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South Carolina State Ports Authority – Continuous Air Monitoring Station for the Wando Welch Terminal

Quarterly Report

July 2011

South Carolina State Ports Authority - Continuous Air Monitoring Station for the Wando Welch Terminal

Quarterly Report

Prepared for:

South Carolina State Ports Authority
176 Concord Street
Charleston
South Carolina 29401

Prepared by:

ARCADIS U.S., Inc.
4915 Prospectus Drive
Suite F
Durham
North Carolina 27713
Tel 919 544 4535
Fax 919 544 5690

Our Ref.:

RN006310

Date:

July 2011

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A Quality Assurance Project Plan for Continuous Air Monitoring Station for the Wando Welch Terminal

1. Introduction

1.1 Scope

ARCADIS U.S., Inc. (ARCADIS) was contracted in late December 2010 to provide Continuous Air Monitoring Services to the South Carolina State Ports Authority (SCSPA) at the Wando Welch Terminal in Charleston. ARCADIS has followed through on the planned schedule and activities since that award. The major accomplishments were to complete the Quality Assurance Plan (QAP), purchase the instruments, complete the site setup, and then to begin acquiring the data. This report begins the submittal of quarterly data reports and presents the data summaries requested by SCSPA and described in the work scope. The data acquisition was started on May 6, 2010 in line with the court mandated start date, so this report encompasses a shortened period to align with normal fiscal quarters. Therefore the time period presented here, is May 6 2010 through June 30 2010.

1.2 Project Description

SCSPA asked for technical support that will provide ambient air quality data including particulate matter less than 2.5 microns ($PM_{2.5}$), SO_2, and NO_2 for a period of 5 years at the Wando Welch Terminal of the port of Charleston. ARCADIS will maintain the monitoring instruments, stock consumables such as filters and calibration gases, and order spare parts such that downtime will be avoided. ARCADIS has established standard operating procedures to perform daily downloads and to provide Level 1 data validation for the resulting data. This monitoring project setup was relatively straightforward and has proven to be reliable and capable of generating valid high quality data of suitable for use in dispersion modeling or other potential purposes.

As required, periodically the QAP and procedures have been updated to reflect improvements to the operating procedures and an update accompanies this report. This QAP also shows an update to the ambient air quality standards for SO_2 as defined by the U.S. Environmental Protection Agency. Excursions beyond this standard have not been seen for any lengthy duration, but a few daily spikes and rises have been noted and correlating local conditions have been investigated in local media outlets and recorded. These observations are tabulated and presented here as well.

The location selected for sampling and the sampling equipment has proven to be well-suited for the project as it is centrally located to the port activities and has proven to be very responsive to local equipment air emissions and the local meteorological conditions. Although this is not a typical fence line site, it has shown high value in permitting the evaluation of port activities and related air quality effects. We have been able to remotely access the control computer and reliably interact with the instruments. We can see immediate reaction from the instruments in response to events such as the morning opening of the front gates to entering truck traffic. These patterns can be reviewed in details in the archived data any time in the future if needed.

2. Quarterly Results

The 24-hr daily averages for PM, NO, NO_2, NO_X, and SO_2 and the maximum daily value (1-hr average) for NO_2 and SO_2 for this period are shown in Table 2-1. The red highlighted cells indicate exceedances. Quarterly statistics showing the averages, minimums and maximums for all parameters are summarized in Table 2-2. 24-hr averages for all constituents are also shown graphically in Figure 2-1. Maximum 1-hr averages for NO_2 and SO_2 are shown in Figure 2-2. Statistics are broken down by months and summarized in Table 2-3.

Table 2-1. 24-Hour Averages

	24-hour Averages					Daily Max 1-hr Avg.	
Date	PM ($\mu g/m^3$)	NO (ppb)	NO_2 (ppb)	NO_X (ppb)	SO_2 (ppb)	NO_2 (ppb)	SO_2 (ppb)
5/4/11	5.50	4.23	6.96	11.17	1.39	18.47	10.38
5/6/11	13.72	6.30	9.68	15.97	0.11	33.67	0.50
5/7/11	12.12	0.34	2.36	2.67	1.90	11.05	5.89
5/8/11	21.68	0.11	1.06	1.12	0.60	12.14	4.66
5/9/11	18.29	1.76	3.06	4.79	0.13	11.45	2.05
5/10/11	18.80	6.76	7.10	13.85	0.14	32.93	0.48
5/11/11	13.46	1.89	4.02	5.89	0.29	21.64	1.84
5/12/11	4.55	2.92	4.60	7.49	0.07	14.19	0.37
5/13/11	11.20	3.72	4.08	7.76	0.26	12.18	2.82
5/14/11	10.39	0.63	1.45	2.06	1.87	7.24	11.41
5/15/11	6.02	0.67	1.72	2.37	0.22	24.12	1.92
5/16/11	9.31	10.29	7.95	18.21	6.41	20.46	23.45
5/17/11	9.32	6.57	5.00	11.52	1.38	15.95	6.11
5/18/11	11.45	4.57	6.47	11.01	1.85	17.85	19.01
5/19/11	20.34	10.83	14.83	25.64	0.88	39.31	6.56
5/20/11	15.69	7.29	8.23	15.50	0.64	31.84	5.69
5/21/11	12.12	0.15	0.50	0.62	1.11	3.40	7.93
5/22/11	11.36	0.05	0.02	0.05	0.18	0.21	0.99
5/23/11	16.15	5.29	3.31	8.51	0.11	12.73	0.62
5/24/11	17.74	4.41	6.55	10.94	0.98	21.41	8.49
5/25/11	14.38	4.83	6.99	11.80	1.16	18.95	6.03

24-hour Averages						Daily Max 1-hr Avg.	
Date	PM ($\mu g/m^3$)	NO (ppb)	NO_2 (ppb)	NO_X (ppb)	SO_2 (ppb)	NO_2 (ppb)	SO_2 (ppb)
5/26/11	5.71	3.65	3.54	7.16	0.04	10.44	0.27
5/27/11	8.60	4.47	3.47	7.87	0.05	11.57	0.48
5/28/11	7.29	0.01	0.04	0.04	0.05	0.56	0.49
5/29/11	5.42	0.01	0.04	0.05	0.04	0.73	0.56
5/30/11	4.79	1.69	1.16	2.71	0.33	8.96	2.71
5/31/11	11.29	4.61	5.59	10.19	2.89	14.83	29.40
6/1/11	11.92	1.42	2.38	3.72	0.10	7.79	1.05
6/2/11	6.61	3.59	4.99	8.55	0.37	12.27	2.71
6/3/11	19.52	3.53	9.81	13.31	2.77	27.19	23.79
6/4/11	9.63	0.01	0.55	0.46	0.02	1.58	0.21
6/5/11	17.41	0.41	1.33	1.66	0.44	9.75	2.23
6/6/11	30.63	1.13	2.55	3.60	0.04	13.60	0.58
6/7/11	14.25	6.92	5.80	12.63	0.04	35.87	0.48
6/8/11	9.32	3.51	3.67	7.12	0.11	12.15	1.00
6/9/11	6.61	3.98	3.93	7.88	0.03	12.95	0.23
6/10/11	7.80	3.64	3.92	7.51	0.75	14.90	5.51
6/11/11	4.96	0.11	0.20	0.27	0.06	2.51	0.56
6/12/11	9.83	0.07	0.03	0.04	0.19	0.62	1.94
6/13/11	19.75	2.99	5.24	8.17	0.98	16.97	6.14
6/14/11	17.64	1.15	2.30	3.40	0.04	9.65	0.80
6/15/11	20.60	1.44	2.34	3.73	0.35	12.13	3.72
6/16/11	12.53	3.51	6.52	10.00	2.23	23.82	11.61
6/17/11	24.45	2.64	5.02	7.65	0.52	14.53	3.56
6/18/11	40.79	0.63	1.32	1.92	1.45	6.85	14.29
6/19/11	21.15	0.41	0.85	1.25	1.20	8.38	12.91
6/20/11	23.56	4.94	4.99	9.89	5.97	14.56	19.82
6/21/11	33.99	3.60	5.85	9.42	1.31	19.43	5.60
6/22/11	38.25	5.97	3.60	9.42	0.33	15.11	0.99
6/23/11	28.32	3.85	4.24	8.05	2.30	16.49	13.06
6/24/11	10.22	4.79	4.24	8.96	1.59	14.77	9.48

24-hour Averages						Daily Max 1-hr Avg.	
Date	**PM ($\mu g/m^3$)**	**NO (ppb)**	**NO_2 (ppb)**	**NO_X (ppb)**	**SO_2 (ppb)**	**NO_2 (ppb)**	**SO_2 (ppb)**
6/25/11	12.99	0.21	1.16	1.36	0.23	9.49	1.33
6/26/11	8.00	0.06	0.28	0.33	0.34	3.89	2.01
6/27/11	11.42	3.14	6.04	9.14	2.69	18.80	14.13
6/28/11	11.14	4.02	3.54	7.43	0.22	13.00	1.74
6/29/11	11.29	5.30	6.52	11.77	4.57	15.72	17.20
6/30/11	13.96	3.47	5.64	9.08	4.15	21.77	28.43

* Red cells indicate exceedances

Table 2-2. Quarterly Statistics

24-hour Averages						Daily Max 1-hr Avg.	
Date	**PM ($\mu g/m^3$)**	**NO (ppb)**	**NO_2 (ppb)**	**NO_X (ppb)**	**SO_2 (ppb)**	**NO_2 (ppb)**	**SO_2 (ppb)**
Average	14.48	3.13	4.01	7.10	1.06	14.65	6.46
Minimum	4.55	0.01	0.02	0.04	0.02	0.21	0.21
Maximum	40.79	10.83	14.83	25.64	6.41	39.31	29.40

