chemiluminescence (Mason)</td>
<td>Aug 25, 2016</td>
</tr>
</tbody>
</table>

Triad Data Available Upon Request
CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number: E02NI99E15A0147  Reference Number: 153-124553646-1
Cylinder Number: CC454265  Cylinder Volume: 144.3 CF
Laboratory: ASG - Tooele - UT  Cylinder Pressure: 2015 PSIG
PGVP Number: B72016  Valve Outlet: 660
Gas Code: NO,NOX,BALN  Certification Date: May 16, 2016

Expiration Date:  May 16, 2024

Certification performed in accordance with “EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)” document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

<table>
<thead>
<tr>
<th>Component</th>
<th>Requested Concentration</th>
<th>Actual Concentration</th>
<th>Protocol Method</th>
<th>Total Relative Uncertainty</th>
<th>Assay Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOX</td>
<td>50.00 PPM</td>
<td>50.45 PPM</td>
<td>G1</td>
<td>+/- 0.9% NIST Traceable</td>
<td>05/09/2016, 05/16/2016</td>
</tr>
<tr>
<td>NITRIC OXIDE</td>
<td>50.00 PPM</td>
<td>50.29 PPM</td>
<td>G1</td>
<td>+/- 0.9% NIST Traceable</td>
<td>05/09/2016, 05/16/2016</td>
</tr>
<tr>
<td>NITROGEN</td>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CALIBRATION STANDARDS

<table>
<thead>
<tr>
<th>Type</th>
<th>Lot ID</th>
<th>Cylinder No</th>
<th>Concentration</th>
<th>Uncertainty</th>
<th>Expiration Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTRM/NO</td>
<td>13061215</td>
<td>CC403892</td>
<td>49.40 PPM NITRIC OXIDE/NITROGEN</td>
<td>+/- 0.8%</td>
<td>Nov 19, 2019</td>
</tr>
<tr>
<td>PRM</td>
<td>12367</td>
<td>APEX1099237</td>
<td>10.00 PPM NITROGEN DIOXIDE/NITROGEN</td>
<td>1.6%</td>
<td>May 29, 2016</td>
</tr>
<tr>
<td>GMIS</td>
<td>0315201603</td>
<td>CC502257</td>
<td>4.875 PPM NITROGEN DIOXIDE/NITROGEN</td>
<td>1.6</td>
<td>Mar 15, 2019</td>
</tr>
</tbody>
</table>

The SRM, PRM or RGM noted above is only in reference to the GMIS used in the assay and not part of the analysis.

ANALYTICAL EQUIPMENT

<table>
<thead>
<tr>
<th>Instrument/Make/Model</th>
<th>Analytical Principle</th>
<th>Last Multipoint Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicolet 6700 AMP0900119 NO LNO</td>
<td>FTIR</td>
<td>May 04, 2016</td>
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<tr>
<td>Nicolet 6700 AMP0900119 NO2 impurity</td>
<td>FTIR NO2 impurity</td>
<td>May 05, 2016</td>
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</table>

Triad Data Available Upon Request
CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number: E02Ni99E15A0147
Cylinder Number: CC157201
Laboratory: 124 - Tooele (SAP) - UT
PGVP Number: B720017
Gas Code: NO, NOX, BALN

Reference Number: 153-401066228-1
Cylinder Volume: 144.3 CF
Cylinder Pressure: 2015 PSIG
Valve Outlet: 660
Certification Date: Dec 11, 2017
Expiration Date: Dec 11, 2025

Certification performed in accordance with “EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)” document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

<table>
<thead>
<tr>
<th>Component</th>
<th>Requested Concentration</th>
<th>Actual Concentration</th>
<th>Protocol Method</th>
<th>Total Relative Uncertainty</th>
<th>Assay Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOX</td>
<td>50.00 PPM</td>
<td>50.24 PPM</td>
<td>G1</td>
<td>+/- 1.4% NIST Traceable</td>
<td>12/04/2017, 12/11/2017</td>
</tr>
<tr>
<td>NITRIC OXIDE</td>
<td>50.00 PPM</td>
<td>50.21 PPM</td>
<td>G1</td>
<td>+/- 1.4% NIST Traceable</td>
<td>12/04/2017, 12/11/2017</td>
</tr>
<tr>
<td>NITROGEN</td>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CALIBRATION STANDARDS

<table>
<thead>
<tr>
<th>Type</th>
<th>Lot ID</th>
<th>Cylinder No</th>
<th>Concentration</th>
<th>Uncertainty</th>
<th>Expiration Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTRM</td>
<td>16060619</td>
<td>CC442576</td>
<td>50.42 PPM NITRIC OXIDE/NITROGEN</td>
<td>0.8%</td>
<td>Jun 27, 2020</td>
</tr>
<tr>
<td>PRM</td>
<td>12367</td>
<td>APEX1099237</td>
<td>9.82 PPM NITROGEN DIOXIDE/NITROGEN</td>
<td>1.6%</td>
<td>May 29, 2016</td>
</tr>
<tr>
<td>GMIS</td>
<td>1114201604</td>
<td>CC507567</td>
<td>4.955 PPM NITROGEN DIOXIDE/NITROGEN</td>
<td>2.0%</td>
<td>Nov 14, 2019</td>
</tr>
</tbody>
</table>

The SRM, PRM or RGM noted above is only in reference to the GMIS used in the assay and not part of the analysis.

