Magee Scientific Aethalometer®

Model AE33

Use of Neutral Density Optical Filter Kit for validation of the Optical Calibration

www.mageescientific.com

Berkeley, Ljubljana, June 2014

Use of Neutral Density Optical Filter Kit for validation of the Optical Calibration of the Magee Scientific Aethalometer® Model AE33

The Aethalometer® is an instrument which measures the concentration of Black Carbon ('BC') aerosols in a sampled air stream, from the rate of increase in optical absorption of the aerosol deposit on a filter spot. The data output is expressed in units of [BC mass] per [volume of sampled air], for example μg/m^3. The accuracy of the BC data depends on accurate calibration of the sampled air volume per reporting period, and the response of the photometric detectors.

Calibration of the air flow sensors, and the correct selection of volume reporting units, is covered in a separate document. The Magee Scientific Aethalometer Model AE33 offers an automatic interface to leading models of air flow meters. This permits a consistent, uniform procedure for air flow validation without the possibility of operator error. The air flow calibration routines also insure that the air volumes are reported at the correct 'standard' conditions of temperature and pressure, selected by the user to be consistent with station requirements and established procedures.

Validation of the reproducibility of the photometric detectors is provided by means of the Neutral Density Optical Filter Kit. This kit consists of a set of metal holders, each of which contains two elements made from precision optically-absorbing glass. These assemblies are denoted as "ND Filters". The glass inserts are made with stable, broad-spectrum absorbing materials whose optical density is traceable back to primary photometric standards offered by national and international standards organizations, e.g. NIST (USA); NPL (UK); etc. Introducing these ND filters into the Aethalometer light path will reduce the transmitted intensity in a reproducible manner.

Aethalometer real-time data is based on measuring the increment of optical absorption of the aerosol collected on the tape spot from one timebase period to the next. However, the cumulative total optical absorption, from initial "clean" tape to a final spot of a much darker coloration, is proportional to the average of BC concentration over the total sampling period. The difference in optical signal between these two end-points may be verified by inserting two ND filters, one of zero optical density, the other of a darker density. Since the optically-absorbing glass is stable over time, consistency of the photodetector responses to the ND filters will validate the consistency of the Aethalometer measurement process. To cover the range of optical absorptions used by the Aethalometer, the ND Kit contains four units with progressively increasing absorption.

When each Magee Scientific Aethalometer Model AE33 is manufactured at Aerosol Co., the response of its photodetectors is recorded for each of four Primary Standard ND Reference Filter Elements which are maintained in the manufacturing calibration facility. This response is recorded both in the instrument's software setup files, as well as in the primary manufacturing records. The initial response establishes the calibration of the instrument's BC data against the suite of primary reference Aethalometer instruments in the calibration facility.

A field-usable ND Kit consists of four ND filter units in a protective case, together with a USB drive containing initialization data. If the ND Kit is issued with the instrument at the time of manufacturing, its first benchmark is performed at the time of initial calibration of the instrument.

The benchmark measurements consist of a dataset which represents the performance during the test with the [ND Field Kit] in comparison to the validation performed at the factory at the time of manufacture with the [Manufacturing Primary Standard Reference Kit]. This data is gathered for both sampling spots ("Spot 1" and "Spot 2") at all seven optical wavelengths. These ratios may differ very slightly from 1.000 within the narrow tolerances of manufacturing differences between different batches of the ND glass: however, the essential nature of the Calibration Validation Process is to ensure that the photodetector response does not change over time.

The in-field Calibration Validation Process consists of inserting the ND filters sequentially into the Aethalometer's optical path. The process is guided by software prompts, and the data processing is automatic. The software compares the ratio of the optical signals "now", to the ratio of the optical signals in the benchmark set. This data is calculated as a statistical regression over the four ordinate values of optical density: for both spots, and for the seven wavelengths. The results are presented as a table of regressions of [Signal ratios now] to [Benchmark signal ratios]. An example ND Test Report is shown below. If the response of the photodetectors is constant over time, these regression slopes will maintain values extremely close to 1.000. This assures the user that the performance of the Aethalometer's optical detection has not changed over time, and is identical to its performance during the primary calibration against the suite of primary reference Aethalometer instruments in the manufacturing calibration facility.

If the ND Kit validation process yields results which differ significantly from 1.000, the user will be prompted to examine and clean the optical chamber, and to insure that the ND filters are clean. Results which remain consistently different from 1.000 can be "calibrated out" by a change in optical parameter setup values, but this must be undertaken only with caution; factory guidance; and acknowledgment of the influence on the data of such a change in calibration. The results of the test are stored in the Aethalometer together with the measurement data, and the results can be downloaded from the instrument at any time. This insures that each measurement file is accompanied with the relevant quality assurance data and that the BC measurement data can be interpreted and reinterpreted (if necessary) in its proper context.

Example ND Test Report

New test: NDtest_AE33-S01-00079_20130501_111808.dat AE33-ND-0001
Ref test: NDtest_AE33-S01-00079_20130517_105543.dat AE33-ND-0031

New test vs ref test slopes:

	Spot1	Spot2
Ch1	0.997	0.997
Ch2	0.999	0.999
Ch3	0.999	0.999
Ch4	0.999	0.999
Ch5	0.999	0.999
Ch6	1.000	1.000
Ch7	1.000	1.000

Technical support and contact information

Please contact the service department through our web sites (Service & Support):
www.mageescientific.com or www.aerosol.si

Aerosol d.o.o.

Kamniška 41
SI-1000 Ljubljana
SLOVENIA
EUROPE
fax: +386 59 191 221
www.aerosol.si

In the US, please contact:
Magee Scientific Corporation
1916A M.L. King Jr. Way
Berkeley CA 94704, USA
fax: +1 510 845 7137
www.magescientific.com