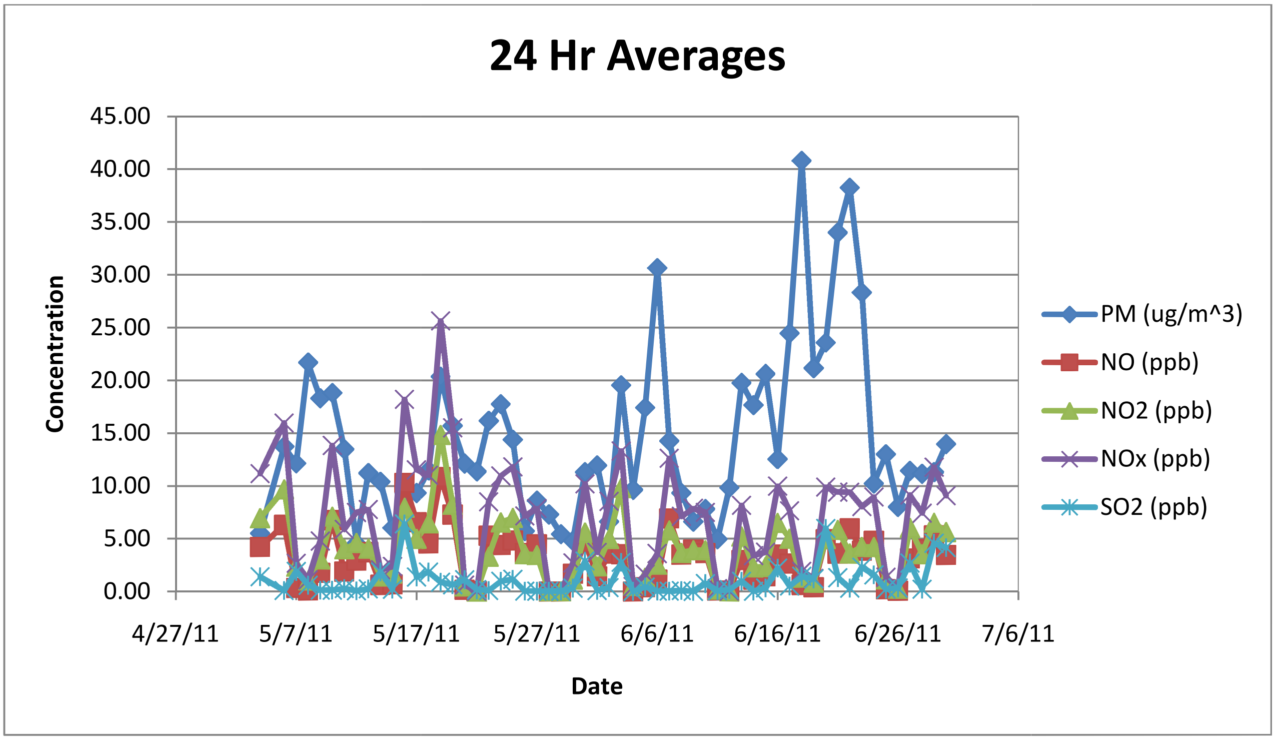

Figure 2-1. 24-hour Averages

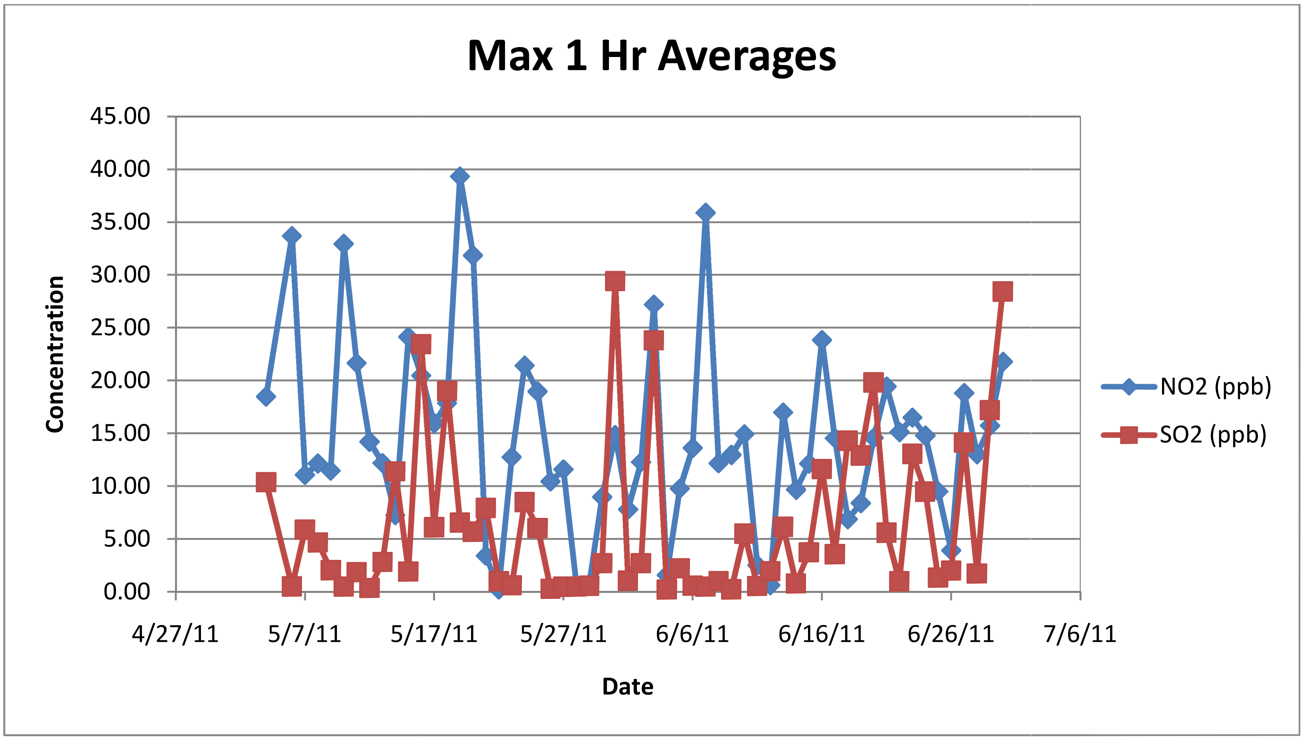

Figure 2-2. Max 1-hour Averages

Table 2-3. Monthly Statistics

Monthly Averages						Monthly Daily Max 1-hr Avg.	
Month	**PM ($\mu g/m^3$)**	**NO (ppb)**	**NO_2 (ppb)**	**NO_X (ppb)**	**SO_2 (ppb)**	**NO_2 (ppb)**	**SO_2 (ppb)**
May 2011	11.73	3.63	4.44	8.04	0.93	15.86	5.97
June 2011	16.95	2.68	3.63	6.26	1.18	13.55	6.90

3. Quality Assurance/Quality Control

QA/QC procedures applied to this project are described in a Quality Assurance Project Plan titled *Continuous Air Monitoring Station for the Wando Welch Terminal* (July 8, 2011)

3.1 Daily QC/Validation

According to the Quality Assurance Project Plan (QAPP) prepared for this work, results were reviewed for anomalies and validated on a daily basis. These validations were recorded on QA/QC Daily Comment Sheets. Irregularities found in the daily validations were logged and are summarized in Table 3-1. The table contains the date the anomaly occurred and the reason/comment.

Table 3-1. QA/QC Daily Comment Sheet

Date	Comment
5/10/2011	5014 showing Gen Alarm at approximately 8:38 am 5/11/11 (most likely humidity interference)
5/17/2011	Data missing around 8:04 and earlier on 5/18/11 due to system maintenance (code changes); Data missing from 17:19 - 17:38 on 5/17/11 due to system maintenance (code changes)
5/18/2011	Data missing from 8:04 - 8:06 due to code updates
5/19/2011	Missing data due to system maintenance from 17:43 - 17:46
5/20/2011	Data missing from 8:12 - 8:13 due to system maintenance
6/9/2011	Unable to take picture of tank gauges with webcam
6/12/2011	Gauge picture taken today, Gauge levels are normal
6/18/2011	PM exceedance likely caused by high wind gusts in Charleston area
6/20/2011	43i alarm triggered at 1:18
6/21/2011	43i alarm triggered at 23:20 and 16:56
6/22/2011	PM exceedance likely caused by smoke from wildfires in area. 43i alarm at 23:21, 19:21, 18:45, 17:13, 13:17
6/23/2011	Camera failed to take picture of tank gauges. 43i alarm at 6:11, 7:55, 8:19, 19:01. SO2 exceedance caused by system maintenance that occurred from approximately 11:10 - 14:17.
6/24/2011	Cylinder picture failed
6/25/2011	43i alarm at 23:20
6/26/2011	43i alarm at 21:35, 19:17, 17:28
6/27/2011	43i alarm at 19:54, 18:25, 1:39

Date	Comment
6/28/2011	43i alarm at 17:06, 9:11, 0:09
6/29/2011	Multiple 43i alarms
6/30/2011	Cylinder picture failed
7/1/2011	Multiple 43i alarms
7/3/2011	Multiple 43i alarms
7/5/2011	Multiple 43i alarms
7/6/2011	Multiple 43i alarms
7/7/2011	Multiple 43i alarms
7/8/2011	Multiple 43i alarms
7/9/2011	Multiple 43i alarms
7/10/2011	43i and 42i alarms
7/11/2011	System down for maintenance during the following times: 8:45-12:04; 12:39-16:52; 17:22-17:28; 17:31-17:40; 17:54-23:59. Insufficient Data. 5014i and 43i alarms.
7/12/2011	System down for maintenance, unable to access computer or data
7/13/2011	System down for maintenance
7/14/2011	System down for maintenance
7/15/2011	System down for maintenance
7/16/2011	System down for maintenance
7/17/2011	System down for maintenance
7/18/2011	43i alarms
7/19/2011	Insufficient Data: 5:00 - 16:00. Multiple 43i alarms. NOx check triggered 4:00 but lasts until 15:59.
7/20/2011	Multiple 43i alarms
7/21/2011	All parameters on PAC display showing as "#". No calibration data as a result. Multiple 43i and 5014i alarms. Unable to take gauge picture with webcam.
7/22/2011	Insufficient Data: 3:00 - 23:59. SO2 check triggered at 2:00 but lasts for rest of the day. Multiple 43i alarms. Weather data frozen from 2:15 onward.
7/23/2011	Insufficient Data at all hours for all parameters except PM. PM value frozen at 9.148 for all hours of the day. Weather data frozen for the entire day. 43i alarm triggered all day.
7/24/2011	43i showing a gen alarm on PAC display. 43i calibration and zero both failed. Insufficient Data at all hours for all parameters except PM. PM value frozen at 9.148 for all hours of the day. Weather data frozen for the entire day. 43i alarm triggered all day.

3.2 Quarterly Data Validation

The quarterly data were assessed as follows:

- Daily QC checks were performed in accordance with Section 5.1 of the QAPP. The PAC display was remotely accessed from the ARCADIS office located in Durham, NC, where instrumentation and trends were monitored for alarms and other irregularities. NOx and SO2 zero and calibration values displayed by the PAC from the previous calibration event were recorded in the QC Log Book. After checking the PAC display for irregularities, the H05 data file from the previous day was accessed and sent via email to the Durham, NC office. The file was saved to a common folder on the Durham office's G: drive and then run with the Microsoft Excel macro. The resulting Excel file provided values for daily averages and maxima, and also displayed alarm and calibration information. This information was recorded as required on the daily QC log sheet. Comments and observations regarding data quality were noted on the QC log sheet, and were also entered into the SCSPA QA/QC Daily Comment Sheet. The Project Manager was notified of any issues immediately.

- One daily Excel file per week was validated by ensuring that the formula ranges used in the Microsoft Excel macro calculations were correct. The ranges used to calculate the PM 2.5 24 hour average, NO2 Daily Max 1 hour average, SO2 Daily Max 1 hour average, and the 24 hour averages for PM, NO, NO2, NOx, and SO2 were checked during each validation. Four random hourly average ranges for PM, NO, NO2, NOx, and SO2 were also checked during each validation. Validated cells were then highlighted according to the following scheme:
    - "Good" cells highlighted green
    - "Questionable" cells highlighted yellow
    - "Bad" cells highlighted red

- No data were flagged as "bad" for any of the days that were validated. 91% of the data were flagged as "good". 8.9% of the data were initially flagged as "questionable" because the last data point in those sets happened to fall exactly on a new hour, and that point was included in the previous hourly range (i.e. 2:00:05 – 3:00:00 rather than 2:00:05 – 2:59:59). The Project Manager was alerted to this issue and it was determined that it had no effect on the quality of the data, thus these data were re-flagged as "good".

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Appendix **A**

Quality Assurance Project Plan for Continuous Air Monitoring Station for the Wando Welch Terminal

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Continuous Air Monitoring Station for the Wando Welch Terminal

Quality Assurance Project Plan

Revision 1

Project No. CIFCRT116

July 8, 2011

ARCADIS

7/8/2011

David Proffitt
ARCADIS U.S., Inc
Project Manager
Date

7/8/2011

Libby Nessley
ARCADIS U.S., Inc.
Quality Assurance Officer
Date

Jeannie Adame
South Carolina State Ports Authority
Manager, Environmental Affairs
Date

Responsible Authority
South Carolina Department of Health and Environmental Control, Bureau of Air Quality
Date

Continuous Air Monitoring Station for the Wando Welch Terminal

Quality Assurance Project Plan (QAPP)

Prepared for:
SCSPA and DEHC

Prepared by:
ARCADIS U.S., Inc.
4915 Prospectus Drive
Suite F
Durham
North Carolina 27713
Tel 919 544 4535
Fax 919 544 5690

Our Ref.:
RN006310

Date:
July 8, 2011

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Appendix A: Standard Operating Procedures

Appendix B: Manufacturer's Instruction Manuals

Distribution List

Copies of this quality assurance project plan (QAPP) and all revisions will be initially sent to the following individuals. It is the responsibility of the ARCADIS Project Manager to make copies of the plan available to all relevant personnel.

David Proffitt, ARCADIS Project Manager: Durham, North Carolina

Phone: (919) 544-4535 Cell (919) 389-0731
Email: David.Proffitt@arcadis-us.com

Libby Nessley, ARCADIS QA Officer: Durham, North Carolina

Phone: (919) 544-4535 Cell (919) 699-1588
Email: Libby.Nessley@arcadis-us.com

Bobby Sharpe, ARCADIS Project Engineer: Durham, North Carolina

Phone: (919) 544-4535 Cell (336) 549-6241
Email: Bobby.Sharpe@arcadis-us.com

Jeannie Adame, SCSPA Manager, Environmental Affairs: Mt. Pleasant, South Carolina

Phone: (843) 577-8175 Cell (843) 514-9593
Email: jadame@SCSPA.com

Revisions (July 8, 2011)

- Table 3-1. National Ambient Air Quality Standards. Revised to correct SO_2 standards. 24-hour and yearly averages eliminated and 75 ppb 1-hour standard entered as implemented in June 2010.

- A Standard Operating Procedure was added to the end of Appendix A detailing data validation steps including rules for determination of data set completeness.

1. Project Description and Objectives

1.1 Purpose

The South Carolina State Ports Authority (SCSPA) has requested technical support to provide continuous ambient air quality data for a period of 5 years at the Wando Welch Terminal in Charleston, South Carolina. The ambient air quality parameters to be provided are as follows:

- Particulate matter less than 2.5 microns ($PM_{2.5}$)
- Sulfur dioxide (SO_2)
- Nitrogen dioxide (NO_2)
- Meteorological data
  - Temperature
  - Wind speed
  - Wind direction
  - Barometric pressure
  - Relative humidity
  - Precipitation

ARCADIS will purchase and install the monitoring instruments and support equipment needed to collect these data, as well as provide consumables (e.g., filters, calibration gases, spare parts, etc.) in order to minimize downtime and data loss. ARCADIS will also be responsible for the installation and startup of these instruments. ARCADIS will manage the data flow and provide Level 1 data validation for the resulting data. ARCADIS will operate the instruments for a period of 60 months beginning May 1, 2011, in a manner consistent with the requirements of 40 Code of Federal Regulations (CFR) Part 58. Additionally, ARCADIS will arrange for real-time data and 1-hour averages to be continuously available on a designated website.

1.2 Project Objectives

The major objective of the project is to provide continuous determination of $PM_{2.5}$, SO_2, and NO_2 ambient concentrations at the Wando Welch Terminal in order to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS) for these pollutants. These standards are provided later in this document in Table 3-1.

2. Project Organization

The roles and responsibilities of the ARCADIS project personnel are discussed in the following paragraphs. Contact information is also provided.

ARCADIS Project Manager, David Proffitt. Mr. Proffitt will work closely with the SCSPA project manager to fully understand the drivers of this project and will lead and coordinate the team to meet project objectives. He will serve as the primary interface for SCSPA. Mr. Proffitt will insure that all requirements and directives obtained in meetings and other means of information exchange between SCSPA, South Carolina Department of Health and Environmental Control's (DHEC) Bureau of Air Quality, and ARCADIS are disseminated to the appropriate personnel. He will serve as the primary point of contact to resolve issues and answer questions originating from SCSPA and/or the ARCADIS project team. Mr. Proffitt will insure that this quality assurance project plan (QAPP) is consistent with the demands of SCSPA and DHEC. He will also efficiently distribute the information to the team while serving as a single, readily-accessible point of contact for SCSPA's Environmental Manager.

