PART FIVE

Continuous $PM_{2.5}$ Chemical Speciation Monitoring

Chapter 7
Part Five - Continuous $PM_{2.5}$ Chemical Speciation Monitoring
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Part Five – Continuous $PM_{2.5}$ Chemical Speciation Monitoring

1.0 Introduction

Along with Toxics, Carbonyls, Ozone precursors and Meteorological data; $PM_{2.5}$ chemical speciation is considered a *Non-Criteria* parameter. However as part of the National Ambient Air Monitoring Stations (NAMS) network, chemical speciation sites help:

- Provide more specific data to define the correlation between particle concentration/composition and public health concerns
- Recognize national trends
- Identify source/receptor relationships and determine the effectiveness of emission control strategies
- Access air quality models and emission inventories
- Support future revisions to the NAAQS

Currently the state operates continuous speciation monitors at 4 sites. The following part of Chapter 7 is intended to outline the monitoring, quality assurance (QA), and quality control (QC) practices associated with continuous chemical speciation sampling. Further information can be found in CFR 40 Part 58

1.1 Sampling Method Overview

1.1.1 Thermo Scientific 5020 Sulfate Particulate Analyzer

The Thermo Scientific 5020 Sulfate Particulate Analyzer (5020) combines a continuous sulfate (SO_4) to sulfur dioxide (SO_2) converter and a trace level sulfur dioxide analyzer. The instrument utilizes a high-temperature converter module and analyzer module where it is continuously measured using a pulsed florescence technique.

The 5020 uses an ultra violet (UV) light to excite the SO_2 molecules, which absorbs the light at one wave length, and emits it at another. A detector measures this emitted UV light, which is directly proportional to the SO_2 concentration. This is in turn converted and displayed as a sulfate value.

1.1.2 Magee Scientific Aethalometer Black Carbon Analyzer

The Magee Scientific Aethalometer provides the capability of continuous monitoring of a variety of carbon species. The models used in Indiana's air monitoring network allow measurement in two wavelengths of light; 880 nm (infrared) and 370 nm (ultraviolet). This distinction can aid in determining the source of carbon; diesel exhaust, wood smoke, etc. The Aethalometer uses filtration and optical measurement to provide continuous concentration data.

2.0 Instrumentation

2.1. Interferences

Both instruments are designed to limit outside interferences. The 5020 uses a combination of denuder and filter to reduce the likely-hood of background interferents that might affect the concentration values. It is possible that extremely high background levels of SO_2 could impact the instrument. This is especially true if the denuder is compromised.

The Aethalometer can be affected by high levels of mineral dust. While mineral dust has not been found to contain high levels of black carbon, it has an absorption cross-section, that if found in concentrations 100 to 1000 times greater than black carbon can produce a comparable optical absorption.

2.2. Instrument Description

2.2.1 Thermo Scientific 5020 Sulfate Particulate Analyzer

The 5020 consists of in inlet system, SO_4 converter, and SO_2 analyzer. It can be rack or desk mounted, and the converter/analyzer does not need to be directly below the inlet.

The inlet is typically a $PM_{2.5}$ cyclone and stainless/Teflon line. It then divides into a main and secondary sample line. The main line continues through a denuder where SO_2 and other acid gases are removed from the sample stream. The secondary line passes through a HEPA filter where sulfate particulate is removed. The 5020 switches between the primary and secondary sample stream, allowing continual adjustment for changes in background signal caused be trace SO_2 or other interferences breaking through the denuder. The sample stream is then passed through a quartz converter core and heated to 1000 °C to convert SO_4 to SO_2. After leaving the converter, the stream travels to the analyzer's fluorescence chamber where it is exposed to ultraviolet light. A mirror assembly, designed to reflect only wavelengths created by the excited SO_2 molecules directs the light onto the detector. The SO_2 concentration is converted to a sulfate equivalent.

2.2.2 Magee Scientific Aethalometer

The Aethalometer is made up of an inlet and the monitor itself. The inlet requirements are not especially stringent; typically only a bug shield and/or filter is required. The ambient black carbon's size (approximately 0.3 µm diameter) is small enough to not be adversely affected by an impactor (such as a $PM_{2.5}$ very sharp cut cyclone) and large enough to mitigate loss due to diffusion to the tubing walls between the inlet and monitor. The run from inlet to monitor should be less than thirty feet. Upon entering the monitor, the sample gas is pulled through a quartz fiber filter tape, where the aerosol black carbon is deposited. The Aethalometer continually analyses the sample gas as the sample is collecting. Once the filter tape has reached a set density, it advances. In an urban setting, this could take place 3-4 times a day. The tape may only advance once a day in more rural locations. The Aethalometer passes a beam of light through the sample depositing on the filter tape. The detector measures the amount of light transmitted through the sample. This quantity is linearly proportional to the black carbon in the filter deposit. This is shown on the instrument as a concentration.

