



WASHINGTON STATE
DEPARTMENT OF
E C O L O G Y

Aethalometer Operating Procedure

Air Quality Program

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If you require this publication in an alternate format, please contact Tami Dahlgren at 360-407-6800 or TTY (for the speech or hearing impaired) 711 or 1-800-833-6388.

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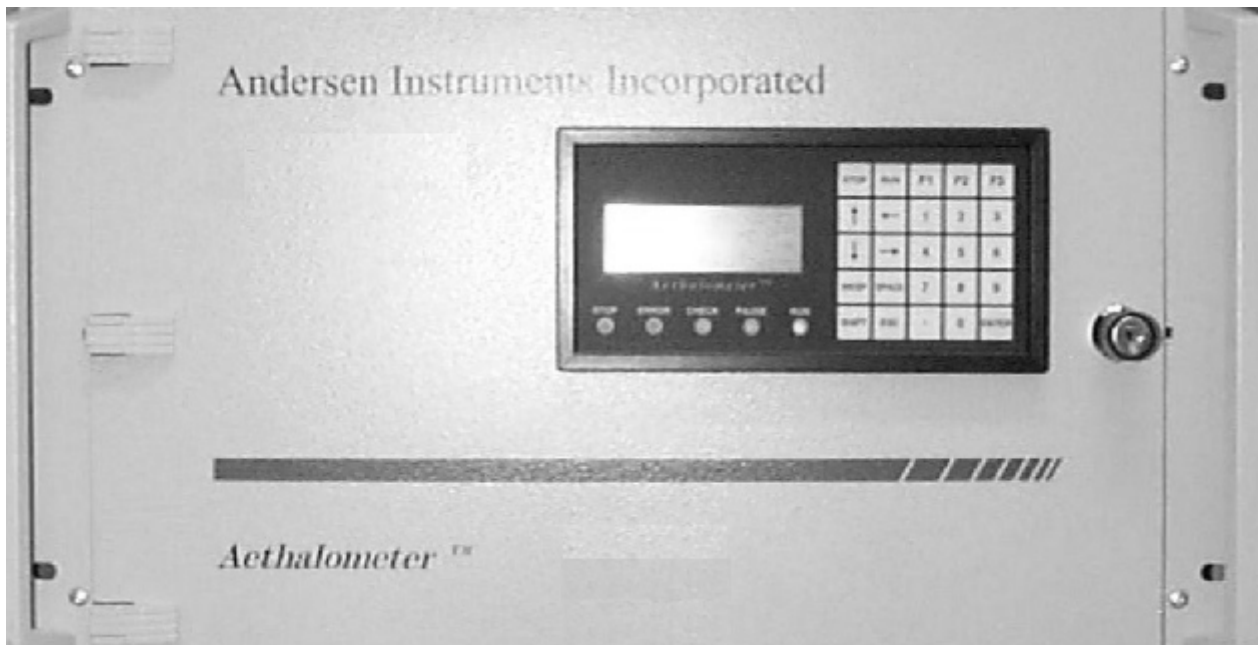
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1 INTRODUCTION

This document describes the procedures used to sample aerosol black carbon, hereafter referred to as BC, in ambient air using the Magee Scientific Aethalometer by the Washington State Department of Ecology - Air Quality Program. It is intended that this document be used together with the sampler-specific information and instructions provided by the manufacturer.

The Aethalometer measures the mass of BC in a given volume of ambient air. The method by which this measurement is obtained is through a direct measurement of the absorption of light at various frequencies. Photons that strike particles in the air will be either absorbed or scattered. Scattered photons can be measured with a nephelometer. Absorbed particles are measured with an Aethalometer. The sum of the absorbed photons, scattered photons and photons exiting the air mass is equivalent to the total number of photons entering the air mass. When using an Aethalometer in conjunction with a nephelometer, an overall quality of visibility can be ascertained.

Figure 1-1 Magee Scientific Aethalometer



1.1 Method of Operation

The Aethalometer uses a method of optical attenuation to develop its value of BC in a given sample of air. A known quantity of air is passed through a fibrous filter. A specific frequency of light is applied to one side of the exposed filter and detected on the opposite side by a photodiode. The instrument calculates the quantity of BC in the sampled air using the value of light attenuation and the sample flow rate over a known period of time.