Phone: (919) 544-4535
Email: David.Proffitt@arcadis-us.com

ARCADIS QA Officer, Libby Nessley. Ms. Nessley will be responsible for reviewing the QAPP and standard operating procedures (SOP) prepared for this project. She will also be responsible for the supervision of quality assurance/quality control (QA/QC) activities performed by project personnel. She will conduct internal data and procedural assessments and provide guidance to the technical personnel in QA/QC related activities.

Phone: (919) 544-4535
Email: Libby.Nessley@arcadis-us.com

ARCADIS Project Engineer, Bobby Sharpe. The Project Engineer will report directly to the Project Manager (David Proffitt) and will direct the installation of the hardware and the development of the data logging and handling processes. Mr. Sharpe will develop the communication interface between the analyzers and the programmable automation controller (PAC), as well as the design of the operator interface. He is responsible for programming the automated calibration procedures for the instruments. He will also interface with SCSPA's information technology (IT) personnel to establish remote connectivity to the supervisory control and data acquisition (SCADA) computer. Mr. Sharpe will be the primary contact for any hardware-related issues and will provide support in diagnosing any data quality issues found during the data validation process.

Phone: (919) 544-4535
Email: Bobby.Sharpe@arcadis-us.com

ARCADIS Ambient Monitoring Task Leader, Gene Stephenson. Mr. Stephenson will report to the Project Engineer (Bobby Sharpe) and be responsible for the startup, installation, and operation of the continuous air monitoring station. He will serve as the primary contact for instrument and calibration related issues.

Phone: (919) 544-4535
Email: Gene.Stephenson@arcadis-us.com

ARCADIS Database/Web Manager, Drew Knott. Mr. Knott will interface with SCSPA's IT personnel to develop a method of securely and efficiently transferring the instrument data from the SCSPA location to a database residing in the ARCADIS corporate data center located in Denver, Colorado. He will also be responsible for deploying the web application to display 1-hour averages of the data for the past 30 days. Any required maintenance of the web application will be handled by Mr. Knott.

Phone: (303) 471-3492
Email: Drew.Knott@arcadis-us.com

ARCADIS Field Technician, Michal Derlicki. Mr. Derlicki will assist Mr. Stephenson in the startup, installation, and operation of the continuous air monitoring station.

Phone: (919) 544-4535
Email: Michal.Derlicki@arcadis-us.com

ARCADIS On-call Local Project Field Engineer, Kevin Eakes. The ARCADIS local project field engineer will be available (on-call) to be dispatched quickly to the site with the tools and equipment necessary to assist in the repair of immediate problems discovered during daily data review and validation.

Phone: (843) 375-5990 ext 22
Email: Keakes@arcadis-us.com

The ARCADIS organizational chart for this project is shown in Figure 2-1.

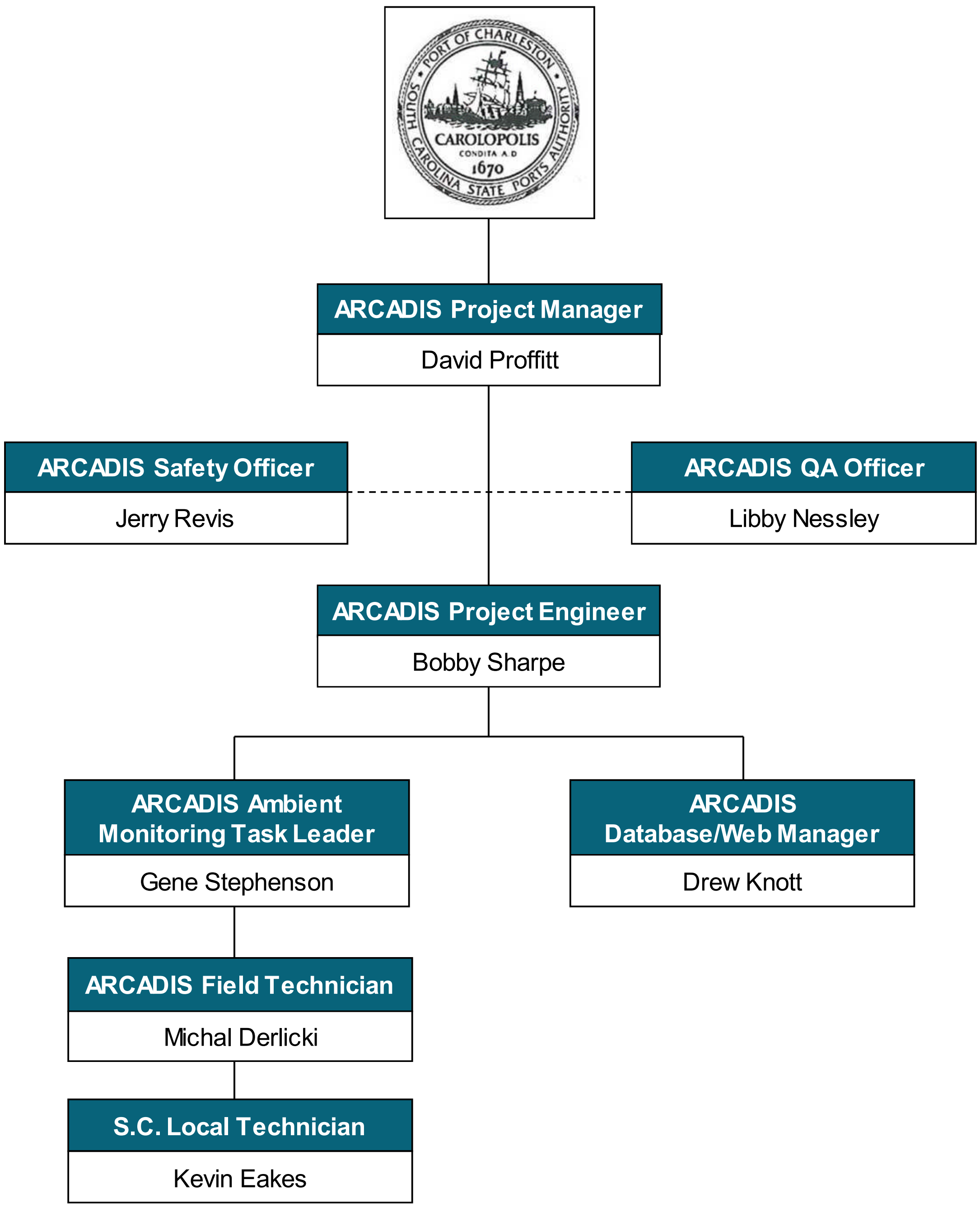

Figure 2-1. Project Organizational Chart

3. Sampling Procedures

ARCADIS will install, maintain, and operate a continuous air monitoring station at the Wando Welch Terminal operated by the SCSPA in Charleston, SC. The continuous monitors comprising the air monitoring station are described in this section, along with the relevant Federal requirements.

3.1 Continuous Monitors

The National Ambient Air Quality Standards (NAAQS) for nitrogen dioxide (NO_2), sulfur oxide (SO_2), and $PM_{2.5}$ created by the 1990 Clean Air Act amendments, are shown in Table 3-1.

Table 3-1. National Ambient Air Quality Standards

Pollutant	Primary Standard		Secondary Standard	
	Level	Averaging Time	Level	Averaging Time
NO_2	53 ppb (1)	Annual (Arithmetic Average)	Same as Primary	
	100 ppb	1-hour (2)	None	
SO_2	75 ppb	1-hour (3)	0.5 ppm	3-hour (4)
$PM_{2.5}$	15.0 µg/m^3	Annual (5) (Arithmetic Average)	Same as Primary	
	35 µg/m^3	24-hour (6)	Same as Primary	

(1) The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard

(2) To attain this standard, the 3-year average of the 98th percentile (8th highest in a year) of the daily maximum 1-hour average at each monitor within the area must not exceed 100 ppb

(3) Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile (4th highest in a year) of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

(4) Not to be exceeded more than once per year.

(5) To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from a single or multiple community-oriented monitors must not exceed 15.0 ug/m^3.

(6) To attain this standard, the 3-year average of the 98th percentile (8th highest in a year) of 24-hour concentrations at each population oriented monitor within an area must not exceed 35 ug/m^3.

Compliance with these standards requires the use of EPA Federal Reference Methods (FRM) or Federal Equivalent Methods (FEM) for the quantification of these pollutants in the engineering units necessary for comparison with the standards. The applicable requirements for FRMs for the measurement of these pollutants are detailed in the appendices of 40 CFR Part 50. Vendors are able to obtain FRM/FEM designation for their instrumentation through the use of the validation procedures detailed in 40 CFR Part 53.

3.1.1 Nitrogen Oxide/Nitrogen Dioxide Monitor

The FRM for NO_2 is detailed in *Appendix F to Part 50--Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence).* In this procedure, atmospheric concentrations of NO_2 are measured indirectly by photometrically measuring the light intensity at wavelengths greater than 600 nm resulting from the chemiluminescent reaction of nitric oxide (NO) with ozone (O_3). NO_2 is first reduced to NO with a converter. NO, which commonly exists in ambient air together with NO_2, passes through the converter unchanged, causing a resultant total oxides of nitrogen (NO_X) concentration equal to NO+NO_2. A sample of the ambient air is also measured without having passed through the converter. This latter measurement (NO) is subtracted from the former measurement (NO_X) to yield NO_2. The NO and NO_X measurements may be made concurrently with dual chemiluminescent analyzer systems, or cyclically with the same system as long as the cycle time does not exceed 1 minute.

For the continuous measurement of NO_2, ARCADIS will utilize one of the instruments that has been designated as an FRM, the Thermo Scientific Model 42i NO-NO_2-NO_X Analyzer. This continuous analyzer uses the chemiluminescence principle required of a NO_2 FRM; it uses the cyclic approach to NO_2 determination. Its Automated Reference Method Designation is RFNA-1289-074.

3.1.2 Sulfur Dioxide Monitor

The FRM for SO_2 is in *Appendix A to Part 50—Reference Method for the Determination of Sulfur Dioxide in the Atmosphere (Pararosaniline Method).* This method involves a manual procedure that requires bubbling an ambient air sample through impingers containing potassium tetrachloromercurate and complex spectrophotometric analytical procedures. It has been largely supplanted by FEMs in practical usage.

For the measurement of SO_2, ARCADIS will utilize one of the instruments that has been designated as an FRM through the use of the 40 CFR Part 53 designation procedure. This instrument is the Thermo Scientific Model 43i SO_2 Analyzer. This continuous monitor uses the principle of pulsed fluorescence and has an Automated Equivalent Method Designation of EQSA-0486-060.

3.1.3 Particulate Monitor

The FRM for $PM_{2.5}$ is described in *Appendix L to Part 50—Reference Method for the Determination of Fine Particulate Matter as $PM_{2.5}$ Atmosphere.* In this method, an electrically powered air sampler draws ambient air at a constant volumetric rate into a specially shaped inlet and through an inertial impactor where PM in the $PM_{2.5}$ size range is separated for collection on a polytetrafluoroethylene (PTFE) filter over the specified sampling period. $PM_{2.5}$ particulate concentration in the atmosphere is calculated from the weight gained on the PTFE filter ($PM_{2.5}$ mass) and the total volume of ambient air sampled (corrected to standard conditions).

ARCADIS will use a Thermo Scientific Model 5014i FH62C14-DHS Continuous Ambient Particle Monitor. This device, when equipped with a PM_{10} size selective inlet and a BGI $PM_{2.5}$ Very Sharp Cut Cyclone (VSCC), is an automated version of the Reference Method described above and has achieved the equivalency designation. It uses the principle of beta attenuation to continuously measure $PM_{2.5}$ particulate. Its Automated Equivalent Method Designation is EQPM-0609-183.

3.1.4 Gas Dilution System/Calibrator

ARCADIS will use a Thermo Scientific Model 146i-AT3BEAA Dynamic Gas Calibrator to generate calibration and span gas concentrations from certified cylinders of SO_2 and NO. It uses high accuracy mass flow controller to blend zero air from the Thermo Scientific Model 1160-AHP2N Zero Air Supply with known concentrations SO_2 and NO from the cylinders to produce very precise, part-per-billion (ppb) concentration of these gases to calibrate and zero/span check the instruments to insure accuracy.

A list of the instruments that will form the basis of the continuous air monitoring station is shown in Table 3-2. Instruction Manuals for these instruments can be found in Appendix B.

Table 3-2. Continuous Air Monitoring Station Components

Model	Description
Thermo Scientific Model 5014i-ABVAA	U.S. EPA FRM $PM_{2.5}$ Particulate Sampler
Thermo Scientific Model 42i-ANMSPAA	NO-NO_2-NO_X Analyzer
Thermo Scientific Model 43i-ANSAA	SO_2 Analyzer
Thermo Scientific Model 146i-AT3BEAA	Dynamic Gas Calibrator
Thermo Scientific Model 1160-AHP2N	Zero Air Supply
Vaisala Model WXT520	Meteorological System

Table 3-3 describes the instrument specifications and completeness goals for the $PM_{2.5}$ particulate, SO_2, and NO_X measurements.

Table 3-3. Air Pollution Measurement Quality Objectives

Measurement	Method	Reporting Units	Operating Range	Resolution	Minimum Sample Frequency	Raw Data Collection	Completeness
$PM_{2.5}$ Particulate	Beta Attenuation	ug/m^3	0 to 10,000	0.1	1 minute	15 sec	90%
SO_2	Pulsed Fluorescence	ppbv	0 to 10,000	0.5	1 minute	15 sec	90%
NO_X	Chemiluminescence	ppbv	0 to 20,000	0.4	1 minute	15 sec	90%

SOPs for the individual elements of the continuous air monitoring station can be found in Appendix A.

