

# Advanced Measurement of Aerosol Black Carbon



## Aethalometer® Model AE33

### KEY FEATURES

- Full Spectrum 7-Wavelength analysis: UV – IR, 1 Hz data rate
- DualSpot™ Technology for compensation of “filter loading effect”
- Real-time source apportionment
- NIST-traceable Calibration/Validation by Neutral Density Optical kit
- Network ready for remote management and data transfer
- Integrates with Total Carbon Analyzer TCA08 for OC/EC analysis
- Integrates with CO<sub>2</sub> and meteorological sensors for additional data

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

### APPLICATIONS

- Air Quality monitoring
- Real-time source apportionment
- Emissions testing
- Climate Change research
- Health Effects research
- Combustion research



## „Good decisions can only be based on good data“

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

- Public Health and Occupational Health
- Climate Change
- Visibility
- Stationary Source Emissions
- Vehicle and Engine Emissions
- Modification of Precipitation
- Impacts on Agricultural Yields
- Degradation of Cultural Heritage

*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 world-wide since commercialization began in 1986, and are now operating on all 7 continents.*

## 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.

### DualSpot™

**Patented automatic compensation for ‘filter loading effect’<sup>1</sup>**

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 advances**.<sup>2</sup>

This compensation depends critically on the aerosol composition and properties. It **must be determined in real time** from the measurement data, as it **cannot be predicted** in advance.

The parameters derived from this analysis also offer additional insights into **aerosol composition and aging**.



*DualSpot enables Aethalometer to be used to be used under dynamically varying ambient conditions. It provides valid Black Carbon measurement data out-of-the-box, with no need for post-processing.*

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.

HOME	OPERATION	DATA	ABOUT
BC		4135	ng/m <sup>3</sup>
BIOMASS BURNING		23.6	%
REPORTED FLOW (AMCA)		5.0	LPM
TIMEBASE		60	s
TAPE ADV. LEFT		544	
STATUS		0	
24 Nov 2015 11:16:45		AE33-504-00101	

## 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 origins.**

A source-apportionment algorithm was verified<sup>3</sup> using C14 analysis based on several year's campaign dataset.

## Calibration/Validation against NIST Standard Reference Materials

The performance of the Aethalometer may be validated by a 'Neutral Density Optical Filter Kit' (optional accessory), which uses NIST-traceable optical standards to verify the analysis and validate the data. 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.

## Networking

The Aethalometer provides digital data outputs ('COM') for local logging and recording; and a network connection ('Ethernet'). Magee Scientific offers networking solutions for **remote access, remote operation, networking, status reporting, alerting** and **data management.**

## Integrate with Total Carbon Analyzer TCA08 for OC/EC analysis

The AE33 Aethalometer may be integrated with the TCA08 Total Carbon Analyzer to provide a **complete characterization of the carbonaceous component of ambient aerosols in near-real time.** This provides TC, "EC/OC", BC and BrC data in a rugged instrument package suitable for laboratory and Air Quality monitoring applications.

<sup>3</sup>- 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/m<sup>3</sup> @ 1 min, 5 LPM.

## DETECTION

Detection Limit (1 hour): <0.005 µg/m<sup>3</sup>

Range: <0.01 to >100 µg/m<sup>3</sup> Black Carbon

Resolution: 0.001 µg/m<sup>3</sup> or 1 ng/m<sup>3</sup> (user-definable display units)

## SAMPLING

Aerosol sample collected on reinforced glass-fiber/PTFE filter tape. Tape advances automatically on aerosol loading or at predefined times or intervals.

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.

## OPERATOR INTERFACE

### Display

8.4" color touch-screen with status indicator LED's.

### Interface

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

### Remote management

Network ready for remote management and data transfer.

## DATA OUTPUT & STORAGE

### Output

- Digital data via RS-232 COM port and Ethernet
- Analog output via AOM module

### 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.

## 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): 28 x 43 x 33 cm
- Weight: 21 kg
- Electrical Power supply: 100-230VAC, 50/60Hz (auto-switching)
- Power consumption: 25 W average
- Internal Vacuum Pump: dual diaphragm, brushless motor
- Modular hardware, constructed in a fully-enclosed 19" rack mount 6U chassis, hermetically sealed

## RELATED PRODUCTS

**Aerosol Inlet Dryer** including external pump (PN 5610)

**AEcessor** remote access from PC, tablet, phone

**AethAlerts** status reporting and system alert service by email

**AethNET** networking solution that connects Aethalometers to a data center where the data is analyzed, stored and made available to users

Integrates with **Total Carbon Analyzer TCA08** for OC/EC analysis

## ACCESSORIES

**Neutral Density Optical Filter validation kit** (PN 7662)

**Ambient Meteorological Sensor**, with 10-m cable (PN 5510)

**PM2.5 inlet** (2.5 µm @ 5 LPM) (PN 4110)

**PM1 inlet** (1 µm @ 5 LPM, 2.5 µm @ 2 LPM) (PN 4114)

**Mini PM Inlet** configurable: PM1, PM2.5, PM4, PM10, TSP (PN 4121)

**CO2 sensor**, integrated with AE33 airflow & data acquisition (PN 5710)

**Flow Calibrator**, with cable for automatic/manual use (PN 7900)

**Insect Screen Assembly with Water Trap** (PN 9556)

**Tape Sensor Calibration Disc kit** (PN 3410)

**Shockproof & waterproof transit case** (PN 9610)

**GPS Module** (PN AE33-GPS)



Scan the code for more info

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