2.3. Ancillary Equipment

Listed below are several (but not inclusive) supplies required for operation of IDEM's monitoring network:

- Certified flow rate transfer standards (Bios, Chinook Streamline FTS kit, TriCal, or similar)
- Certified Barometer
- Certified thermometer
- Logbooks and database/laboratory and maintenance
- Manufacturer recommended spare parts

3.0 Site Selection

3.1. Siting Requirements

Basic siting criteria for the placement of ambient air samplers are documented in Table 1 in this section. This is not a complete listing of siting requirements; instead, an outline to be used by the operating agency to determine a sampler location. Complete siting criteria are presented in 40 CFR 58, Appendix E. All sampling locations must meet the guidelines set forth in 40 CFR Part 50 Appendix L, and Part 58 Appendix D as well as the siting guidelines outlined in Chapter 1, Section 4.0 of this manual.

As with any type of air monitoring study in which sample data are used to draw conclusions about a general population, the validity of the conclusions depends on the representativeness of the sample data. Therefore, the primary goal of a monitoring project is to select a site or sites where the collected particulate mass is representative of the monitored area.

Table 1
Example of Minimum Sampler Siting Criteria

Scale	Height Above Ground	Distance from supporting structure, meters		Other spacing criteria
		Vertical	Horizontal [a]	
Micro	2 to 7 meters	>2	>2	1. Should be >20 meters from trees.
Middle, Neighborhood, Urban, & Regional	2 to 15 meters	>2	>2	2. Distance from sampler to obstacle, such as buildings, must be twice the height that the obstacle protrudes above the sampler.
				3. Must have unrestricted airflow 270 degrees around the sampler inlet.
				4. No furnace or incineration flues should be nearby.[b]
				5. Spacing from roads varies with traffic (see (40 CFR 58, Appendix E).
				6. Sampler inlet is at least 2 m, but not greater than 4 m from any collocated sampler having flow rates greater than 200 L/min, or 1 meter from samplers having flow rates less than 200 L/min (See 40 CFR 58, Appendix E).

[a] When inlet is located on rooftop, this separation distance is in reference to walls, parapets, or penthouses located on the roof.

[b] Distance depends on the height of furnace or incineration flues, type of fuel or waste burned, and quality of fuel (sulfur, ash, or lead content). This is to avoid undue influences from minor pollutant sources. As a precautionary measure, the sampler should be placed at least 5 meters from the furnace or incinerator flue.

3.2. Site Safety and Security

Additional factors not specified in the Code of Federal Regulations (CFR) must be considered in determining where the monitor is deployed. These factors include accessibility under all weather conditions, availability of adequate electricity, and security of the monitoring personnel and equipment. The monitor must be situated where the operator can reach it safely despite adverse weather conditions. If the monitor (or part of the monitor i.e., sample inlet) is located on a rooftop, care should be taken that the operator's personal safety is not jeopardized by a slippery roof surface during inclement weather. Consideration also should be given to the fact that routine operation (i.e., calibration, maintenance, flow check, and audit) involves transporting supplies and equipment to and from the monitoring site.

To ensure that adequate power is available, consult the manufacturer's instruction manual for the sampler's minimum voltage and power requirements. Lack of stable power source can result in the loss of data because of power interruptions.

The security of the sampler itself depends mostly on its location. Rooftop sites with locked access and ground-level sites with fences are common. In all cases, the security of the operating personnel as well as the sampler should be considered.

4.0 Monitor Installation, Calibration, and Operation

4.1. Monitor Installation

All site selections and installations shall comply with siting criteria presented in 40 CFR 58, Appendix E. Installation should also adhere to section 3.2 Site Safety and Security in this document. The following is a general guideline for instrument installation. More detailed instructions should be referenced in their corresponding manuals.

Once a site has been selected and the instrument tested and found to be in working order:

1. Determine the exact location of the monitor and all included equipment, such as pumps. Care should be taken to allow room for both sample and electrical connections.
   - Neither instrument needs to be placed directly below a down tube.
2. Drill or use an existing opening in the structure's roof or wall to allow for the instruments' inlet tube. In addition, mount the tripod or other down tube support structure, if needed, and the temperature/pressure sensor (5020).
3. Inside the shelter, mount the instrument on a rack using the appropriate hardware, or place on a sturdy flat surface, such as a table or counter top.
   - If not rack mounting, be sure to properly secure the instrument to account for vibrations
4. Make all electrical, communication, and air connections. Be sure all packing material, shipping screws, and other similar materials have been removed prior to turning on.
5. Once installed, power on, allow instrument to warm up, and ensure that all functions are working properly.