3.2 System Installation and Calibration

Initial flow checks and calibrations for all sampling equipment will be completed at the ARCADIS office in Durham, North Carolina. The instruments will be connected to a custom built control panel containing all hardware necessary for interfacing with the instrumentation, calibration hardware, and communicating with SCSPA's local area network (LAN). Programming of the automated calibration procedures will be finalized, and all data collection capabilities will be checked and confirmed to be operating properly. The instruments will then be set up to sample air from outside the ARCADIS Durham Office for a period of 4 to 7 days and will be closely monitored to confirm that they are reliable and meeting performance specifications. Once all of these preliminary checks have been passed (flows, calibration, and calibration checks), the instruments will be carefully disconnected and prepared for shipment to Wando Welch Terminal in Charleston for installation and startup at the site.

The instruments will be installed permanently in the conditioned space provided by SCSPA. They will be connected to calibration gases installed in the same room and to a data line that will allow for both data transfer and remote operation of the system. The initial system calibrations will be performed and will be followed by a sampling period to confirm stable and reliable long-term operation. Further calibration will be performed yearly or on an as-needed basis (if a daily zero/span check fails).

3.3 Meteorological System and Sensors

Meteorological instruments, in the form of the Vaisala WXT520, will be deployed to continuously measure the following parameters:

- Wind Speed
- Wind Direction
- Relative Humidity

- Temperature
- Barometric Pressure
- Precipitation

The parameters to be collected will provide sufficient data for determination of local meteorology in the area of the Wando Welch Terminal. Table 3-4 lists the instrument specifications and completeness goals for the meteorological measurements. The meteorological sensors will also be checked annually as described in Section 4 to ensure they are consistently providing accurate data.

Table 3-4. Meteorological Measurement Specifications

Measurement	Method	Reporting Units	Operating Range	Resolution	Minimum Sample Frequency	Raw Data Collection	Completeness
Ambient Temperature	Capacitive Ceramic	°C	-52 to 60	0.1	1 min	15 sec	90%
Relative Humidity	Capacitive Thin Film	%	0 to 100	0.1	1 min	15 sec	90%
Wind Speed	Ultrasonic	m/s	0 to 60	0.1	15 sec	15 sec	90%
Wind Direction	Ultrasonic	Degrees Compass	0 to 360°	1°	15 sec	15 sec	90%
Barometric Pressure	Capacitive Silicon	hPa	600 – 1100	0.1	1 min	15 sec	90%
Precipitation	Piezoelectric	mm accumulated	n/a	0.01	1 min	15 sec	90%

Each of these monitoring instruments and meteorological sensors meets SCSPA's requirements regarding (FRM) standards, and each will be able to run with minimal maintenance and problems for a period exceeding 5 years. Additional equipment to be integrated into the system includes calibration gases, control valves, and electronic switching circuitry necessary for remote calibrations.

4. Quality Assurance/Quality Control (QA/QC) Procedures

QA/QC will be performed as described in the sections and tables below.

4.1 $PM_{2.5}$, SO_2, and NO_2 QA/QC Checks

Table 4-1 details the verification/calibration and accuracy criteria for the air monitors. The ambient air flow rate into the $PM_{2.5}$ monitor will be continuously monitored internally and logged; it will be specifically checked and recorded daily as part of the QA program. A calibration of the $PM_{2.5}$ monitor, using the mass foil kit provided by the manufacturer, will be performed yearly. Daily zero/span checks will be performed on the gas analyzers, and a full calibration will be performed if any instrument does not pass the zero/span check.

Table 4-1. Verification/Calibration and Accuracy Criteria for Air Monitors

Measurement	Verification/Calibration		
	Type	**Acceptance Criteria**	**Frequency**
$PM_{2.5}$ Particulate Monitor Sample Flow	Internal Mass Flowmeter	16.67 L/min, ±0.67 L/min	Daily
$PM_{2.5}$ Particulate Monitor Mass Calibration	Calibration Mass Foil Kit	Re-cal	Yearly
SO_2 Monitor Zero / Span Check	Zero gas/Span gas	±8 ppb / ±8 ppb	Daily
NO_2 Monitor Zero / Span Check	Zero gas/Span gas	±8 ppb / ±8 ppb	Daily

4.2 Meteorological System QA/QC Checks

Table 4-2 details the verification/calibration and accuracy criteria for the meteorological measurement parameters. All checks are performed annually unless a failure occurs. In that case, immediate corrective actions will be initiated.

Table 4-2. Verification/Calibration and Accuracy Criteria for Meteorological Measurements

Measurement	Verification/Calibration		
	Type	**Acceptance Criteria**	**Frequency**
Ambient Temperature	3 pt. water bath with NIST-traceable thermistor or thermometer	±1.0 °C	Annually
Relative Humidity	NIST-traceable psychrometer or standards solution	±10% RH	Annually
Wind Speed	Solar Noon, GPS, or Magnetic Compass	±0.2 m/s	Annually
Wind Direction	Solar Noon, GPS, or Magnetic Compass	±5 degrees; includes orientation error	Annually
Barometric Pressure	NIST-traceable aneroid barometer	±3 mb	Annually

4.3 General Instrument Maintenance Checks

All three air samplers will undergo required maintenance as shown in Table 4-3, and the $PM_{2.5}$ monitor will undergo filter reel inspection. Daily zero/span checks will be automatically performed on the two gas analyzers for NO_X and SO_2. If the zero/span checks do not fall within acceptance criteria detailed in Table 4-3, a full calibration with six gas concentrations will be performed. The $PM_{2.5}$ monitor performs a series of automatic internal performance checks daily. The $PM_{2.5}$ monitor will undergo flow checks yearly and a manual calibration check using NIST-traceable foils yearly.

Table 4-3. Instrument Maintenance Checks

Instrument	Maintenance Activity	Interval
$PM_{2.5}$ Particulate Monitor	Filter Reel Inspection	Yearly or upon Failure
	Sample Pump Inspection	Yearly or upon Failure
	PM_{10} Impactor Disassembly & Cleaning	Monthly
	$PM_{2.5}$ Cyclone Disassembly & Cleaning	Quarterly
	Heated and Unheated Sample Tube Cleaning	Yearly
	Cooling Air Fan Inspection	As needed (visible dust build-up)
SO_2 Monitor	Sample Pump Inspection	Yearly or upon Failure
	Cooling Air Fan Inspection	As needed (visible dust build-up)
NO_2 Monitor	Sample Pump Inspection	Yearly or upon Failure
	Cooling Air Fan Inspection	As needed (visible dust build-up)
Meteorological System	Physical Inspection of Roof Unit	Yearly or upon Failure

5. Data Reduction, Validation, and Reporting

5.1 Data Acquisition

All of the Thermo Scientific instruments have advanced communication features that permit digital communication via Ethernet. Using this interface, the user has access to virtually every parameter within the instrument as well remote control capabilities. The many advantages of this interface are obvious when compared to the old method of sending a single voltage representative of a concentration to an analog input of a data acquisition system. The Thermo Scientific instruments utilize the standard MODBUS TCP protocol for digital communication over Ethernet. ARCADIS will install a PAC to handle the MODBUS TCP interface with the sampler, analyzers, and calibrator. It will also handle calculating the hourly averages, triggering calibrations, and any other input/output needs. The PAC will communicate with a SCADA computer that will provide the main operator interface to the instruments. The SCADA computer will also handle the data logging needs of the system as well.

The PAC system components are manufactured by Opto 22. A photo of a typical PAC is shown in Figure 5-1. Additional information on the hardware and software can be found at http://www.opto22.com/site/snap_pac_system.aspx. With the Opto 22 system, all control logic and any safety interlocks take place inside the PAC and not in the personal computer (PC). This provides for a much more robust and safer system when compared to one running on a PC. The main advantage of this robust industrial control method is that if and when the supervisory PC crashes, the communication and automated calibration procedures for the analyzers continue to function properly. The PC can be restarted logging data and providing an operator interface where it left off.

ARCADIS will supply one PAC assembled in an industrial control panel for the SCSPA monitoring station. A supervisory computer running Opto 22's PAC Control and PAC Display software will be configured and installed. The computer will connect to the PAC controller via an industrial Ethernet switch. The PAC Control software will be used to program and implement any safety interlocks, handle communication with the analyzers, and automate calibration procedures including the switching of any solenoid valves or other support equipment. The PAC Display software will serve as the basis of the SCADA system and provide a user friendly operator interface as well as well as a data acquisition system. Other advantages directly from Opto 22 include: lifetime warranty on I/O modules, free technical support, and no support contracts. The Opto system is highly configurable in software and hardware and has the ability to interface with virtually any piece of industrial control hardware using off-the-shelf I/O modules that support high speed counter inputs, RS-485, RS-232, TCP/IP, Profibus, stepper motors, access control hardware, as well as the typical voltage, milliamp, and temperature sensor inputs.

Figure 5-1. Opto 22 PAC

ARCADIS IT will work with SCSPA to establish a secure remote access solution. A Windows Remote Desktop solution has worked well for similar installations. Typically, this involves a virtual private network (VPN) connection (e.g., Check Point Software's SecureClient, Cisco System's VPN Client) or some other means of computer access such as Real VNC (http://www.realvnc.com). Once we are on the SCSPA network, we can access and remotely control the data acquisition computer by referencing its internet protocol (IP) address.

5.2 Data Analysis

Data will be downloaded, reviewed, and Level-1 validated (see Section 5.3) at the ARCADIS office, daily. Data discrepancies and/or alarm values will be dealt with immediately. If the question cannot be resolved remotely, the local project field technician will be dispatched to the site immediately with tools and equipment prepared to fix the problem. If the problem is not immediately addressable, he will be shipped a replacement sampler to bring online to replace the inoperative sampler. Only after the replacement is online and proving to operate consistently will the broken sampler be sent back to the manufacturer for repair.

Following each day's data validation and completeness check, it is confirmed that the samplers are operating properly. If there are questions, initial investigation will be by a remote query. If calibration checks cannot be attained, a technician will be dispatched to investigate further. If the problem cannot be fixed, the manufacturer will be brought in to add additional technical remedies. At this time, if it appears that a timely solution is doubtful, a replacement sampler will be sent to the site for immediate startup. Once the original sampler is ready for installation, it will be used, and the replacement will be returned.

5.3 Data Validation

Data validation, as defined in EPA's QA handbook for Air Pollution Measurement Systems EPA/600/R-94/0386, is to detect and then verify any data values that may not represent actual air quality conditions at the sampling station. Effective data validation procedures are usually handled independently from the procedures of initial data collection. Data validation is necessary to identify data with errors, biases, and physically unrealistic values before they are used for identification of exceedances, for analysis, or for modeling. The levels of data validation are summarized in Table 5-1.

Table 5-1. Data Validation Levels

Level	Objective
Level 0	Conversion of instrument output voltages to their scaled scientific units using nominal calibrations. May incorporate data logger inserted flags.
Level 1	Observations have received quantitative and qualitative reviews for accuracy, completeness and internal consistency. Final audit reviews are required.
Level 2	Measurements are compared for external consistency against other independent data sets
Level 3	Ongoing evaluation of the data as part of data interpretation process

For this work, ARCADIS will complete Level 0 and Level 1 data validation activities prior to reporting the data. Level 1 validation includes the following:

- Placing data in a common data format with descriptive information concerning variables, validation level, QC codes, and standard units
- Ensuring that results of and suggestions from daily data checks have been incorporated into the database
- Reviewing simple statistics for unrealistic maxima or minima and for consistency with nearby stations

The point is to ensure that the data reported from the instrumentation and monitoring equipment is reliable.

Data-logger inserted flags will include calibration events and warnings of span values outside acceptance criteria. System performance monitoring will be on a continuous basis by the data acquisition system and reviewed daily for completeness by a trained ARCADIS staff member (excluding weekends and holidays, which will be performed the following work day). Any problems discovered in this daily review will be reported to the ARCADIS Project Manager and corrective actions taken as necessary. Problems affecting the accuracy or completeness of the data set will also be reported to the ARCADIS QA Officer.

Data will be flagged where significant deviations from measurement assumptions have occurred. Data that are known to be invalid due to instrument malfunctions will be flagged or eliminated. Data will also be evaluated to determine whether or not data quality goals have been met in terms of accuracy, precision, and completeness. A Microsoft Excel macro will be developed to aid in the daily data validation checks. The macro will process and graph the time-stamped data from the data acquisition system so that the user can easily detect any anomalies or omissions in the data.

5.4 Reporting

ARCADIS will host a website on our corporate server in Denver, Colorado, for displaying the environmental data as specified in the RFP. This will include 1-hour averages of the $PM_{2.5}$, SO_2, and NO_2 measurements for the past 30 days. The presentation format will be similar to the SCDHEC website listed below.

http://www.scdhec.gov/environment/baq/airlabdata/search.asp

Details of automating the data transfer from the monitoring location to our Denver server will be coordinated with SCSPA's IT personnel. ARCADIS can set up an automated data transfer process from the SCSPA network to the ARCADIS network to eliminate the need for a manual update to the data displayed on the website. There are several options for implementing this automated transfer process:

- FTP Transfer – This would be the simplest solution to implement while still maintaining the ability to have access level security to the data.
- HTTP Transfer – This is also possible, although FTP would be preferred. Again, this maintains the ability to have access level security to the data.
- Windows File Transfer – This would provide the highest data security, but at the cost of the most complex implementation. The performance and reliability of this option is also lower than the aforementioned options.

Once the data have been transferred, the application within the ARCADIS network will automatically update the database with the latest data received, and the information will then be available on the website.