ANALYTICAL EQUIPMENT

<table>
<thead>
<tr>
<th>Instrument/Make/Model</th>
<th>Analytical Principle</th>
<th>Last Multipoint Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicolet 6700 AHR0801550 NO LNO</td>
<td>FTIR</td>
<td>Nov 29, 2017</td>
</tr>
<tr>
<td>Nicolet 6700 AHR0801550 NO2 impurity</td>
<td>FTIR NO2 impurity</td>
<td>Nov 30, 2017</td>
</tr>
</tbody>
</table>

Triad Data Available Upon Request

Signature on file
Approved for Release
CERTIFICATE OF ANALYSIS  
Grade of Product: EPA Protocol

Part Number: E02N99E15A0302  
Cylinder Number: CC79639  
Laboratory: 124 - Tooele (SAP) - JCT  
PGVP Number: B72015  
Gas Code: CO,BALN  
Reference Number: 153-124503149-1  
Cylinder Volume: 144.3 CF  
Cylinder Pressure: 205 PSIG  
Valve Outlet: 350  
Certification Date: Jul 13, 2015  
Expiration Date: Jul 13, 2023

**ANALYTICAL RESULTS**

<table>
<thead>
<tr>
<th>Component</th>
<th>Requested Concentration</th>
<th>Actual Concentration</th>
<th>Protocol Method</th>
<th>Total Relative Uncertainty</th>
<th>Assay Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARBON MONOXIDE</td>
<td>50.00 PPM</td>
<td>50.60 PPM</td>
<td>G1</td>
<td>+/- 0.7% NIST Traceable</td>
<td>07/13/2015</td>
</tr>
<tr>
<td>NITROGEN</td>
<td>Balance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CALIBRATION STANDARDS**

<table>
<thead>
<tr>
<th>Type</th>
<th>Lot ID</th>
<th>Cylinder No</th>
<th>Concentration</th>
<th>Uncertainty</th>
<th>Expiration Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTRM</td>
<td>1</td>
<td>CC434355</td>
<td>49.88 PPM CARBON MONOXIDE/NITROGEN</td>
<td>0.6</td>
<td>Feb 20, 2020</td>
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</tbody>
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**ANALYTICAL EQUIPMENT**

<table>
<thead>
<tr>
<th>Instrument/Make/Model</th>
<th>Analytical Principle</th>
<th>Last Multipoint Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicolet 6700 AMP900119 CO LCO</td>
<td>FTIR</td>
<td>Jun 19, 2015</td>
</tr>
</tbody>
</table>

Triad Data Available Upon Request

---

*Signature on file*

Approved for Release
CERTIFICATE OF ANALYSIS

Grade of Product: CERTIFIED STANDARD-SPEC

<table>
<thead>
<tr>
<th>Part Number:</th>
<th>X57N99CA980000</th>
<th>Reference Number:</th>
<th>160-400834613-1</th>
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</thead>
<tbody>
<tr>
<td>Cylinder Number:</td>
<td>ST0000167275</td>
<td>Cylinder Volume:</td>
<td>98.0 LG</td>
</tr>
<tr>
<td>Laboratory:</td>
<td>124 - Plumsteadville - PA</td>
<td>Cylinder Pressure:</td>
<td>1800 PSIG</td>
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<td>Analysis Date:</td>
<td>Jan 19, 2017</td>
<td>Valve Outlet:</td>
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<td>Lot Number:</td>
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<td>Jan 19, 2018</td>
</tr>
</tbody>
</table>

Product composition verified by direct comparison to calibration standards traceable to N.I.S.T. weights and/or N.I.S.T. Gas Mixture reference materials.