A reference photodiode is located below the filter media in an area where no aerosol is being collected. The signal from the main photodiode and the reference photodiode are mathematically combined in order to maintain a high degree of accuracy. This method of measurement eliminates any errors that may be introduced due to fluctuating light intensity.

2 EQUIPMENT & SUPPLIES

- Magee Scientific Aethalometer
- Pump & Plumbing material
- Hand tools
- BGI PM_{2.5} inlet (SCC 1.829)
- A supply of MS-DOS formatted 3½" disks
- Additional filter media
- Optical Test Strip
- QC worksheets (copy from document)
- ESC Data logger
- Flow measuring device (BIOS or Gilibrator)
- Station Logbook

3 SITING REQUIREMENTS

Aethalometers can be used for a variety monitoring applications. Because of this, specific siting criteria can not be detailed in this text. Comprehensive siting requirements can be found in Title 40 CFR 58, Appendix E.

http://www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_40/40cfr58_00.html

Aethalometers are commonly used in conjunction with nephelometers for measuring the quality of air with respect to visibility. In this case the same siting criteria required for the nephelometer is to be adhered to. The main requirements are as follows:

3.1 Basic Requirements

It is important to site the instrument far enough away from roadways to minimize any effects of re-entrained dust. The following table is a list of distances based on vehicles traveling the roadway.

Table 3-1 Distance From Roadway

Less than 3000 cars per day	sampler should be \geq 25 meters from road
3000 to 10,000 cars per day	sampler should be $>$ 25 meters from road
10,000 to 20,000 cars per day	sampler should be $>$ 50 meters from road
20,000 to 40,000 cars per day	sampler should be $>$ 75 meters from road
40,000+ cars per day	sampler should be $>$ 100 meters from road

- To keep impacts from wind blown dust to a minimum, stations should not be located on barren ground and should be located at least one quarter mile from potential sources of dust.
- Avoid areas with excessive smoke from local combustion sources.
- There must be no obstructions that would limit the sampler's ability to collect aerosols representing the regional area.
- An open horizontal arc of at least 270^o or greater must surround the sampler inlet with prevailing winds entering the arc. Any obstructions within this arc must be twice the distance from the sampler inlet as they are tall.
- The probe inlet must be located between 2 and 15 meters above ground level.

Simplified siting criteria can be found in the IMPROVE SOP 126 (09/12/96)
<http://www.aqd.nps.gov/ard/vis/sop/sop126procedures.html>.

Other factors must be remembered when considering a location for installation. The operator's personal safety is an important consideration. It must be remembered that during times of inclement weather the site may still need to be accessed. Power & telephone line availability is a concern. Security of both the operator and the equipment can be an issue. Access to the site must be such that the operator has the ability to bring tools and supplies in and out. All sensitive electronic equipment must be kept in a temperature-controlled environment that isolates it from moisture and rapid temperature changes.

3.2 Installation of the Aethalometer

Upon receipt of the Aethalometer, visually inspect it to ensure that all components are accounted for. Notify the Air Monitoring Unit immediately if any equipment is missing or damaged. Carefully transport the Aethalometer to the field site.

Proper installation of the sample probe is very important. Care must be exercised to eliminate the possibility of drawing in water and insects with the air sample. A fine mesh screen should surround the inlet. If there is a concern for water being drawn into the sample line then a water

trap should be installed. The probe inlet, if mounted to the side of the building should be at least 3 feet from the wall.

Decide on a location within the shelter that will not be directly impacted by the flow of air from a heater or an air conditioner. Connect vacuum to the outlet port if using an external pump. Connect the probe (< 30 ft.) to the inlet port. Insert a pre-formatted 3½” disk into the floppy drive slot. Plug the unit into an outlet that supplies 120VAC, 60Hz and turn the power switch on. The display panel will illuminate and display a flashing cursor for approximately 30 seconds before automatically going into sample mode.

3.3 System Operation and Setup

The Air Monitoring Unit will have programmed the Aethalometer according to its specific data collecting requirements. Ecology operates their Aethalometers in the volumetric mode with parameters programmed to 760mm Hg at 25⁰C. From the operator’s standpoint, no programming should be required. If it becomes necessary to change the programming of the Aethalometer, specific details are located in the manufacturer’s operations manual.