4.2. Calibration of Components

4.2.1 Overview of Calibration Procedures

The following is a general guide to calibrating the continuous monitors used by IDEM. For more detailed instructions, refer to the specific monitor's user manual and the IDEM OAQ instrument specific SOP(s).

Useful Formulas for Calibration/Audit Procedures:

Reference Flow

$$Q_{Ref} = m * \left[\sqrt{\frac{\Delta P \ * \ T_{amb}}{P_{amb}}}\right] + b$$

Where:

Q_{Ref}	=	Reference flow (liters per minute)
m	=	FTS Slope
b	=	FTS Intercept
ΔP	=	Manometer reading ("H_2O)
T_{amb}	=	Reference ambient temperature (K)
P_{amb}	=	Reference ambient pressure (atm)

Temperature Conversion, Celsius to Kelvin

$$T_K = T_c + \ 273$$

Where:

T_K	=	Temperature in Kelvin
T_C	=	Temperature in Celsius

Barometric Pressure Conversion, mmHg to atm

$$P_{atm} = \frac{P_{mmHg}}{760}$$

Where:

P_{atm}	=	Pressure in atm
P_{mmHg}	=	Pressure in mmHg

Flow Conversion, True to Standard

$$Q_{std} = Q_{true}\left[\left(\frac{298}{T_{amb}}\right) * \left(\frac{P_{amb}}{760}\right)\right]$$

Q_{std}	=	Standard flow (liters per minute)
Q_{true}	=	True Flow (liters per minute)
T_{amb}	=	Reference ambient temperature (K)
P_{amb}	=	Reference ambient pressure (mmHg)

To calculate Reference/Observed Flow Difference

$$Diff = \left(\frac{Q_{Obs} - Q_{Ref}}{Q_{Ref}}\right) \times 100$$

Where:

Q_{Ref} = Reference flow (liters per minute)
Q_{Obs} = Observed flow (liters per minute)
Diff = Difference in percent

SO_2 Concentration Calculation

$$[SO_2]_{out} = \frac{F_{SO_2} * [SO_2]_{std}}{F_{SO_2} + F_d}$$

Where:

$[SO_2]_{out}$ = output concentration of SO_2 measured in ppm
$[SO_2]_{std}$ = certified concentration of the SO_2 gas cylinder measured in ppm
Fso_2 = cylinder flow of the SO_2 gas measured in cc/min at SRC
F_d = flow of the dilution gas (zero air) measured in cc/min at SRC

4.2.2 Thermo 5020 Calibration Procedure

Equipment required for calibration:

- Zero Air Supply
- Span SO_2 Tank (5-10 parts per billion, ppb, for direct cylinder calibrations)
- Gas Calibrator (Not used for direct cylinder calibrations)
- Atmospheric By-Pass (to vent cal gas in direct or otherwise unvented cal systems)
- Calibration Form

1. Disable the corresponding channel in the LEADS system.
2. Remove the line connecting the converter box to the analyzer. Attach the calibration system to the analyzer.
3. Generate a zero using a source with the ability to remove background SO_2 sources. Ensure gas delivery is around 5Lpm. If the calibration system is not vented, place an atmospheric bypass in-line between the system and analyzer.
4. From the 5020's Main Menu, select "Calibration Factors". Press the down button until "Instrument Zero" is highlighted, then press ENTER.

5. Allow the instrument to equilibrate for at least 30 minutes. The display should appear as below:

```
INSTUMENT ZERO
SO2 ppb:    XXX.XX
   ZERO:    XXX.XX
↑↓   CHANGE ZERO
```

6. The 5020 should have a zero value under 4 ppb.
7. Once stable, press the up or down arrow keys to adjust the instrument zero reading to 0.00. Press ENTER to confirm the new zero.
8. Enter the zero value on the calibration form.
9. Begin with a cylinder of known concentration, or use a calibration system to generate a span point of approximately 40ppb. The gas should be delivered at a flow rate of at least 2 lpm, and should be vented.
10. Press MENU to return to the Calibration Factors menu. Use the up and down arrows to select "Span Coefficient". The screen should be appear as below:

```
SO2 SPAN COEFFICIENT
SO2 ppb:    XXX.XX
   COEF:    XXX.XX
↑↓   CHANGE COEF
```

11. Wait for at least 30 minutes for the instrument to equilibrate.
12. Use the up and down arrow keys to adjust the span coefficient until the reading matches the calibration gas concentration. Press ENTER to confirm the entry.
13. Enter the new span coefficient on the calibration form.
14. Disconnect the calibration system from the analyzer and reattach the converter box
15. Allow the instrument to sample ambient air for at least 15 minutes.
16. Once the value is stable, enable the corresponding LEADS channel and leave an electronic operator log entry.

