

Advanced Portable Measurement of Black Carbon



Magee Scientific Aethalometer® Model AE43

KEY FEATURES

- Light-weight/Portable Aethalometer
- Full Spectrum 7-Wavelength analysis: UV – IR, 1 Hz data
- DualSpot™ Technology* for filter “loading effect” compensation
- Real-time source apportionment
- NIST-traceable Calibration/Validation by ND optical kit
- Real time graphical data display

*United States Patent 8,411,272, United States Patent 9,018,583, other patents pending

APPLICATIONS

- Mobile measurements, mobile labs
- Wildfire smoke monitoring
- Vertical profiling – aircraft, balloons
- Real-time source apportionment
- Emissions testing
- Pollution Hot-spot identification
- Health Effects research
- Pollution mapping



Manufactured in Europe by
Aerosol d.o.o., Ljubljana, Slovenia

“Real-time decision-making requires reliable real-time data.”

The **Aethalometer® AE43** provides advanced real-time monitoring, quantitation and speciation of **Black Carbon (BC) and ‘Brown’ Carbon (BrC)** aerosols. This data is used to study:

- Mobile monitoring (e.g. mobile laboratory, measurements from aircraft and balloons, ...)
- Vehicle and Engine Testing Emissions
- Pollution mapping
- Specific industrial applications (e.g. fence line monitoring, mine ventilation optimization)
- Public Health Effects studies

Light-weight design for portability

The **Model AE43 Aethalometer®** is designed for simplicity and portability. It meets all **laboratory** and **mobile monitoring requirements**. It is ruggedly constructed of lightweight materials and specifically designed for mobile and portable operation.



Advanced real-time charting and data analysis

The Model AE43 Aethalometer® displays the most relevant data (BC @ all wavelengths, % Biomass burning) for instant monitoring and reporting. It can display charts of BC data (from fossil fuel, or from wood burning) relative to wind speed and direction to provide instantaneous reporting of impacts due to extreme events such as wildfires.



External Power Supply for “off grid” monitoring applications

The **Model AE43 Aethalometer®** may operate from an **integrated lightweight external power supply** (optional accessory) providing up to 15 hours of run time. It may also operate from other DC power sources such as vehicle batteries, solar panels, etc.



The Aethalometer® measurement principle

The Aethalometer® draws the sample air stream through a filter tape with a flow rate from 2 to 5 liters per minute. Aerosols are collected on two spots on the tape, and are illuminated by a multi-wavelength light source. Detectors measure the attenuation of light by the absorbing components of the aerosols, relative to a reference through an un-exposed portion of the tape.

The filter tape advances on a time schedule, or when a pre-set loading limit is reached. The instrument operates completely automatically from power-up, and provides continuous real-time data with no operator attention.

*The Aethalometer® is the instrument most-used in the world for **real-time** monitoring and speciation of Black Carbon. Thousands of instruments have been installed on all seven continents starting in 1986.*

DualSpot™

Patented automatic compensation for 'filter loading effect'¹

Sample collection and analysis is performed on two filter spots simultaneously at different flow rates. Mathematical combination of the data eliminates the "Filter Loading Effect" and provides continuously-corrected data in real time with **no discontinuities at filter advances²**.



Real-time source apportionment

The Aethalometer® analyzes the sample at 7 optical wavelengths from UV (370 nm) to IR (950 nm). Optical absorption by different aerosol components may have different variations across the spectrum: most notably, the differences between diesel exhaust and emissions from biomass burning. The 7-wavelength data allows for a separation of these components, providing a **real-time speciation of the aerosol sources and a determination of their origins³**.

Calibration/Validation of the instrument

Performance of the Aethalometer® may be validated *in situ* by several quality test protocols. Analytical validation is provided by the 'Neutral Density Optical Filter Kit' (optional accessory), which uses NIST-traceable optical standards to verify the analytical performance. This can be performed at the instrument site: it is not necessary to take the instrument out of service. This **maximizes up-time and minimizes expense**.

High time resolution (1 Hz) analytical response

Sampling, analysis and all calculations are performed at a fundamental rate of 1 Hz. Standard reporting time bases of 1 second or 1 minute permit **the identification of temporal patterns and the study of direct emission sources** such as engines, stoves, etc. Data may be aggregated into averages of 1 hour (or other intervals) for air-quality reporting. All data and internal diagnostics are stored internally with an instrument capacity of many years.

1- United States patents US 8411272 and US 9018583; and European patent applications EP 2 151 679 A3 and EP 2 498 079 A2; cover aspects of the proprietary technology embodied in the Aethalometer®.

2- Drinovec et al.: The "dual-spot" Aethalometer: an improved measurement of aerosol black carbon with real-time loading compensation, *Atmos. Meas. Tech.*, 8, 1965-1979, 2015.

3- Zotter et al.: Evaluation of the absorption Ångström exponents for traffic and wood burning in the Aethalometer-based source apportionment using radiocarbon measurements of ambient aerosol, *Atmos. Chem. Phys.*, 17, 4229-4249, 2017.