Data summary reports will be provided to SCSPA for posting on their web page. An Excel macro will be written as part of Task 3 to process the data into the format required by SCSPA. The assembly of calibration and audit records, a narrative of instrument performance, analysis of data issues, and a list of corrective actions will be included as part of the monthly report. Data summaries will be generated each quarter and formatted to SCSPA specifications. This report will include the following:

- Assembling Level 1 database
- Placing data in a common data format with descriptive information concerning variables, QC codes, and standard units
- Assembling calibration and audit records for that reporting period
- Reviewing accuracy and completeness of data set
- Describing instrument performance and any events contributing to monthly data recovery less than 75 percent per parameter and associated corrective actions
- Minimum reporting requirements listed in the request for proposal (RFP)

This report will be prepared by ARCADIS staff and reviewed by the ARCADIS QA Officer prior to being released. Additional statistics and graphs can easily be added if requested by SCSPA. At SCSPA's request, the more rigorous QA guidelines listed in 40CFR, Part 58, including independent performance audits and collocated instrumentation, can be implemented at additional cost.

Appendix A: SOPs for Elements of the Continuous Air Monitoring Station

Standard Operating Procedures for the Continuous Air Monitoring Station at Wando Welch Terminal South Carolina Ports Authority

Standard Operating Procedures: Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer

Introduction

NO_2 Monitoring Methodological Requirements

The Federal Reference Method (FRM) for nitrogen dioxide (NO_2) is described in: *Appendix F to 40 CFR Part 50 - Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence).* In this procedure, atmospheric concentrations of NO_2 are measured indirectly by photometrically measuring the light intensity, at wavelengths greater than 600 nm, resulting from the chemiluminescent reaction of nitric oxide (NO) with ozone (O_3). NO_2 is first reduced to NO with a converter. NO, which commonly exists in ambient air together with NO_2, passes through the converter unchanged, causing a resultant total NO_X concentration equal to NO+NO_2. A sample of the ambient air is also measured without having passed through the converter. This latter measurement (NO) is subtracted from the former measurement (NO_X) to yield NO_2. The NO and NO_X measurements may be made concurrently with dual chemiluminescent analyzer systems or cyclically with the same system as long as the cycle time does not exceed one minute.

NO_2 Analyzer Description

For the measurement of NO_2, one of the instruments that have been designated as a FRM for NO_2, the Thermo Scientific Model 42*i* NO-NO_2-NO_X Analyzer, has been chosen for the Continuous Air Monitoring Station at Wando Welch Terminal - South Carolina Ports Authority. It uses the cyclic measurement option mentioned in Appendix F to 40 CFR Part 50. The Model 42*i*'s Automated Reference Method Designation is RFNA-1289-074. The Model 42*i* operates on principles closely linked to those required in the FRM: Nitric oxide (NO) and ozone (O_3) react to produce a characteristic luminescence with intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to lower energy states. Specifically: Nitrogen dioxide (NO_2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a molybdenum NO_2-to-NO converter heated to about 325 °C. The ambient air sample is drawn into the Model 42*i* through the sample bulkhead. The sample flows through a capillary, and then to the mode solenoid valve. The solenoid valve routes the sample either straight to the reaction chamber (NO mode) or through the NO2-to-NO converter and then to the reaction chamber (NO_X mode). A flow sensor to the reaction chamber measures the sample flow. Dry air enters the Model 42*i* through the dry air bulkhead, passes through a flow switch, and then through a silent discharge ozonator. The ozonator generates the ozone needed for the chemiluminescent reaction. At the reaction chamber, the ozone reacts with the NO in the sample to produce excited NO_2 molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the luminescence generated during this reaction. From the reaction chamber, the exhaust travels through the ozone (O_3) converter to the pump, and is released through the vent. The NO and NO_X concentrations calculated in the NO and NO_X modes are stored in memory. The difference between the concentrations is used to calculate the NO_2 concentration. The Model 42*i* outputs NO, NO_2, and NO_X concentrations to the front panel display, the analog outputs, and also makes the data available over the serial or Ethernet connection.

Procedures

Please note that the procedures detailed below have largely been automated in the Continuous Air Monitoring Station for the Wando Welch Terminal. This document is intended to aid in the initial set up, maintenance, and manual operation of the Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer. Data Acquisition and Control System connection is not covered in this SOP; it will be addressed in a separate document.

NO_2 Analyzer Start-Up Procedure

Insure that the overall Ambient Air Sample Delivery System has been properly configured and leak checked).

Use the following procedure when starting the Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer. For details on the instrument front panel controls and operating procedures throughout this SOP, see the Thermo Scientific Model 42*i* Instruction Manual.

Equipment required:

1. Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer.

Start-up Stepwise Instructions:

1. Turn the power ON.
2. Insure that the boot process is complete and the instrument comes up to the “Run” screen.
3. Insure that the ozonator is in the “On” position
4. Allow at least 90 minutes for the instrument to stabilize electronically and thermally. (Note it is best to turn the ozonator on and let the instrument warm up overnight prior to calibration in order to obtain the most accurate readings.)
5. Prior to use, insure the Thermo Scientific Model 42i Chemiluminescence NO-NO_2-NO_X Analyzer is in the 0-200 ppbv range.

NO_2 Analyzer Calibration Procedure

Equipment required:

1. Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer.
2. Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
3. Thermo Scientific Model 1160 Zero Air Supply.
4. NIST traceable NO gas (in N_2 balance) cylinder, ~10 ppmv, Size 150 AL.
5. Gas pressure regulator, CGA 580 inlet fitting - 1/4" swage outlet fitting with non-reactive diaphragm and internal parts & output gauge resolvable to ±1 psig.
6. Continuous Air Monitoring Station Ambient Air Sample Delivery System.
7. Continuous Air Monitoring Station Data Acquisition and Control System

Note that the zero air supply serially compresses, dries, oxidizes, scrubs, and filters ambient air to produce zero air suitable for use both directly as zero air and as a diluent for a gas calibrator in analyzer calibration. The gas calibrator then blends (using gas phase titration [GPT] with ozone) appropriate portions of zero air and the NIST traceable NO gas to produce the concentrations of NO_2 calibration gases needed for calibration of the Model 42*i*. The instrument must be calibrated prior to use and at defined intervals (for details see *Quality Assurance Project Plan - Continuous Air Monitoring Station for the Wando Welch Terminal* for the South Carolina Ports Authority).

Calibration Stepwise Instructions:

1. Open main valve on NIST traceable NO gas cylinder and set gas regulator output pressure to approximately 40 psig.
2. Set the flow from the Model 146*i* Dynamic Gas Calibrator at 1.5 L/min (see Standard Operating Procedures - Thermo Scientific Model 146*i* Dynamic Gas Calibrator for details throughout this procedure).
3. Disconnect the Teflon line between the NIST traceable NO gas cylinder and the inlet of the gas calibrator; purge for 15 seconds to eliminate air which may affect the operation of the GPT system. Reconnect and tighten.
4. Set the operating range of the Model 42*i* to the 0-200 ppbv setting.
5. Set the averaging time to 300 seconds.
6. Insure the ozonator is in the "OFF" position.
7. Insure the instrument is in the "NO/NO_X" position.
8. Set "Cal Pressure" to current reactor pressure.
9. Challenge the Model 42*i* with zero air from the gas calibrator; wait seven minutes for the readings to stabilize.

10. Set both NO and NO_X backgrounds to "Zero". Record the data acquisition and control system NO, NO_X, and NO_2 readings as "Calibration Zero Values" in the appropriate place in the site logbook.
11. Stop the flow of zero air from the gas calibrator.
12. Challenge the Model 42*i* with 180 ppbv NO from the gas calibrator; wait seven minutes for the readings to stabilize.
13. Set both NO and NO_X readings to 180. Record the NO, NO_X, and NO_2 readings as "Calibration Span Values" in the appropriate place in the site logbook.
14. Serially challenge the Model 42*i* with 150, 120, 90, 60, and 30 ppbv NO gas from the gas calibrator and record NO, NO_X, and NO readings as "Midrange Calibration Gas" 1-5 in the appropriate place in the site logbook. **Make no adjustments to the instrument during this process!**
15. Stop the flow of calibration gas from the gas calibrator.

NO_2 Analyzer Converter Efficiency Check Procedure

Equipment required:
1. Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer.
2. Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
3. Thermo Scientific Model 1160 Zero Air Supply.
4. NIST traceable NO gas (in N_2 balance) cylinder, ~10 ppmv, Size 150 AL.
5. Gas pressure regulator, CGA 580 inlet fitting - 1/4" swage outlet fitting with non-reactive diaphragm and internal parts & output gauge resolvable to ±1 psig.
6. Continuous Air Monitoring Station Ambient Air Sample Delivery System.
7. Continuous Air Monitoring Station Data Acquisition and Control System

Converter Efficiency Check Stepwise Instructions:

1. Open main valve on NIST traceable NO gas cylinder and set gas regulator output pressure to approximately 40 psig.
2. Set the flow from the Model 146*i* Dynamic Gas Calibrator at 1.5 L/min (see Standard Operating Procedures - Thermo Scientific Model 146*i* Dynamic Gas Calibrator for details throughout this procedure).
3. Disconnect the Teflon line between the NIST traceable NO gas cylinder and the inlet of the gas calibrator; purge for 15 seconds to eliminate air which may affect the operation of the GPT system. Reconnect and tighten.
4. Set the operating range of the Model 42*i* to the 0-200 ppbv setting.
5. Set the averaging time to 300 seconds.
6. Insure the ozonator is in the "OFF" position.
7. Insure the instrument is in the "NO/NO_X" position.

8. Set “Cal Pressure” to current reactor pressure.
9. Challenge the Model 42*i* with zero air from the gas calibrator; wait seven minutes for the readings to stabilize.
10. Set both NO and NO_X backgrounds to “Zero”. Record the data acquisition and control system NO, NO_X, and NO_2 readings as “Converter Efficiency Check Zero Values” in the appropriate place in the site logbook.
11. Stop the flow of zero air from the gas calibrator.
12. Challenge the Model 42*i* with 180 ppbv NO from the gas calibrator; wait seven minutes for the readings to stabilize.
13. Set both NO and NO_X readings to 180. Record the NO, NO_X, and NO_2 readings as “Converter Efficiency Check ‘Ozone Off’ Values” in the appropriate place in the site logbook.
14. Turn the ozonator to the “ON” position.
15. Adjust the ozonator to the “17%” output position using the “Manual” adjust; wait seven minutes.
16. Record the data acquisition and control system NO, NO_X, and NO_2 readings as “Converter Efficiency Check ‘Ozone On’ Values” in the appropriate place in the site logbook.
17. Calculate: Converter Efficiency% = $NO_{Xon} – NO_{on}/NOX_{off} - NO_{on}$ X 100. Record in the appropriate place in the site logbook.

NO_2 Analyzer Zero and Span Check Procedure

Equipment required:

1. Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer.
2. Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
3. Thermo Scientific Model 1160 Zero Air Supply.
4. NIST traceable NO gas (in N_2 balance) cylinder, ~10 ppmv, Size 150 AL.
5. Gas pressure regulator, CGA 580 inlet fitting - 1/4” swage outlet fitting with non-reactive diaphragm and internal parts & output gauge resolvable to ±1 psig.
6. Continuous Air Monitoring Station Data Acquisition and Control System.
7. Continuous Air Monitoring Station Ambient Air Sample Delivery System.

Zero and Span Check Stepwise Instructions:

1. Open main valve on NIST traceable NO gas cylinder and set gas regulator output pressure to approximately 40 psig.
2. Set the flow from the Model 146*i* Dynamic Gas Calibrator at 1.5 L/min (see Standard Operating Procedures - Thermo Scientific Model 146*i* Dynamic Gas Calibrator for details throughout this procedure).

3. Disconnect and the Teflon line between the NIST traceable NO gas cylinder and the inlet of the gas calibrator; purge for 15 seconds to eliminate air which may affect the operation of the GPT system. Reconnect and tighten.
4. Challenge the Model 42*i* with zero air from the gas calibrator; wait seven minutes for the readings to stabilize.
5. Record the data acquisition and control system NO, NO_X, and NO_2 readings as "Span Check Zero Values" in the appropriate place in the site logbook.
6. Stop the flow of zero air from the gas calibrator.
7. Challenge the Model 42*i* with approximately 40 ppbv NO_2 from the gas calibrator; wait seven minutes for the readings to stabilize.
8. Record the NO, NO_X, and NO_2 readings as "Span Check Span Values" in the appropriate place in the site logbook.
9. Stop the flow of calibration gas from the gas calibrator.

If the zero has changed by more than 10 ppbv, a new calibration must be performed. If the span check indicates a gain of more than 10%, a new calibration must be performed. For details see *Quality Assurance Project Plan - Continuous Air Monitoring Station for the Wando Welch Terminal* for the South Carolina Ports Authority.

NO_X Analyzer Bias Check Procedure

The bias check involve challenging the entire Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer ambient air sampling system (from the probe tip forward) with a known concentration of NO_2 from a different source (un-gas phase titrated, undiluted, NO_2 gas) to assess any possible bias induced by the calibrations system or the conveyance system (rain hat, probe, sample line, filter, sample manifold, bias line) itself.

Equipment required:

1. Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer.
2. Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
3. Thermo Scientific Model 1160 Zero Air Supply.
4. NIST traceable NO_2 gas (in zero air balance) cylinder, ~100 ppbv, Size 150 AL.
5. Gas pressure regulator, CGA 580 inlet fitting - 1/4" swage outlet fitting with non-reactive diaphragm and internal parts & output gauge resolvable to ±1 psig.
6. Continuous Air Monitoring Station Data Acquisition and Control System.
7. Continuous Air Monitoring Station Ambient Air Sample Delivery System.