4.2.3 Aethalometer Calibration Procedure

Equipment required for calibration:

- Certified Thermometer/Temperature Probe
- Certified Barometer
- Certified Flow Transfer Standards (BIOS or similar)
- Calibration/Audit Line
- Optical Test Strip
- Calibration Form

The only *calibration* required during the normal operation of the Aethalometer is a flowmeter calibration. Flowmeter calibration is only needed if the true flow is suspected of being more than ±10% different from the displayed flow.

Flowmeter Calibration:

1. Disable the corresponding channel in the LEADS system.
2. Remove the sample line from the rear of the Aethalometer and replace with a calibration/audit line attached to a certified BIOS flow transfer standard.
3. Record the ambient conditions; shelter temperature and pressure on the calibration form.
4. On the Aethalometer, navigate the menu to "Calibrate Flowmeter" and press ENTER. Select "YES."
5. Remove the vacuum line from, or unplug the electrical connection of the internal pump.
6. Allow instrument to equilibrate for a stable "zero voltage". After a short time, the zero voltage is automatically measured.
7. Plug in the pump to resume air flow.
8. Allow instrument to equilibrate once again. After flow is stable, use the "Burst" measurement on the BIOS to determine a reference flow. Record this flow on the Aethalometer Calibration Form.

   Note: If Aethalometer is not set up to correct to standard conditions, covert the observed flow using the formula above.
9. If the reference flow is within ±10%, no calibration is required, and the instrument can be returned to service.
10. If displayed flow value is outside ±10% use the arrow keys to change the "flow scale factor to read the same as the reference flow. Press ENTER to change and retain the new flow scale factor.
11. Exit back to the main menu.
12. Use the BIOS to test the flow from the back of the unit. Note the results in the "As Left" section of the calibration form.
13. Replace the sample line. Allow the Aethalometer to equilibrate, then repeat the BIOS flow check from the inlet and note results in the "As left… through the probe" section of the calibration form.
14. Enable the corresponding LEADS channel and leave an electronic operator log entry.

Optical Test Procedure:

Note: This is a QC/QA check of the photodetectors using a test strip of known optical density. The test strip is paired with an individual Aethalometer, as the check is only relevant when using the same test strip repeatedly. While the strip test is an optional part of the calibration, it can provide some useful data.

1. Disable the corresponding channel in the LEADS system.
2. Navigate the menu to “Optical Test”. Ensure that the instrument has a disk or compact flash card inserted.
3. Open the door and remove the two thumb screws that secure the sampling chamber cover.
4. Using scissors cut the filter tape on the left side of the sampling chamber.
5. Press ENTER and the remaining tape will be pulled to the right side spool.
6. Insert the test strip from the left side. The serial number should be upwards on the right side of the strip.
7. Push it in until the tip of the arrow on the strip is just visible and in alignment with the edge of the base block
8. Press ENTER again.
9. The Aethalometer will proceed with the test automatically. Once complete the transmission values will be displayed. Record these values on the calibration form.
10. Press ENTER. The instrument will continue with the automated test procedure.
11. The results will be saved to disk automatically as a text file. The results from the display should be placed with the calibration form. If the result is outside ±10% the instrument should be returned to Magee for service.
12. Remove the test strip and re-spool the filter tape from the left side, attaching it to the take up spool on the right.
13. Replace the sampling chamber cover and tighten screws.
14. Exit to the main menu. Allow instrument to equilibrate, and return to service.
15. Enable the corresponding LEADS channel and leave an electronic operator log entry.

4.3. Monitor Operation

Each monitor should be operated in accordance with the user’s manual. In general, each should:

1. Be properly sited (refer to section 3 in this part)
2. Be connected to a reliable power source
3. Have a valid calibration prior to collecting usable data

5.0 Data Acquisition

Data is collected and stored using a disk or usb thumbdrive and collected monthly.

Disable data logger during maintenance, calibrations, and audits. This prevents erroneous results from being considered valid by LEADS.

6.0 Data Validation

Data validation criteria were developed from the instruments' operation manual recommendations and from staff's operational experience. In general, if the instrument is operating with a valid calibration, has passed QA/QC audits, and is operating without alarms, warnings, or status lights, it is considered capable of producing valid data.

7.0 Performance Audit Procedures

The primary goal of an auditing program is to identify problems that may result in suspect or invalid data. Performance audits should be conducted under the following guidelines:

- Audits must be done without special preparation or adjustments made to the system.
- The individual performing the audit should be someone other than the routine operator and must have a thorough knowledge of all instruments or processes being evaluated.
- All aspects of the audit must be completely documented including the types of instruments and transfer standards, model and serial numbers, calibration information, etc.

Quality Assurance audits are conducted at least once per quarter.

Audits should start at the beginning of an hour or at least completed during the hour to minimize data loss.