4 FIELD OPERATIONS

The day to day operation of the Aethalometer is relatively simple. There are no required gases or comparison standards to be concerned with. Calibrations are done automatically within the Aethalometer when necessary. The operator must be aware of the remaining quantity of filter tape and blank space on the 3½” disk. Filter tape and disk usage is based on parameters that were set during programming. Before a disk is full it must be replaced with a new one or data will be overwritten. Always label disks with the starting date and time, Aethalometer identification number and site name before use. Replace disks as close to the hour as possible to avoid loss of data and always make sure the disk access lamp is not lit during the exchange.

5 QUALITY CONTROL

5.1 Bimonthly Site Visit

Do not exceed 14 days between site visits. Verify that the time on the Aethalometer and the time on the data logger are within 5 minutes of each other. If the time is not within 5 minutes then the Aethalometer must be stopped in order to reset the time. It is not necessary to disable the data logger. The data (disk) will be flagged when the Aethalometer is stopped. Note any adjustments on the log sheet and in the logbook.

Check the sample flow on the Aethalometer display. If it is off by 10% or more, it will require adjustment. This adjustment is made at the small screwdriver-slot control located left of the ‘Tape Advance’ switch on the 2-channel Aethalometer. On the 7-channel version it is a thumb

control on the back of the unit. Note any adjustments made on the log sheet and in the station logbook.

Check the filter tape supply and replace the 3½” disk if necessary. Disk replacement may not be necessary every visit, if the Aethalometer is programmed to store data in a compressed format. Inspect the sample probe and water trap (if used).

5.2 Monthly QC Check Procedure

Disable the data logger. While in sample mode, remove the sample inlet and connect a certified transfer standard flow device, such as a BIOS or Gilibrator to the sample inlet port. If the reading obtained from the transfer standard is at ambient temperature and pressure, a conversion must be done as the Aethalometer displays flow at standard conditions of 760mm Hg at 25°C. Convert the transfer standard reading using the following formula:

$$\text{Flow at STP} = \text{Measured Flow} \times \left[\frac{298}{^{\circ}\text{C} + 273} \right] \times \left[\frac{BP}{760} \right]$$

Where STP is Standard Temperature and Pressure and BP is barometric pressure in mm Hg.

Calculate the percentage of difference (% Δ) between the Aethalometer’s indicated flow and the actual flow using the following formula:

$$\% \Delta = \left[\frac{I - A}{A} \right] \times 100$$

Where *I* is the indicated flow from the Aethalometer Display and *A* is the actual flow taken from the flow transfer standard.

Calculate the percentage of difference (% Δ) between the design flow rate and the actual flow using the following formula:

$$\% \Delta = \left[\frac{A - D}{D} \right] \times 100$$

Where *D* is the design flow and *A* is the actual flow taken from the flow transfer standard. As of this writing, design flow for all of Ecology’s Aethalometers is 5 liters-per-minute.

If the difference is greater than 10% in either of the two previous calculations then an adjustment is required. If adjustment is not possible then contact Ecology’s Air Monitoring Unit at (360) 407-6030.

Reconnect the sample line and enable the data logger.

Table 5-1 Flow Check Limits

10 > Flow % Δ > 7	Requires adjustment.
Flow % Δ > 10	Requires adjustment and invalidation of data back to previous passing flow check.