Product specifications

MEASUREMENT PRINCIPLE

Continuous collection of aerosol on filter with simultaneous measurement of attenuation of transmitted light at wavelengths of 370, 470, 520, 590, 660, 880 and 950 nm. Black Carbon concentration measurement is defined by the absorption measurement at 880 nm. Multiple wavelength analysis for source apportionment (identification of biomass smoke), studies of aerosol light absorption, radiative transfer, atmospheric optics. High data rate capability for source and emissions testing.

DUALSPOT™ TECHNOLOGY

Simultaneous analysis of light absorption by aerosol deposits collected on 2 spots in parallel at different loading rates*. Mathematical combination of data yields Black Carbon result independent of "spot loading effects" and provides additional information about aerosol composition.

*United States Patent 8,411,272, United States Patent 9,018,583, other patents pending

SOURCE APPORTIONMENT

Discrimination of Black Carbon from fossil fuel versus biomass combustion possible with built-in analysis by a two-component model.

SENSITIVITY

Proportional to time-base and sample flow rate settings: approximately 0.03 µg/m³ @ 1 min, 5 LPM.

DETECTION

Detection Limit (1 hour): <0.005 µg/m³
Range: <0.01 to >100 µg/m³ Black Carbon
Resolution: 0.001 µg/m³ or 1 ng/m³

SAMPLING

Aerosol sample collected on filter tape consisting of PTFE-coated glass fibers, supported by a reinforcement backing. Tape advances automatically when user selectable loading threshold is reached, typically once every few hours depending on concentration and flow rate.

Size selective inlets (impactor, cyclone) may be attached.

- Time-base 1 second or 1 minute, post-processing to any time resolution.
- Flow-rate 2 to 5 LPM provided by internal pump. Flow measured by two mass flow sensors and stabilized by closed-loop control.
- Tape advances automatically on aerosol loading or at predefined Times or time intervals.

OPERATOR INTERFACE

Display

10.1" color touch-screen (1280 x 800 px) with status indicator LED's.

Interface

Graphical User Interface with basic data display and control, advanced screens for detailed reporting and parameter setup.

Charts

Charting of most relevant data (BC1, BC6, BB%, BCff and BCbb) for Instant identification of sources.

Charting of wind speed and direction related to BC measurements (applicable with **Wind speed and direction sensor** (PN 5520)).

Remote management

Network ready for remote management and data transfer.

STORAGE

Data are written to internal memory once every time-base period. Stored data may be transferred over a network or to a manually inserted USB drive.

DATA OUTPUT

- 5 x USB (1x charge only)
- 6 x RS232
- 1 x Ethernet
- 1 x HDMI (service only)

QUALITY CONTROL AND ASSURANCE

Automatic or manual sample flowrate calibration using an externally-attached calibrator.

Verification of optical performance using a set of NIST-traceable neutral density optical filters.

Automatic or manual "Dynamic Active Zero" and stability tests may be programmed to occur at specified time intervals.

PHYSICAL SPECIFICATIONS

- Dimensions (HxWxD): 22 x 40 x 23 cm
- Weight: 11.5 kg
- Electrical Power supply:
 - AC: 100-230VAC, 50/60Hz (auto-switching)
 - DC: 12 V
- External battery power supply offered as an optional accessory
- Power consumption: 25 W average
- Internal Vacuum Pump: dual diaphragm, brushless motor
- Modular hardware, hermetically sealed

RELATED PRODUCTS

Battery: Lithium, LiFePo4 chemistry

Weight: 5.4 kg (in chassis with LED indicators)

Run time @ 2 LPM flow rate: up to 15h

AEccessor remote access from PC, tablet, phone

AethAlerts status reporting and system alert service by email

AethNET networking solution connects to data center where the data is analyzed, stored and presented to users

INSTALLATION REQUIREMENTS

- Temperature: 5°C - 55°C
- Rel. humidity: 5% - 95% (non-condensing)
- Operating altitude: Sea Level to 3000 m**

** Operating range can be extended from basic 3000 m a.s.l. to 5000 m a.s.l. with an external air pump – optional accessory.

ACCESSORIES

External power supply with indicators (PN AE43-BAT)

Neutral Density Optical Filter validation kit (PN M7662)

Ambient meteorological sensor, with 10-m cable (PN M5510)

Wind speed and direction sensor (PN M5520)

Sample stream dryer (PN M5610-220V-A)

PM2.5 inlet (2.5 µm @ 5 LPM) (PN M4110)

PM1 inlet (1 µm @ 5 LPM, 2.5 µm @ 2 LPM) (PN M4114)

CO2 sensor, integrated with AE33 airflow&data (PN M5710)

Flow Calibrator, with cable for automatic/manual use (PN M7950)

Insect Screen Assembly with Water Trap (PN M9556)

Tape Sensor Calibration Disc kit (PN M3410)

GPS module (PN AE33-GPS)

External pump for high-altitude operation (AETH-HA-PUMP)

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