7.1 Audit Procedures

7.1.1 Audit Equipment

- Certified Flow Transfer Standard (BIOS or TetraCal).
- Certified Digital or aneroid barometer
- Certified Temperature Probe or Thermometer
- Certified SO_2 Cylinder (Thermo 5020)
- Gas Calibrator or Direct Cylinder Calibration System (Thermo 5020)
- Zero Air Source (Thermo 5020)
- Audit Forms

Audit Equations

Table 2
Conversions

mmHg to atmospheres (atm)	mmHg/760
atm to mmHg	atm* 760
°C to Kelvin (K)	°C + 273

Standard Temperature/Pressure (SRC) Flow correction

$$Q_{true} = Q_{ob}\left[\left(\frac{293}{T_{amb} + 273}\right)\left(\frac{P_{amb}}{760}\right)\right]$$

Where:

Q_{true} = True Flow rate, m^3/min
Q_{ob} = Observed Flow Rate, m^3/min
P_{amb} = Ambient barometric pressure, mmHg
T_{amb} = Ambient Temperature ˚C

$$\%\ Difference = \left[\frac{(Q_{ob} - Q_{true})}{Q_{true}}\right] * 100$$

Where:

Q_{true} = True Flow rate, m^3/min
Q_{ob} = Observed (Sampler) Flow rate, m^3/min

If the sampler requires the conversion of actual/standard flow, use the following equation:

$$Q_{std} = Q_a(P_a/P_{std})(T_{std}/T_a)$$

$$Q_a = Q_{std}(P_{std}/P_a)(T_a/T_{std})$$

Where:

Q_{std} = standard volume flow rate, m^3/min
Q_a = actual volume flow rate, m^3/min
P_a = ambient barometric pressure, mmHg
P_{std} = standard barometric pressure, 760 mmHg
T_{std} = standard temperature, 298 K (25 °C + 273)
T_a = ambient temperature, K (°C + 273)

Difference, in Percent calculation

$$Diff = \left(\frac{V_{Obs} - V_{Ref}}{V_{Ref}}\right) \times 100$$

Where:

V_{Ref} = Reference Value
V_{Obs} = Observed Value
Diff = Difference in percent

SO_2 Concentration Calculation

$$[SO_2]_{out} = \frac{F_{SO_2} * [SO_2]_{std}}{F_{SO_2} + F_d}$$

Where:

$[SO_2]_{out}$ = output concentration of SO_2 measured in ppm
$[SO_2]_{std}$ = certified concentration of the SO_2 gas cylinder measured in ppm
F_{SO_2} = cylinder flow of the SO_2 gas measured in cc/min at SRC
F_d = flow of the dilution gas (zero air) measured in cc/min at SRC

7.2 Overview of Audit Procedures

The following is only a general guide, for more detailed, sampler specific instructions, refer to the user's manual and instrument specific SOPs.

7.2.1 Thermo Scientific 5020 Audit Procedures

1. Disable the corresponding LEADS channel
2. Place a certified temperature probe or thermometer near the 5020's ambient temperature shield. Allow sufficient time for equilibration. Note both the reference and observed values on the Audit Form.
3. Using a certified barometer, record the reference and observed ambient pressure.
4. Perform a through the probe flow check from the inlet. Remove the inlet and place a certified BIOS/TetraCal in-line.
5. Take the Standard Flow measurement. Use the "Burst" mode with a BIOS to take an average of 10 flow measurements.
6. Replace inlet. Remove sample line between converter and analyzer and replace with a vented zero air source.
7. Select "Calibration Factors" from the Main Menu. Use the arrows to scroll to "Instrument Zero"

8. Allow the instrument to sample zero air for at least 30 minutes and longer as needed. Once the value is stable, record the zero response on the Audit Form. The zero response should be roughly 3 ppb.
9. Remove the zero air and replace with either a vented direct cylinder or mass flow calibration system.
10. Generate a concentration of roughly 40 ppb. Allow the instrument to sample for at least 30 minutes. Once the value is stable, record the value on the Audit Form.
11. A new calibration should be performed by the operator if the value is ≥ ±5%. Data collection is considered invalid if outside ±15%.
12. Remove the calibration system and replace the sample line between the converter and analyzer.
13. Enable the corresponding LEADS channel and leave an electronic operator log entry.

7.2.2 Magee Scientific Aethalometer Audit Procedures

1. Disable the corresponding LEADS channel.
2. Perform a through the probe flow check from the inlet. Remove the inlet and place a certified BIOS or TetraCal in-line.
3. Allow the instrument flow to equilibrate.
4. Record the ambient temperature and pressure using a certified temperature probe or thermometer and barometer.
5. Take the standard reference flow. Use the "Burst" mode on the BIOS to take an average of 10 flow measurements. Record the reference flow in SRC on the Audit Form. Use the calculation above to convert actual flow to standard.
6. Record the Aethalometer's observed flow. The reference should be within ±10% of the observed flow.
7. Remove the Bios or TetraCal and replace the inlet.
8. Enable the corresponding LEADS channel and leave an electronic operator log entry.