5.3 Biannual Photodetector Test

Every six months it is necessary to run a test on the optical characteristics of the photodetectors. The Aethalometer is supplied with an optical test strip. Make sure that the serial number on the test strip matches the serial number on the instrument. To perform the photodetector test it is necessary to stop the machine. Press the stop button on the keypad. To verify, press stop a second time. Next you will be prompted to enter the security code. The default is 111. From the main menu, scroll down to the Optical Test option using the down arrow button and press ENTER. Again, you must enter the security code. When prompted, key in the serial number from the optical strip and press ENTER. This is the first 3 digits stamped on the test strip. Remove the two thumbscrews and the metal cover. Cut the filter tape on the left side of the optical unit and press ENTER when prompted. The tape will spool onto the take-up hub on the right side of the filter tape transport. Hold the optical test strip with the serial number facing upwards and to the right. Slide the test strip into the same location that the filter would pass through with the arrow just visible below the base block and press ENTER. The Aethalometer will make some measurements and display the reference numbers on the screen. The values will be stored on disk. These reference numbers should be written in the logbook for future reference. Press ENTER to continue. The mechanism will draw the test strip through the light path while making a series of measurements. This takes approximately 5 minutes. After the test is completed, a file is written to disk. The file name is in the format of OTxxxxxx.TXT. Write the values down in the logbook. The display will prompt to reinstall the filter tape. Replace the metal cover and thumbscrews. For a more indepth explanation of this procedure see page 93 of “The Aethalometer”, Magee Scientific, April 2003.

5.4 Annually

Clean or replace the sample inlet probe. Replace the funnel if it is cracked or brittle and replace the bug screen if necessary.

6 MAINTENANCE

The Aethalometer is a self-calibrating instrument requiring little or no operator maintenance. Clean the disk drive if write errors are occurring and visually inspect the entire system at each visit.

7 DATA MANAGEMENT

Valid data collected on the 3½” disk will be permanently stored and sent to EPA. The data collected by the data logger is invalid. It is used to view the approximate values collected in real time, via Ecology’s telemetry system. Because the methods used by the data logger and the Aethalometer to produce hourly averages are not compatible, a comparison of the 24 x 31 generated from data logger data and data generated from the Aethalometer’s internal circuitry will differ somewhat. Collected data is to be sent to the AIRS Coordinator for processing and importation into the telemetry system.

8 DATA DOCUMENTATION AND VALIDATION

Refer to the “Automated Method Data Documentation and Validation Procedures” under the Data Validation Section of this manual for a detailed description of handling, recording, and validating of air monitoring data. All data will be reviewed and certified by the Quality Assurance Unit prior to being reported to the EPA and prior to use in decisions concerning air quality management.

9 DATA QUALITY ASSESSMENT

For each calendar quarter and year, the Quality Assurance Unit will prepare data precision, accuracy, and completeness reports.

9.1 Accuracy

Data accuracy will be evaluated and reported using results from the performance audits.

9.2 Data Completeness

Data completeness will be determined for each analyzer and expressed as a percentage. Percent valid data will be a gauge of the amount of valid data obtained compared to the amount expected under ideal conditions (24 hours per day, 365 days per year). Exceptions will be made for analyzers operating on a seasonal basis.

10 REFERENCES

- 1) "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I - Principles." EPA-600/9-76-005. December, 1984.
- 2) "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II - Ambient Air Specific Methods." EPA-600/4-77-027a. January, 1983.
- 3) Code of Federal Regulations, Title 40, Part 58 (40 CFR 58).
- 4) "State of Washington Department of Ecology, Air Quality Program, Automated Method Data Documentation and Validation Procedures." December 1993.
- 5) "The Aethalometer", Magee Scientific, April 2003.

11 FORMS

Monthly Aethalometer QC Check Form

Aethalometer Maintenance Schedule

Monthly Aethalometer QC Check Form

Station Name _____

Station Number _____

Date _____

Operator _____

Temperature _____ °C

Barometric Pressure _____ mm Hg

State ID or ID Number _____

Flow at Ambient _____ lpm

DCN offline at _____ PST

Flow at STP _____ lpm

DCN online at _____ PST

Sampler Calibration Flow Rate Difference _____

Sampler Design Flow Rate Difference _____

$$\text{Flow at STP} = \text{Measured Flow} \times \left[\frac{298}{^{\circ}\text{C} + 273} \right] \times \left[\frac{BP}{760} \right]$$

$$\text{Sampler Calibration Flow Rate Difference} = \left[\frac{I - A}{A} \right] \times 100$$

$$\text{Sampler Design Flow Rate Difference} = \left[\frac{A - D}{D} \right] \times 100$$

Aethalometer Maintenance Schedule

Site Name _____ Site Number _____

Date	Bimonthly			Monthly	Biannually	Annually	Operator
	Time Check	Display Flow	Tape & Disk	Actual Flow	Optical Strip Value	Probe Cleaned or Replaced	

Note: Initial each task as completed