Bias Check Stepwise Instructions:

1. Open main valve on NIST traceable NO_2 gas cylinder and set gas regulator output pressure to approximately 40 psig.
2. Set the flow from the Model 146*i* Dynamic Gas Calibrator at 1.5 L/min (see Standard Operating Procedures - Thermo Scientific Model 146*i* Dynamic Gas Calibrator for details throughout this procedure).
3. Challenge the Model 42*i* sampling system with zero air from the gas calibrator; wait seven minutes for the readings to stabilize.
4. Record the data acquisition and control system NO, NO_X, and NO_2 readings as "Bias Check Zero Values" in the appropriate place in the site logbook.
5. Stop the flow of zero air from the gas calibrator.
6. Challenge the Model 42*i* sampling system with 100 ppbv NO_2 from the NIST traceable NO_2 gas cylinder (as routed through the Thermo Scientific Model 146*i* Dynamic Gas Calibrator). Wait seven minutes for the readings to stabilize.
7. Record the data acquisition and control system NO, NO_X, and NO_2 readings as "Bias Check NO_2 Values" in the appropriate place in the site logbook.

NO_X Analyzer Sampling Procedure

The normal operation of the Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer is straight-forward after it has been calibrated.

Equipment required:

1. Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer.
2. Continuous Air Monitoring Station ambient air sample delivery system.
3. Continuous Air Monitoring Station data acquisition and control system (see Figure 3).

Stepwise Operating Instructions:

1. Insure the sample inlet on the roof is unobstructed.
2. Insure the sample inlet rain hat is pointed down.
3. Insure that a slight vacuum is on the sample inlet tube.
4. Insure that a slight flow is exiting the exhaust line on the roof.
5. Wait seven minutes and check the front panel NO, NO_X, and NO_2 readings for positive values.
6. Compare front panel NO, NO_X, and NO_2 readings with the same readings on data acquisition and control system.

If the front panel NO, NO_X, and NO_2 readings and those on data acquisition and control system are identical, the system is operational. If not, repeat Bias Check above.

Standard Operating Procedures: Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer

Introduction

SO_2 Monitoring Methodological Requirements

The FRM for sulfur dioxide (SO_2) is described in: *Appendix A to 40 CFR Part 50 - Reference Method for the Determination of Sulfur Dioxide in the Atmosphere (Pararosaniline Method)*. This method involves a manual procedure that requires the bubbling of an ambient air sample through impingers containing potassium tetrachloromercurate and complex spectrophotometric analytical procedures. It has been largely supplanted by Federal Equivalent Methods (FEMs) in practical usage.

SO_2 Analyzer Description

For the measurement of SO_2, one of the instruments that have been designated as an FEM for SO_2, the Thermo Scientific Model 43*i* SO_2 Analyzer has been chosen. This continuous monitor uses the principle of Pulsed Fluorescence and has an Automated Equivalent Method Designation of EQSA-0486-060. The Model 43*i* operates on the principle that SO_2 molecules absorb ultraviolet (UV) light and become excited at one wavelength, then decay to a lower energy state emitting UV light at a different wavelength. Specifically, the sample is drawn into the Model 43i through the SAMPLE bulkhead, as shown in Figure 4. The sample flows through a hydrocarbon “kicker,” which removes hydrocarbons from the sample by forcing the hydrocarbon molecules to permeate through the tube wall. The SO_2 molecules pass through the hydrocarbon “kicker” unaffected. The sample then flows into the fluorescence chamber, where pulsating UV light excites the SO_2 molecules. The condensing lens focuses the pulsating UV light into the mirror assembly. The mirror assembly contains four selective mirrors that reflect only the wavelengths which excite SO_2 molecules. As the excited SO_2 molecules decay to lower energy states they emit UV light that is proportional to the SO_2 concentration. The bandpass filter allows only the wavelengths emitted by the excited SO_2 molecules to reach the photomultiplier tube (PMT). The PMT detects the UV light emission from the decaying SO_2 molecules. The photodetector, located at the back of the fluorescence chamber, continuously monitors the pulsating UV light source and is connected to a circuit that compensates for fluctuations in the UV light. As the sample leaves the optical chamber, it passes through a flow sensor, a capillary, and the “shell” side of the hydrocarbon kicker. The sample then flows to the pump and is exhausted out the EXHAUST bulkhead of the analyzer. The Model 43*i* outputs the SO_2 concentration to the front panel display and the analog outputs, and also makes the data available over the serial or Ethernet connection.

Procedures

Please note that the procedures detailed below have largely been automated in the Continuous Air Monitoring Station for the Wando Welch Terminal. This document is intended to aid in the initial set up, maintenance, and manual operation of the Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer. Data Acquisition and Control System connection is not covered in this SOP; it will be addressed in a separate document.

SO_2 Analyzer Start-Up Procedure

Insure that the overall ambient air sample delivery system has been properly configured and leak checked (see Figure.

Use the following procedure when starting the Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer. For details on the instrument front panel controls and operating procedures throughout this SOP, see the Thermo Scientific Model 43*i* Instruction Manual.

Equipment required:

1. Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer.

Start-up Stepwise Instructions:

1. Turn the power ON.
2. Insure that the boot process is complete and the instrument comes up to the "Run" screen.
3. Allow at least 90 minutes for the instrument to stabilize electronically and thermally. (Note it is best to let the instrument warm up overnight prior to calibration in order to obtain the most accurate readings.)
4. Prior to use, insure the Thermo Scientific Model 43i Sulfur Dioxide Analyzer is in the 0-200 ppbv range.

SO_2 Analyzer Calibration Procedure

Equipment required:

1. Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer.
2. Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
3. Thermo Scientific Model 1160 Zero Air Supply.
4. NIST traceable SO_2 gas (in N_2 balance) cylinder, ~10 ppmv, Size 150 AL.

5. Gas pressure regulator, CGA 580 inlet fitting - 1/4” swage outlet fitting with non-reactive diaphragm and internal parts & output gauge resolvable to ±1 psig.
6. Continuous Air Monitoring Station Data Acquisition and Control System.
7. Continuous Air Monitoring Station Ambient Air Sample Delivery System.

Calibration Stepwise Instructions:

1. Open main valve on NIST traceable SO_2 gas cylinder and set gas regulator output pressure to approximately 40 psig.
2. Set the flow from the Model 146*i* Dynamic Gas Calibrator at 1.5 L/min (see Standard Operating Procedures - Thermo Scientific Model 146*i* Dynamic Gas Calibrator for details throughout this procedure).
3. Set the operating range of the Model 43*i* to the 0-200 ppbv setting.
4. Set the averaging time to 300 seconds.
5. Set “Cal Pressure” to current reactor pressure.
6. Challenge the Model 43*i* with zero air from the gas calibrator; wait seven minutes for the readings to stabilize.
7. Set SO_2 to zero. Record the data acquisition and control system SO_2 reading as “Calibration Zero Values” in the appropriate place in the site logbook.
8. Stop the flow of zero air from the gas calibrator.
9. Challenge the Model 43*i* with 180 ppbv SO_2 from the gas calibrator; wait seven minutes for the readings to stabilize.
10. Set SO_2 reading to 180. Record the SO_2 reading as “Calibration Span Values” in the appropriate place in the site logbook.
11. Serially challenge the Model 43*i* with 150, 120, 90, 60, and 30 ppbv SO_2 gas from the gas calibrator and SO_2 readings as “Midrange Calibration Gas” 1-5 in the appropriate place in the site logbook. **Make no adjustments to the instrument during this process!**
12. Stop the flow of calibration gas from the gas calibrator.

SO_2 Analyzer Zero and Span Check Procedure

Equipment required:

1. Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer.
2. Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
3. Thermo Scientific Model 1160 Zero Air Supply.
4. NIST traceable SO_2 gas (in N_2 balance) cylinder, ~10 ppmv, Size 150 AL.
5. Gas pressure regulator, CGA 580 inlet fitting - 1/4” swage outlet fitting with non-reactive diaphragm and internal parts & output gauge resolvable to ±1 psig.

6. Continuous Air Monitoring Station Data Acquisition and Control System.
7. Continuous Air Monitoring Station Ambient Air Sample Delivery System.

Zero and Span Check Stepwise Instructions:

1. Open main valve on NIST traceable SO_2 gas cylinder and set gas regulator output pressure to approximately 40 psig.
2. Set the flow from the Model 146*i* Dynamic Gas Calibrator at 1.5 L/min (see Standard Operating Procedures - Thermo Scientific Model 146*i* Dynamic Gas Calibrator for details throughout this procedure).
3. Challenge the Model 43*i* with zero air from the gas calibrator; wait seven minutes for the readings to stabilize.
4. Record the data acquisition and control system SO_2 readings as “Span Check Zero Values” in the appropriate place in the site logbook.
5. Stop the flow of zero air from the gas calibrator.
6. Challenge the Model 43*i* with approximately 40 ppbv SO_2 from the gas calibrator; wait seven minutes for the readings to stabilize.
7. Record the data acquisition and control system SO_2 readings as “Span Check Span Values” in the appropriate place in the site logbook.
8. Stop the flow of calibration gas from the gas calibrator.

If the zero has changed by more than 8 ppbv, a new calibration must be performed. If the span check indicates a change of more than 8 ppbv, a new calibration must be performed. For details see *Quality Assurance Project Plan - Continuous Air Monitoring Station for the Wando Welch Terminal* for the South Carolina Ports Authority.

SO_2 Analyzer Bias Check Procedure

The bias check involve challenging the entire Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer ambient air sampling system (from the probe tip forward) with a known concentration of SO_2 from a different source (undiluted SO_2 gas) to assess any possible bias induced by the calibrations system or the conveyance system (rain hat, probe, sample line, filter, sample manifold, bias line) itself.

Equipment required:

1. Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer.
2. Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
3. Thermo Scientific Model 1160 Zero Air Supply.
4. NIST traceable SO_2 gas (in zero air balance) cylinder, ~100 ppbv, Size 150 AL.

5. Gas pressure regulator, CGA 580 inlet fitting - 1/4” swage outlet fitting with non-reactive diaphragm and internal parts & output gauge resolvable to ±1 psig.
6. Continuous Air Monitoring Station Data Acquisition and Control System.
7. Continuous Air Monitoring Station Ambient Air Sample Delivery System.

Bias Check Stepwise Instructions:

1. Open main valve on NIST traceable SO_2 gas cylinder and set gas regulator output pressure to approximately 40 psig.
2. Set the flow from the Model 146*i* Dynamic Gas Calibrator at 1.5 L/min (see Standard Operating Procedures - Thermo Scientific Model 146*i* Dynamic Gas Calibrator for details throughout this procedure).
3. Challenge the Model 43*i* sampling system with zero air from the gas calibrator; wait seven minutes for the readings to stabilize.
4. Record the data acquisition and control system SO_2 reading as “Bias Check Zero Values” in the appropriate place in the site logbook.
5. Stop the flow of zero air from the gas calibrator.
6. Challenge the Model 43*i* sampling system with 100 ppbv SO_2 directly from the NIST traceable SO_2 gas cylinder; make sure the rotameter is set to 1.5 L/min. Wait seven minutes for the readings to stabilize.
7. Record the data acquisition and control system SO_2 reading as “Bias Check SO_2 Values” in the appropriate place in the site logbook.

SO_2 Analyzer Sampling Procedure

The normal operation of the Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer is straight-forward after it has been calibrated.

Equipment required:

1. Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer.
2. Continuous Air Monitoring Station Data Acquisition and Control System.
3. Continuous Air Monitoring Station Ambient Air Sample Delivery System.

Stepwise Operating Instructions:

1. Insure the sample inlet on the roof is unobstructed.
2. Insure the sample inlet rain hat is pointed down.
3. Insure that a slight vacuum is on the sample inlet tube.
4. Insure that a slight flow is exiting the exhaust line on the roof.

5. Wait seven minutes and check the front panel SO_2 readings for positive values.
6. Compare front panel SO_2 readings with the same readings on data acquisition and control system.

If the front panel SO_2 readings and those on data acquisition and control system are identical, the system is operational. If not, repeat Bias Check above.

Standard Operating Procedures: Thermo Scientific Model 146*i* Dynamic Gas Calibrator and Thermo Scientific Model 1160 Zero Air Supply

Introduction

Calibration Gas Delivery System Methodological Requirements

The Federal Reference Method (FRM) for nitrogen dioxide (NO_2) is in: *Appendix F to 40 CFR Part 50 - Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide.* It describes a gas calibration system capable of providing accurate levels of NO_2 calibration gas between zero and 80% of full-scale range for an NO_2 analyzer. This system features: a gas phase titration (GPT) apparatus; ozone generator capable of generating sufficient and stable levels of O_3 for reaction with NO to generate NO_2 concentrations in the range required; non-reactive connection materials; air flow controllers capable of maintaining constant air flows within ±2% of the required flow rate; NO flow controller capable of maintaining constant NO flows within ±2% of the required flow rate; air flow meters capable of measuring and monitoring air flow rates with an accuracy of ±2% of the measured flow rate; NO flowmeter capable of measuring and monitoring NO flow rates with an accuracy of ±2% of the measured flow rate; a pressure regulator for standard NO cylinder with a nonreactive diaphragm/internal parts and a suitable delivery pressure; a reaction chamber constructed of glass, Teflon, or other nonreactive material, for the quantitative reaction of O_3 with excess NO (the chamber should be of sufficient volume such that the residence time meets the requirements specified in Section 1.4 of Appendix F); a mixing chamber constructed of glass, Teflon, or other nonreactive material and designed to provide thorough mixing of reaction products and diluents air; an output manifold constructed of glass, Teflon, or other non-reactive material of sufficient diameter to insure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to insure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold. A valve may be used to divert the NO flow when zero air is required at the manifold. The calibration system must provide a flow rate of at least 0.5 LPM for an instrument with the standard flow instruments with higher flow rates will require a higher minimum calibration system flow rate). All calibration gas should be derived from local or working standards (such as cylinders of compressed gas or permeation devices) that are certified as traceable to an NIST primary standard.