7.3 Audit Data Reporting

Inform the site or network operator of the audit results as soon as possible after audit completion. A paper copy of the audit may be forwarded to the operator or personnel may view the audit in the database. If data is invalid, the auditor should promptly inform the operator verbally and in written form (memo or email).

7.4 Audit Frequency

The Indiana Department of Environmental Management conducts verifications of all real-time speciation monitors in its network at least once each month to ensure minimal data loss.

7.5 Systems Audit

A system audit is review of the total monitoring process from site location, safety, and sampling to final analysis and data reporting and includes an on-site inspection. System audits are generally done at the initial set up of a network and on an annual or on an as needed basis thereafter. The specific guidelines and procedures for this type of audit are found in Chapter 15 of this manual, System Audit Criteria and Procedures for Evaluating Ambient Air Monitoring Networks.

8.0 Precision and Accuracy Assessment

8.1 Precision

Precision is the measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is estimated by the use of a duplicate or collocated sampler at a selected monitoring location in a measurement network. One sampler is designated as the reporting sampler and one sampler is designated as the collocated sampler. The collocated sampler must be maintained, operated, calibrated, and audited in the same manner as the reporting sampler. Precision is calculated from the difference in the concentrations from the reporting and collocated samplers over a calendar quarter. Currently, no collocated real-time speciation monitors are in use within Indiana's ambient monitoring network. They are all, however, operated at sites which also consist of intermittent speciation monitors. The Met One Speciation Air Sampling System (SASS) and University Research Glassware (URG) 3000N, discussed in the previous section of this chapter, allow a 24 hour site concentration comparison.

8.2 Accuracy

The accuracy of the network is measured by auditing the performance of the samplers in the network. This is done by performing flow audits on both instruments and running a zero/span on the 5020. The percentage difference between the audit reference values and the sampler observed value is used to determine accuracy.

The USEPA requires that 25 percent of the samplers within a reporting organization's network be audited for accuracy each quarter. To improve accuracy estimates, additional accuracy flow rate audits may be conducted each calendar quarter. IDEM-OAQ-QAS audits all continuous speciation samplers in its monitoring network at least once each quarter. This audit frequency provides additional accuracy flow rate data and also ensures minimal data loss due to "out-of-calibration" conditions.

9.0 Maintenance

Routine preventive maintenance helps prevent failures of the monitoring processes. The overall objective is to increase measurement reliability and prevent data loss. Follow the manufacturer's recommended guidelines for routine maintenance procedures.

Maintenance records must be kept for each sampler or instrument. These records should contain a history of the sampler, including all replacement parts, suppliers, costs, installation dates, etc.

9.1 Recommended Maintenance and Frequency

Table 3
Thermo Scientific 5020 Recommended Maintenance

Maintenance	Frequency
Clean PM_{10} or $PM_{2.5}$ inlet	Monthly
In-line filter change	Monthly
Flow Check	Monthly
Denuder check/recoating	Quarterly
Capillary Inspection	Annually
Change converter core assembly	6 months or as needed
Rebuild pump	Annually or as needed

Table 4
Magee Scientific Aethalometer Recommended Maintenance

Maintenance	Frequency
Optical Sampling and Analysis Cylinder cleaning	1-2 Years as needed
Bypass Filter Cartridge Replacement	1-2 Years as needed

9.2 As Needed Maintenance

- Exchange fuses
- Clock adjustment
- Resetting system
- System software download

10.0 Forms

Form 1
Thermo Scientific 5020 Calibration Form

Sulfate Quarterly Calibration

Operator		Site	
Date		AQS	
Start			
End			

Analyzer Information		Calibrator Information	
Brand		Brand	
Model		Model	
SN		SN	
		Cert. Date	
		Gas Slope	
		Gas Int.	
		Air Slope	
		Air Int.	

Cylinder Information	
Brand	
SN	
Conc.	
Cert. Date	
Pressure	
Initial Offset Value	
Initial Span Value	
Zero Response	

Audit Point

Calibrator Setting	Gas Flow	Total Flow	Response	Measured	Standard	% Diff.

Check One

Analyzer within +/-5%, within calibration	
Analyzer greater than +/-5%, but within +/-15%, out of calibration, data valid, run Span	
Analyzer greater than +/-15%, out of calibration, data invalid, run Span	

Span Point

Calibrator Setting	Gas Flow	Total Flow	Response	Measured	Standard	% Diff.