ANALYTICAL RESULTS

<table>
<thead>
<tr>
<th>Component</th>
<th>Req Conc</th>
<th>Actual Concentration (Mole %)</th>
<th>Analytical Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2,3 TRIMETHYL BENZENE</td>
<td>1.000 PPM</td>
<td>1.040 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>1,2,4 TRIMETHYL BENZENE</td>
<td>1.000 PPM</td>
<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>1,3,5 TRIMETHYL BENZENE</td>
<td>1.000 PPM</td>
<td>1.070 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>1,3 DIETHYL BENZENE</td>
<td>1.000 PPM</td>
<td>1.040 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>1 BUTENE</td>
<td>1.000 PPM</td>
<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>2 ETHYL TOLUENE</td>
<td>1.000 PPM</td>
<td>1.070 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>3 ETHYL TOLUENE</td>
<td>1.000 PPM</td>
<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>4 ETHYL TOLUENE</td>
<td>1.000 PPM</td>
<td>1.000 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>1 HEXENE</td>
<td>1.000 PPM</td>
<td>1.030 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>1 PENTENE</td>
<td>1.000 PPM</td>
<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>2,2 DIMETHYL BUTANE</td>
<td>1.000 PPM</td>
<td>1.040 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>2,3,4 TRIMETHYL PENTANE</td>
<td>1.000 PPM</td>
<td>1.040 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>2,3 DIMETHYL BUTANE</td>
<td>1.000 PPM</td>
<td>1.020 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>2,3 DIMETHYL PENTANE</td>
<td>1.000 PPM</td>
<td>1.020 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>2,4 DIMETHYL PENTANE</td>
<td>1.000 PPM</td>
<td>1.020 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>2 METHYLHEPTANE</td>
<td>1.000 PPM</td>
<td>1.070 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>2 METHYL 1,3 BUTADIENE</td>
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<td>1.090 PPM</td>
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</tr>
<tr>
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<td>1.040 PPM</td>
<td>+/- 5%</td>
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<tr>
<td>2 METHYL PENTANE</td>
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<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>3 METHYLHEPTANE</td>
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<td>1.040 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>3 METHYL HEXANE</td>
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<td>+/- 5%</td>
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<tr>
<td>3 METHYL PENTANE</td>
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<td>1.050 PPM</td>
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<td>ACETYLENE</td>
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<td>BENZENE</td>
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<td>+/- 5%</td>
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<td>CIS 2 BUTENE</td>
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<td>1.070 PPM</td>
<td>+/- 5%</td>
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<td>CIS 2 PENTENE</td>
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<td>1.030 PPM</td>
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<td>CUMENE</td>
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<td>+/- 5%</td>
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<td>CYCLOHEXANE</td>
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<td>+/- 5%</td>
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<td>CYCLOPENTANE</td>
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<tr>
<td>DODECANE</td>
<td>1.000 PPM</td>
<td>1.020 PPM</td>
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<tr>
<td>ETHANE</td>
<td>1.000 PPM</td>
<td>1.020 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>ETHYL BENZENE</td>
<td>1.000 PPM</td>
<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>ETHYLENE</td>
<td>1.000 PPM</td>
<td>1.070 PPM</td>
<td>+/- 5%</td>
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Approved for Release
<table>
<thead>
<tr>
<th>Compound</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>Tolerance</th>
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<tbody>
<tr>
<td>ISOBUTANE</td>
<td>1.000 PPM</td>
<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>ISOCTANE</td>
<td>1.000 PPM</td>
<td>1.050 PPM</td>
<td>+/- 5%</td>
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<tr>
<td>ISOPENTANE</td>
<td>1.000 PPM</td>
<td>1.080 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>M,P XYLENE</td>
<td>1.000 PPM</td>
<td>1.070 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>METHYL CYCLOHEXANE</td>
<td>1.000 PPM</td>
<td>1.080 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>METHYL CYCLOPENTANE</td>
<td>1.000 PPM</td>
<td>1.050 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>N BUTANE</td>
<td>1.000 PPM</td>
<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>N DECANE</td>
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<td>1.070 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>N HEPTANE</td>
<td>1.000 PPM</td>
<td>1.040 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>HEXANE</td>
<td>1.000 PPM</td>
<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>N NONANE</td>
<td>1.000 PPM</td>
<td>1.080 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>N OCTANE</td>
<td>1.000 PPM</td>
<td>1.080 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>N PENTANE</td>
<td>1.000 PPM</td>
<td>1.070 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>N PROPYL BENZENE</td>
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<td>1.040 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>O XYLENE</td>
<td>1.000 PPM</td>
<td>1.060 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>1,4 DIETHYL BENZENE</td>
<td>1.000 PPM</td>
<td>1.020 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>PROPANE</td>
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<td>+/- 5%</td>
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<td>+/- 5%</td>
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<tr>
<td>STYRENE</td>
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<td>+/- 5%</td>
</tr>
<tr>
<td>TOLUENE</td>
<td>1.000 PPM</td>
<td>1.080 PPM</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>TRANS 2 BUTENE</td>
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<td>1.080 PPM</td>
<td>+/- 5%</td>
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<td>1.040 PPM</td>
<td>+/- 5%</td>
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<td>UNDECANE</td>
<td>1.000 PPM</td>
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<td>+/- 5%</td>
</tr>
</tbody>
</table>