With appropriate operational modifications e.g., not using the GPT system, this **c**alibration gas delivery system is sufficient for the calibration of all ambient air gas monitors in the Continuous Air Monitoring Station for the Wando Welch Terminal.

Calibration Gas Delivery System Description

The Thermo Scientific Model 146*i* Dynamic Gas Calibrator has been chosen for the Calibration Gas Delivery System at the Continuous Air Monitoring Station at Wando Welch Terminal - South Carolina Ports Authority. It has all the capabilities described above in an integrated, micro-processor controlled package. It is supported by the Thermo Scientific Model 1160 Zero Air Supply which serially compresses, dries, oxidizes, scrubs, and filters ambient air to produce zero air suitable for use both directly as zero air and as a diluent for a gas calibrator in analyzer calibration. The Model 146*i* Dynamic Gas Calibrator dilutes calibration gases to precise concentrations. The diluted gases are used to perform zero, precision and Level 1 span checks, audits, and multipoint calibration of analyzers. In addition, it used GPT to produce NO_2 calibration gas from a NIST traceable NO gas cylinder. The design of the Model 146*i* meets or exceeds all published U.S. Environmental Protection Agency requirements for multipoint calibration, audit, Level 1 span and precision checks.

Procedures

Please note that the procedures detailed below have largely been automated in the Continuous Air Monitoring Station for the Wando Welch Terminal. This document is intended to aid in the initial set up, maintenance, and manual operation of the Thermo Scientific Model Dynamic Gas Calibrator and. Data Acquisition and Control System connection is not covered in this SOP; it will be addressed in a separate document.

Calibration Gas Delivery System Start-Up Procedure

Use the following procedure when starting the Calibration Gas Delivery System. For details on the instruments' front panel controls and operating procedures, see the Thermo Scientific Model 146*i* Dynamic Gas Calibrator and Thermo Scientific Model 1160 Zero Air Supply Instruction Manual.

Equipment required:

1. Thermo Scientific Model 1160 Zero Air Supply.
2. Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
3. NIST traceable NO gas (in N_2 balance) cylinder, ~10 ppmv, Size 150 AL.
4. NIST traceable SO_2 gas (in N_2 balance) cylinder, ~10 ppmv, Size 150 AL.
5. Two (2) each, gas pressure regulator, CGA 580 inlet fitting - 1/4" swage outlet fitting with non-reactive diaphragm and internal parts & output gauge resolvable to ±1 psig.
6. 1/4" Teflon tubing, ~ 25 ft. w/nut & ferrules

7. Continuous Air Monitoring Station Data Acquisition and Control System.
8. Continuous Air Monitoring Station Ambient Air Sample Delivery System.

Start-up Stepwise Instructions:

1. Insure that the scrubber canisters of the Thermo Scientific Model 1160 Zero Air Supply are loaded with fresh adsorbent.
2. Turn the power switch to the “On” position. Allow instrument to warm up for 15 minutes.
3. Adjust the outlet pressure to 40 psig.
4. Insure that a significant pressurized flow is exiting the “Out” fitting on the back of the Thermo Scientific Model 1160 Zero Air Supply.
9. Connect a 1/4” Teflon line between the “Out” bulkhead fitting on the back of the Thermo Scientific Model 1160 Zero Air Supply and the “Zero Air” bulkhead fitting on the back of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
10. Connect 1/8” Teflon lines from the two “Drain” bulkhead fittings on the Thermo Scientific Model 1160 Zero Air Supply to an appropriate water drain to avoid condensate dripping on other instrumentation.
5. Connect a 1/4” Teflon line between the outlet of the gas regulator on the NIST traceable NO gas cylinder and the “A“ bulkhead fitting on the back of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
6. Connect a 1/4” Teflon line between the outlet of the gas regulator on the NIST traceable SO_2 gas cylinder and the “B“ bulkhead fitting on the back of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
4. Connect a 1/4” Teflon line between the “Vent” bulkhead fitting on the back of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator and the exhaust manifold of the Continuous Air Monitoring Station Ambient Air Sample Delivery System.
7. Connect a 1/4” Teflon line between the “Output” bulkhead fitting on the back of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator and the calibration manifold on the Continuous Air Monitoring Station Ambient Air Sample Delivery System.
8. Turn the power switch of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator to the “On” position. Verify that the front panel comes up to the “Power Up” screen and after a few minutes, comes up to the “Run” screen.
9. Allow the instrument to warm up for 90 minutes.

Calibration Gas Delivery System Operational Procedures

Separate modes of operation are needed to successfully calibrate, zero/span check, and bias check the Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer and the Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer. The NO_X analyzer requires operation of the GPT function of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator; the SO_2 analyzer does not.

Both require the use of the dilution function of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator. Given that the Thermo Scientific Model 146*i* Dynamic Gas Calibrator operates (prepares and mixes the proper gases for instrument calibration) intuitively from simple front panel controls, the following procedures are mainly concerned with initial set-up of the calibrator, e.g., informing the software of the gases connected, calibration concentrations desired, flows desired, and calibration sequences necessary to calibrate and zero/span check the Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer and the Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer.

Calibration Gas Delivery System Operational Procedure – General Set-Up

This portion of the procedure will prepare the internal programming of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator to mix the proper calibration and span gases for both the Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer and the Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer. Procedures covered later will program the calibrator for Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer specific operation.

Equipment required:

1. Thermo Scientific Model 1160 Zero Air Supply.
2. Thermo Scientific Model 146*i* Dynamic Gas Calibrator.
3. Thermo Scientific Model 42*i* Chemiluminescence NO-NO_2-NO_X Analyzer.
4. Thermo Scientific Model 43*i* Sulfur Dioxide Analyzer.
5. NIST traceable NO gas (in N_2 balance) cylinder, ~10 ppmv, Size 150 AL.
6. NIST traceable SO_2 gas (in N_2 balance) cylinder, ~10 ppmv, Size 150 AL.
7. Two (2) each, gas pressure regulator, CGA 580 inlet fitting - 1/4" swage outlet fitting with non-reactive diaphragm and internal parts & output gauge resolvable to ±1 psig.
8. Continuous Air Monitoring Station Data Acquisition and Control System.
9. Continuous Air Monitoring Station Ambient Air Sample Delivery System.

General Set-Up Stepwise Instructions:

1. Insure that the scrubber canisters of the Thermo Scientific Model 1160 Zero Air Supply are loaded with fresh adsorbent.
2. Turn the Thermo Scientific Model 1160 Zero Air Supply on and insure that it is at its operational pressure of 40 psig.
3. On the front panel of the Thermo Scientific Model 146*i* Dynamic Gas Calibrator, go to the "Gas Set-up" menu.
4. Choose "Gas A".
5. Choose "Gas Name", and type in "NO_2" and insure "Saving" is briefly displayed on the screen.

6. Back step in the menu; ignore the “Tank Sol” option and choose “Tank Conc”.
7. Type in the actual concentration (in ppmv) of the NIST traceable NO gas (in N_2 balance) cylinder and insure “Saving” is briefly displayed on the screen.
8. Back step in the menu and choose “Zero”.
9. Type in “1500” CCM and insure “Saving” is briefly displayed on the screen.
10. Back step in the menu and choose “Span 1”, then choose “Conc”.
11. Type in “0.180” PPM and insure “Saving” is briefly displayed on the screen.
12. Choose “TFlow”, type in 1500 and “Saving” is briefly displayed on the screen.
13. Back step in the menu and choose “Span 2”.
14. Type in “0.144” PPM and insure “Saving” is briefly displayed on the screen.
15. Choose “TFlow”, type in 1500 and “Saving” is briefly displayed on the screen.
16. Back step in the menu and choose “Span 3”.
17. Type in “0.108” PPM and insure “Saving” is briefly displayed on the screen.
18. Choose “TFlow”, type in 1500 and “Saving” is briefly displayed on the screen.
19. Back step in the menu and choose “Span 4”.
20. Type in “0.072” PPM and insure “Saving” is briefly displayed on the screen.
21. Choose “TFlow”, type in 1500 and “Saving” is briefly displayed on the screen.
22. Back step in the menu and choose “Span 5”.
23. Type in “0.036” PPM and insure “Saving” is briefly displayed on the screen.
24. Choose “TFlow”, type in 1500 and “Saving” is briefly displayed on the screen.
25. Back step in the menu and Choose “Gas B”.
26. Choose “Gas Name”, and type in “SO_2” and insure “Saving” is briefly displayed on the screen.
27. Back step in the menu; ignore the “Tank Sol” option and choose “Tank Conc”.
28. Type in the actual concentration (in ppmv) of the NIST traceable SO_2 gas (in N_2 balance) cylinder and insure “Saving” is briefly displayed on the screen.
29. Repeat steps 10-24.

Standard Operating Procedures: Thermo Scientific Model 5014*i* Continuous Ambient Particulate Monitor

Introduction

$PM_{2.5}$ Particulate Monitoring Methodological Requirements

The Federal Reference Method (FRM) for particulate matter less than or equal to an aerodynamic diameter of 2.5 microns ($PM_{2.5}$) is described in: *Appendix L to 40 CFR Part 50 – Reference Method for the Determination of Fine Particulate Matter as $PM_{2.5}$ in the Atmosphere.* In this method an electrically powered air sampler draws ambient air at a constant volumetric flow rate into a specially shaped inlet and through an inertial particle size separator (impactor) where the suspended particulate matter in the $PM_{2.5}$ size range is separated for collection on a polytetrafluoroethylene (PTFE) filter over the specified sampling period. The air sampler and other aspects of this reference method are specified either explicitly in this appendix or generally with reference to other applicable regulations or quality assurance guidance. Each filter is weighed (after moisture and temperature conditioning) before and after sample collection to determine the net gain due to collected $PM_{2.5}$. The total volume of air sampled is determined by the sampler from the measured flow rate at actual ambient temperature and pressure and the sampling time. The mass concentration of $PM_{2.5}$ in the ambient air is computed as the total mass of collected particles in the $PM_{2.5}$ size range divided by the actual total volume of air sampled (corrected to EPA standard conditions), and is expressed in micrograms per cubic meter of air ($\mu g/m^3$).

$PM_{2.5}$ Particulate Monitor Description

For the measurement of $PM_{2.5}$, one of the instruments that have been designated as a Federal Equivalent Method (FEM) for $PM_{2.5}$, the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor, has been chosen for the Continuous Air Monitoring Station at Wando Welch Terminal - South Carolina Ports Authority. This device, when equipped with a PM_{10} size selective inlet and a BGI $PM_{2.5}$ Very Sharp Cut Cyclone (VSCC), is an automated version of the Federal Reference Method described above. The Model 5014*i* uses the radiometric principle of beta attenuation through a known area on a fibrous filter tape to continuously detect the mass of deposited ambient particles. Additionally, the Model 5014*i* measures alpha particle emissions directly from the ambient aerosol being sampled and excludes negative mass artifacts from the daughter nuclides of radon gas decay to achieve a refined mass measurement. Simultaneous refined mass measurements of sampled particulate on the filter tape and sample volume measurement provide a continuous concentration measurement of ambient particulate concentration. In all other respects it is similar to the FRM in its operation. Its Automated Equivalent Method Designation is EQPM-0609-183.

Procedures

Please note that the procedures detailed below have largely been automated in the Continuous Air Monitoring Station for the Wando Welch Terminal. This document is intended to aid in the initial set up, maintenance, and manual operation of the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor. Data Acquisition and Control System connection is not covered in this SOP; it will be addressed in a separate document.

$PM_{2.5}$ Monitor Acceptance Testing and Start-Up Procedure

Insure that the overall Ambient Air Sample Delivery System has been properly configured and leak checked.

Use the following procedure when acceptance testing and starting up the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor. For details on the instrument front panel controls and operating procedures throughout this SOP, see the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor Instruction Manual.

Equipment required:

1. Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor.
2. Ambient temperature/RH cable assembly.
3. Vacuum Pump Assembly.
4. Flow Adapter Assembly.
5. NIST-traceable thermometer.
6. NIST-traceable hygrometer.
7. NIST-traceable barometer.
8. NIST-traceable manometer, 2 ea.
9. NIST-traceable volumetric flow transfer standard.
10. Heated Sample Tube Assembly.
11. PM_{10} Size Selective Inlet.
12. BGI $PM_{2.5}$ Very Sharp Cut Cyclone (VSCC).
13. Inlet support stand.
14. Roof Flange Assembly.
15. T/RH Assembly.

Acceptance Testing Stepwise Instructions:

1. Allow Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor and all accessories and support equipment to equilibrate to room temperature for at least 24 hours after unpacking.
2. Remove the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor's side panel and inspect the filter tape, insuring that it is in place and centered.
3. Plug in the power cord. Leave the Heated Sample Tube Assembly aside at this time.
4. Connect the green vacuum pump tube to the pump intake and to the vacuum pump port on the rear panel of the instrument.
5. Connect the vacuum pump power cord to the plug labeled "Pump" on the rear panel of the instrument.
6. Connect the 4-pin Temperature/RH cable to the plug labeled RH/TEMP" on the rear panel of the instrument.
7. Insure the pressure sensor calibration port toggle switches on the rear panel of the instrument are pushed outward and away from the barbed ± Delta P.
8. Turn the power switch to the "On" position.
9. Insure that the boot process is complete and the instrument comes up to the "Run" screen.
10. Allow at least 12 hours for the instrument and beta detector to stabilize electronically and thermally. (Note it is best to turn power on and let the instrument warm up overnight prior to continuing acceptance testing).
11. Select "Main Menu>Diagnostics>RH/Temperatures".
12. Compare "Ambient Temp", "Flow Temp" (measured at the inlet on top of the instrument), and "Board Temp" with the NIST-traceable thermometer; if any of these temperatures is not within ±3C, the relevant temperature sensor must be calibrated (see Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor Instruction Manual).
13. Compare the "Ambient RH" with the NIST-traceable hygrometer; if it is not within ±3% RH, the RH sensor must be calibrated (see Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor Instruction Manual).
14. Back step in menu and choose "Diagnostics>Pressure/Vacuum".
15. Compare "Barometric" with the NIST-traceable barometer; if it is not within ±10 mm Hg, the barometric sensor must be calibrated (see Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor Instruction Manual).
16. Back step in menu and choose "Diagnostics>Flows".
17. Attach the flow adapter assembly to the inlet of the instrument and the NIST-traceable flow transfer standard. Allow 60 seconds for the flow to stabilize.
18. Take three readings of "Flow" and the flow indicated by the NIST-traceable flow transfer standard; average these values.
19. If the % difference (as described by the equation on page 2-8 of the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor Instruction Manual) is not within ±5%, a

volumetric flow calibration must be performed (see the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor Instruction Manual).