Final Offset Value			
Final Span Value			
Change Denuder		OT check +/- 4 C	
Leak Check		BP check +/- 10 MMHG	
Sample Flow		Conv. Filter Flow	
Vent Flow			

See back of sheet for additional maintenance

Comments

Thermo Scientific 5020 Calibration Form (Continued)

Additional Maintenance	
Clean Fan on rear panel every six months	
Change converter core every six months	
Inspect analyzer and converter capillaries every six months	
Replace External HEPA filter every six months	
Change two oven thermocouples annually	
Change pump diaphragm in both the analyzer and converter module annually	
Replace Internal HEPA filter annually	
Replace 1/8" Teflon tubing annually	
Perform dynamic zero test annually	

Form 2
Thermo Scientific 5020 Audit Form

Sulfate Quarterly Audit

Auditor		Site	
Date		AQS	
Start			
End			

Analyzer Information

Brand	
Model	
SN	
Cal Date	

Calibrator Information

Brand	
Model	
SN	
Cert. Date	
Gas Slope	
Gas Int.	
Air Slope	
Air Int.	

Cylinder Information

Brand	
SN	
Conc.	

	Ser. #	Cert Date
Temp Probe		
Barometer		

	Analyzer	QA	Difference
Temperature			
Pressure			

Offset Value	
Span Value	
Zero Response	

Audit Point

Calibrator Setting Gas	Calibrator Setting Flow	Gas Flow	Air Flow	Response	Measured	Standard	% Diff.

Check One:

Analyzer within +/-5%, in calibration	
Analyzer greater than +/-5%, but within +/-15%, out of calibration, data valid, run span	
Analyzer greater than +/-15%, out of calibration, data invalid, run span	

Comments

Form 3
Aethalometer Annual Calibration Form

Aethalometer Annual Calibration
Office of Air Quality - Air Monitoring Branch

Date: _____ Site: _____ AQS#: _____

Start time: _____ End time: _____ Performed by: _____

Aethalometer Brand & Model: **Magee Scientific /** _____ Serial Number: _____

Calibration Device Information

Flow Device SN: _____ Certification Date: _____

Thermometer SN: _____ Certification Date: _____

Barometer SN: _____ Certification Date: _____

As found calibration check through the probe

Ambient Temperature: _____ °C Barometric Pressure _____ mmHg

Aethalometer Display: _____ lpm Observed Flow

Flow Device Display: _____ lpm Flow not corrected to STP

True Flow: _____ lpm Flow corrected to STP

% Difference: _____

≤10% = in cal, data valid; >10% but ≤15% = out of cal, data valid; >15% out of cal, data invalid

As found calibration check back of unit

Ambient Temperature: _____ °C Barometric Pressure _____ mmHg

Aethalometer Display: _____ lpm Observed Flow

Flow Device Display: _____ lpm Flow not corrected to STP

True Flow: _____ lpm Flow corrected to STP

% Difference: _____

≤10% = in cal, data valid; >10% but ≤15% = out of cal, data valid; >15% out of cal, data invalid

Formulas & Conversions

$$\text{True Flow} = \text{Flow Device} * \left[\frac{293}{(\text{Amb Temp} + 273)}\right]\left[\frac{\text{Baro Press}}{760}\right]$$

$$\%\ \text{Difference} = \left[\frac{\text{Observed Flow} - \text{True Flow}}{\text{True Flow}}\right] * 100$$

Conversions: °C = (°F - 32) * 0.5556 mmHg = "Hg * 25.4
°K = °C +273

Standard Conditions: 20 °C (293 °K) 760 mmHg (29.92 "Hg)

Maintenance prior to "As Left Calibration"

Cleaned Optics area _____

Cleaned bug filter _____

Replaced Bypass Cartridge Filte_____ (every 2 years)

As left calibration check back of unit

Ambient Temperature: _____ °C Barometric Pressure _____ mmHg

Aethalometer Display: _____ lpm Observed Flow
Flow Device Display: _____ lpm Flow not corrected to STP
True Flow: _____ lpm Flow corrected to STP
% Difference: _____ Pass if % Difference < 10%

As left calibration check through the probe

Ambient Temperature: _____ °C Barometric Pressure _____ mmHg

Aethalometer Display: _____ lpm Observed Flow
Flow Device Display: _____ lpm Flow not corrected to STP
True Flow: _____ lpm Flow corrected to STP
% Difference: _____ Pass if % Difference < 10%

Aethalometer time: _____ Standard Time _____
Is the Aethalometer time within +/- 5 minutes? ____
If not, make note of the difference and if the time was corrected. _____

Is the date correct? _____
If not, make note of the difference and if the date was corrected. _____