**Balance**

**Notes:**

PO Number: F464275

Catalog ID: 41978-U

---

Approved for Release
Primary Flow Standard Certification Sheet
Calibration Certificate

Certificate No. 168981
Product DCL-MH DryCal DC-Lite Medium High
Serial No. 3216
Cal. Date 19-May-2017

Sold To: Airtech Environmental Services Inc.
1371 Brumme Avenue
Elk Grove Village, IL 60007
US

All calibrations are performed at Mesa Laboratories, Inc., 10 Park Place, Butler, NJ, 07405, an ISO 17025:2005 accredited laboratory through NVLAP of NIST. This report shall not be reproduced except in full without the written approval of the laboratory. Results only relate to the items calibrated. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

As Received Calibration Data

<table>
<thead>
<tr>
<th>Technician</th>
<th>Lianna Malinowska</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument Reading</td>
<td>Lab Standard Reading</td>
</tr>
<tr>
<td>201.5 ccm</td>
<td>201.6 ccm</td>
</tr>
<tr>
<td>4989 ccm</td>
<td>5000.5 ccm</td>
</tr>
<tr>
<td>17160 ccm</td>
<td>17233.5 ccm</td>
</tr>
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</table>

As Received Standards Used

<table>
<thead>
<tr>
<th>Description</th>
<th>Standard Serial Number</th>
<th>Calibration Date</th>
<th>Calibration Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML_500_10</td>
<td>113778</td>
<td>27-Feb-2017</td>
<td>27-Feb-2018</td>
</tr>
<tr>
<td>ML_500_44</td>
<td>113762</td>
<td>26-Apr-2017</td>
<td>26-Apr-2018</td>
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</table>
As Shipped Calibration Data

<table>
<thead>
<tr>
<th>Instrument Reading</th>
<th>Lab Standard Reading</th>
<th>Deviation</th>
<th>Allowable Deviation</th>
<th>As Shipped</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.3 ccm</td>
<td>200.35 ccm</td>
<td>-0.02%</td>
<td>1.00%</td>
<td>In Tolerance</td>
</tr>
<tr>
<td>4988 ccm</td>
<td>5001.5 ccm</td>
<td>-0.27%</td>
<td>1.00%</td>
<td>In Tolerance</td>
</tr>
<tr>
<td>17090 ccm</td>
<td>17146.5 ccm</td>
<td>-0.33%</td>
<td>1.00%</td>
<td>In Tolerance</td>
</tr>
</tbody>
</table>

Mesa Laboratories Standards Used

<table>
<thead>
<tr>
<th>Description</th>
<th>Standard Serial Number</th>
<th>Calibration Date</th>
<th>Calibration Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML_500_10</td>
<td>113778</td>
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</tr>
<tr>
<td>ML_500_44</td>
<td>113762</td>
<td>26-Apr-2017</td>
<td>26-Apr-2018</td>
</tr>
</tbody>
</table>

Calibration Notes

All units are flow tested in accordance with our Procedure PR05-02 or PR01-10 with an expanded uncertainty of 0.27% using high-purity nitrogen or filtered laboratory air.

The expanded uncertainty of flow has a coverage factor of k = 2 for a confidence interval of approximately 95%.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Technician Notes:

Louis Guido, Chief Metrologist
NAAQS Table
# National Ambient Air Quality Standards

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Primary Standards</th>
<th>Secondary Standards</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>Averaging Time</td>
<td>Level</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9 ppm (10 mg/m$^3$)</td>
<td>8-hour</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>35 ppm (40 mg/m$^3$)</td>
<td>1-hour</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>53 ppb</td>
<td>Annual (Arithmetic Average)</td>
<td>Same as Primary</td>
</tr>
<tr>
<td></td>
<td>100 ppb</td>
<td>1-hour</td>
<td>None</td>
</tr>
<tr>
<td>Particulate Matter (PM$_{10}$)</td>
<td>150 µg/m$^3$</td>
<td>24-hour</td>
<td>Same as Primary</td>
</tr>
<tr>
<td>Particulate Matter (PM$_{2.5}$)</td>
<td>12 µg/m$^3$</td>
<td>Annual (Arithmetic Average)</td>
<td>15 µg/m$^3$</td>
</tr>
<tr>
<td></td>
<td>35 µg/m$^3$</td>
<td>24-hour</td>
<td>Same as Primary</td>
</tr>
<tr>
<td>Ozone$^5$</td>
<td>0.070 ppm</td>
<td>8-hour</td>
<td>Same as Primary</td>
</tr>
</tbody>
</table>