20. Replace the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor's side panel.

Start-up Stepwise Instructions:

1. Insure that the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor's power switch is in the "Off" position.
2. Insure that the roof penetration has been made and the Roof Flange Assembly has been correctly installed by the contractor.
3. Insert the Heated Sample Tube Assembly through the Roof Flange Assembly support temporarily.
4. Align the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor's inlet tube directly under the Roof Flange Assembly.
5. Lower the Heated Sample Tube Assembly through the Roof Flange Assembly and attach to the 5/8" inlet tube on top of the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor; tighten the support nut.
6. Run the Heated Sample Tube Assembly heater wire through the Roof Flange Assembly and connect it to the point on the instrument labeled "Heater 1".
7. Set up the inlet support tripod and attach the PM_{10} Size Selective Inlet to the inlet support stand.
16. Attach the BGI $PM_{2.5}$ Very Sharp Cut Cyclone to the base of the PM_{10} Size Selective Inlet.
8. Attach the Heated Sample Tube Assembly to the base of the BGI $PM_{2.5}$ Very Sharp Cut Cyclone.
9. Insure that the various components are aligned, leveled, and leak free.
10. Attach the Ambient T/RH Assembly to the tripod extension using the supplied clamp.
11. Attach the Ambient T/RH Assembly radiation shield.
12. Connect one end of the Ambient T/RH sensor cable to the Ambient T/RH Assembly; run the other through the Roof Flange Assembly and connect to the instrument at the point on the instrument labeled "RH/Temp".
13. Tighten the waterproof nut on the Heated Sample Tube Assembly and put in place the watertight capping.
14. Turn the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor's power switch to the "On" position. After booting and self-test, the display will come up to the primary Run Screen. Concentrations of $PM_{2.5}$ particulate matter (in ug/m^3) will be displayed (as "PM"). Note that other instrument parameters, - sample flow, ambient temperature/RH, barometric pressure, sample conditions, and beta counts, can be displayed by scrolling through additional, secondary run screens.

$PM_{2.5}$ Monitor Calibration Procedure

Equipment required:

1. Scientific Model 5014*i* Continuous Ambient Particle Monitor.
2. NIST-traceable thermometer.
3. NIST-traceable hygrometer.
4. NIST-traceable barometer.
5. NIST-traceable volumetric flow transfer standard.
6. Calibration Mass Foil Kit
7. Continuous Air Monitoring Station Data Acquisition and Control System.

Note that although the Scientific Model 5014*i* Continuous Ambient Particle Monitor is calibrated at the factory prior to shipment, it still must be calibrated prior to use and at defined intervals (for details see *Quality Assurance Project Plan - Continuous Air Monitoring Station for the Wando Welch Terminal* for the South Carolina Ports Authority).

This procedure will calibrate the sensors that failed the earlier acceptance testing checks and any sensors that subsequently fail the later QA checks as described in the *Quality Assurance Project Plan - Continuous Air Monitoring Station for the Wando Welch Terminal* for the South Carolina Ports Authority.

Calibration Stepwise Instructions:

1. Insure that the Scientific Model 5014*i* Continuous Ambient Particle Monitor is on and has been operating normally for 24 hours prior to calibration.
2. Remove the instrument cover and the Heated Sample Tube Assembly from the top of the instrument and allow it to sample room-temperature air for at least one hour prior to calibration.
3. Back step from the Run Screen to the Main Menu; choose "Instrument Controls>Service Mode". Toggle to invoke service mode.
4. Back-step to the Service Menu and choose "Service>RH/Temp Calibration>Ambient Temp".
5. Place the NIST-traceable thermometer next to the ambient RH/temperature sensor (see Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor Instruction Manual for layout of the interior of the instrument).
6. After a 5 minute equilibration period, take three readings, one minute apart, of both the "Temperature" of the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor and the NIST-traceable thermometer.
7. Average the difference between the three sets of readings and enter as "Zero" in the Calibrate Ambient Temperature Menu.

8. Re-check the difference between the two readings; if it has shifted in the wrong direction, change the sign of the offset value.
9. Back-step in the Service Menu and choose “RH Temp Calibration>Ambient RH”.
10. Place the NIST-traceable hygrometer next to the ambient RH/temperature sensor.
11. After a 5 minute equilibration period, take three readings, one minute apart, of both the “Rel Humidity” of the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor and the NIST-traceable hygrometer.
12. Average the difference between the three sets of readings and enter as “Zero” in the Calibrate Ambient RH Menu.
13. Re-check the difference between the two readings; if it has shifted in the wrong direction, change the sign of the offset value.
14. Back-step in the Service Menu and choose “RH Temp Calibration>Flow Temp”.
15. Place the NIST-traceable thermometer next to the air inlet on top of the instrument.
16. After a 5 minute equilibration period, take three readings, one minute apart, of both the “Temperature” of the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor and the NIST-traceable thermometer.
17. Average the difference between the three sets of readings and enter as “Zero” in the Calibrate Flow Temp Menu.
18. Re-check the difference between the two readings; if it has shifted in the wrong direction, change the sign of the offset value.
19. Back-step in the Service Menu and choose “Pres/Vacuum Calibration>Baro Pres Calibration>Span”.
20. Take the reading of the NIST-traceable barometer and convert to mmHg; enter as “Set to:” in the Cal Baro Pressure Span menu; repeat at necessary to within 2 mmHg.
21. Back-step in the Service Menu and choose “Pres/Vacuum Calibration>Baro Pres Calibration>Span”.
22. Back-step in the Service Menu and choose “Flow Calibration>Auto”.
23. Attach the NIST-traceable flow transfer standard to the inlet tube of the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor; insure that the connection is leak-free.
24. After a five minute warm-up/stabilization period, take three flow readings of the NIST-traceable flow transfer standard one minute apart.
25. Enter the average of the three readings as “Set to:” in the Flow Auto Calibration menu. Repeat as necessary to within ±2%.
26. Back-step in the Service menu and choose “Mass Calibration>Mass Coefficient>Auto”.
27. Enter the Span Foil value from the Calibration Mass Foil Kit as “Foil Value” in the Auto menu (the beta attenuation chamber will open).
28. The Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor will now walk you through the remainder of the auto mass calibration process.
29. Back-step in the Service Menu and choose “Detector Calibration>Auto”.

30. Press enter to start; the procedure will take approximately 30 minutes to complete at which time the detector parameters will be assigned new values.

$PM_{2.5}$ Monitor Sampling Procedure

The normal operation of the Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor is straight-forward after it has been calibrated.

Equipment required:

1. Thermo Scientific Model 5014*i* Continuous Ambient Particle Monitor.
2. Continuous Air Monitoring Station data acquisition and control system.

Stepwise Sampling Instructions:

1. Insure the sample delivery system (.PM_{10} Size Selective Inlet, BGI $PM_{2.5}$ Very Sharp Cut Cyclone, Inlet support stand, Roof Flange Assembly, T/RH Assembly) are assembled, connected to the instrument and unobstructed.
2. Step the Main Menu to the Run Screen.
3. Compare front panel PM concentration reading with that on data acquisition and control system.

If the front panel NO, NO_X, and NO_2 readings and those on data acquisition and control system are identical, the system is operational and can be safely left unattended.

Standard Operating Procedures: Data Validation Procedure for Daily Reports (Continuous Air Monitoring Station for the Wando Welch Terminal)

Title: Data Validation Procedure for Daily Reports

Purpose: To ensure documentation of data validation/QC

Scope: This procedure is used to perform data validation on daily data acquisition reports received from the continuous air monitoring station at the Wando Welch Terminal in Charleston, SC.

Procedure:

1. Locate and open the excel file for the previous day's data acquisition. The file will be named RDYYMMDD.H05.
2. Run the Excel macro "SCSPA Macro.xls". The file will be automatically saved as an *.xlsx file to the same folder as the *.H05 file.
3. Go to the next available QC Log sheet and record the date that the data was acquired.
4. Part I: Calibration/QC
    a. Go to the AVERAGES tab of the workbook.
    b. Check that the instruments performed the necessary Calibration/QC checks by viewing the status in Column J. At approximately 1:00 AM, status should indicate "Zero Chk". At approximately 2:00 AM, status should indicate "SO2 Chk" and at approximately 4:00 AM status should indicate "NOx Chk".
    c. If a QC check failed, the instrument will trigger a calibration, which will also be indicated in Column J. Please note this in the QC Log if a calibration was triggered for SO2 or NOx.
5. Part II: Raw Data QC
    a. Stay on the AVERAGES tab and scan the data in Columns C through G to ensure that there are no negative values.
    b. Go to the RDYYMMDD tab and ensure that metrology data was acquired.
6. Part III: Verify Limits

   a. Back to the AVERAGES tab. Scroll down to the bottom of the spreadsheet.
   b. Verify that the averages for PM2.5-24hr, NO2-1hr and SO2-1hr shown in the box are below the limits to the right. Record these three numbers on the form.
   c. If any data is outside the acceptance criteria, please Proffitt or Sharpe and note on QC Log form

7. Part IV: Invalid Data
   a. If the data validator receives a call at any time from the field technician regarding system maintenance and/or manual audit checks (e.g. SO2 check gas), the time frames of these events need to be noted on the correct day the activities take place so the appropriate data can be flagged.
8. If the validator has any additional comments or observations, please note them in the designated area on the QC Log form.
9. On each and every Friday, the data validator will remotely access the SCADA computer and check the remaining pressures showing on the calibration gas cylinder gages via the webcam. If any of the primary stage pressures have fallen below 300 psi, the validator shall notify the project manager to arrange for replacement cylinders. Note that the cylinders must be changed out every 6 months regardless of the pressure because of method specified shelf life.
10. Once the validation has been completed, the data validator needs to sign and date the appropriate lines on the QC Log.

Rules used for data validation:

1 - Data from the SO_2 and NO_x instruments collected during QC checks or calibrations are removed to prevent any effects on completeness or reporting calculations. PM data remains as it is not impacted by daily QC checks. However all of this data is archived and available for review if desired.

2 - In any events where instrument maintenance takes an instrument off line or it is not sampling outdoor air, this data is removed from the reported data.

3 - Data that is less than zero is a known artifact of the type of PM sampling device deployed at this site. Any such data points are resolved to zero and highlighted in the daily workbooks.

4 - Data is collected every 15 seconds. A minimum of 30 minutes of data is required to quantify a one hour period of ambient conditions. This allows for momentary and short outage periods for calibration or zero checks. If less than 30 minutes is available for any given hour that period is labeled as “Insufficient Data” in the daily report.

5 – 24-hour or daily averages are calculated by averaging the 24 hourly averages from each day. The hourly averages are done based on all points between hour designated times. That is they are not hourly rolling averages. Hourly averages with "Insufficient Data" do not participate in the calculation.

6 – All calibration checks are completed at times that are expected to be low or below NAAQS criteria. If SCSPA desires a shift in these times they must notify ARCADIS of the intended shift.

Documentation and Records:

- QC Log Sheet (blank form attached)

EXAMPLE QC LOG SHEET

Date Acquired: __________________

I	**Calibration/QC**		**Yes**	**No**	**Calibration Triggered?**	
	SO2/NOx Zero	1:00 AM				
	SO2 QC (36 ppb)	2:00 AM				
	NOx QC (36 ppb)	4:00 AM				
II	**Raw Data QC**				**Yes**	**No**
		Negative values blanked out?	PM (Column C)			
			NO (Column D)			
			NO2 (Column E)			
			NOx (Column F)			
			SO2 (Column G)			
		Meteorological data acquired?	T, RH, Wind Speed			
III	**Verify Limits**				**Yes**	**No**
		PM2.5, 24-hr	<35 ug/m3?			
		NO2, 1-hr	< 100 ppb			
		SO2, 1-hr	<75 ppb			
IV	**Invalid Data**	Time Frame	From		To	
		System Maintenance				
		Manual Audit Checks				

QC'd by:_________________________

Date:____________________________

Additional Comments:

Friday? Check cylinder pressures_______________

Appendix B: Instruction Manuals for Continuous Air Monitoring Station Components

Manuals for the following equipment will be made available at a later date:

- Thermo Scientific Model 5014i-ABVAA (U.S. EPA FRM $PM_{2.5}$ Particulate Sampler)
- Thermo Scientific Model 42i-ANMSPAA (NO-NO_2-NO_X Analyzer)
- Thermo Scientific Model 43i-ANSAA (SO_2 Analyzer)
- Thermo Scientific Model 146i-AT3BEAA (Dynamic Gas Calibrator)
- Thermo Scientific Model 1160-AHP2N (Zero Air Supply)
- Vaisala Model WXT520 (Meteorological System)