Peform self-test? _____ Did everything pass the self-te_____

Has the strip test been perform_____

S0 = S1 = R0 = R1 =
S0 = S2 = R0 = R2 =
S Density = R Density = Balance =

Comments: _____

Aethalometer Annual Calibration / Quarterly Audit

Office of Air Quality - Air Monitoring Branch

Date: _____ Site: **Indianapolis - I-70E** AQS#: 18-097-0087

Start time: _____ End time: _____ Performed by: _____

Aethalometer Brand & Model: **Teledyne API / 633** Serial Number: **AE33-S01-00122**

Calibration Device Information

Flow Device SN: _____ Certification Date: _____

Thermometer SN: _____ Certification Date: _____

Barometer SN: _____ Certification Date: _____

As found calibration Through the Probe

Aethalometer Display: _____ lpm Observed Flow EPA Std

Flow Device Display: _____ lpm Qstd - Actual Flow

% Difference: _____ (see formula below)

≤10% = in cal, data valid; >10% but ≤15% = out of cal, data valid; >15% out of cal, data

MFC Flow verfication "As Found"

	F_N (flow device)	F1	%	Fc	%
0.9 lpm	_____	_____		_____	
3.0 lpm	_____	_____		_____	
5.0 lpm	_____	_____		_____	

Maintenance prior to "As Left Calibration"

Cleaned Optics area _____

Cleaned bug filter _____

Replaced Bypass Cartridge Filte _____ (As needed)

Leak Check

Through tape Flow _____ mlpm Leak check percent _____

Through pad Flow _____ mlpm

MFC Flow verfication "As Left"				
	F_{IN} (flow device)	F1	%	Fc	%
0.9 lpm	_____	_____		_____	
3.0 lpm	_____	_____		_____	
5.0 lpm	_____	_____		_____	

MFC Flow calibration IF NEEDED		
	F_{IN} (flow device)	% (set pt - Qstd/Qstd * 100)
0.9 lpm	_____	_____
3.0 lpm	_____	_____
5.0 lpm	_____	_____

As left calibration check through the probe

Aethalometer Display: _____ lpm Observed Flow
Flow Device Display: _____ lpm Qstd - Actual Flow
% Difference: _____ Pass if % Difference < 10%

Aethalometer time: _____ Standard Time _____
Is the Aethalometer time within +/- 5 minutes? ____
If not, make note of the difference and if the time was corrected. _____

Is the date correct? _____
If not, make note of the difference and if the date was corrected. _____

Number of Tape Advances Left _____

Comments: _____

_____

_____

_____

Form Revised 05-14-15

Form 4
Magee Scientific Aethalometer Audit Form

IDEM

Aethalometer Quarterly Audit
Office of Air Quality - Air Monitoring Branch

Date: _____ Site: _____ AQS#: _____

Start time: _____ _____ Performed by: _____

Aethalometer Brand & Model: _____ Serial Number: _____

Calibration Date: _____

Transfer Standard Information

Flow Device SN: _____ Certification Date: _____

Thermometer SN: _____ Certification Date: _____

Barometer SN: _____ _____

Back of unit Verification

Ambient Temperature: _____ Baropmetric Pressure _____ mmHg

_____ lpm Observed Flow

Flow Device Display: _____ lpm Flow not corrected to STP

True Flow: _____

% Difference: _____ (see formula below)

≤10% = in cal, data valid; >10% but ≤15% = out of cal, data valid; >15% out of cal, data invalid

Through the probe Verification

Ambient Temperature: _____ Barometric Pressure _____ mmHg

Aethalometer Display: _____

Flow Device Display: _____ lpm Flow not corrected to STP

True Flow: _____ lpm Flow corrected to STP (see formula below)

% Difference: _____ (see formula below)

≤10% = in cal, data valid; >10% but ≤15% = out of cal, data valid; >15% out of cal, data invalid

Formulas & Conversions

$$\text{True Flow} = \text{Flow Device} * \left[\frac{293}{(\text{Amb Temp} + 273)}\right]\left[\frac{\text{Baro Press}}{760}\right]$$

$$\%\ \text{Difference} = \left[\frac{\text{Observed Flow} - \text{True Flow}}{\text{True Flow}}\right] * 100$$

Magee Scientific Aethalometer Audit Form (Continued)

Conversions:	$^{o}C = (^{o}F - 32) * 0.5556$ $^{o}K = {}^{o}C + 273$	mmHg = " Hg * 25.4
Standard Conditions:	20 ^{o}C (293 ^{o}K)	760 mmHg (29.92 " Hg)

Aethalometer time: _____

Standard time: _____

Is the Aethalometer time within +/- 5 minutes?
If not, make note of the difference and contact parameter specialist

Is the date correct? _____

NOTE: To change the flash drive, turn the unit off, remove the current flash drive, install the new flash drive, turn unit on.

Comments: _____

_____

_____

_____

Form Revised 08-23-10