

Replacement Filter Tape for the Magee Scientific Model AE33 Aethalometer®



Results of research testing and evaluation of replacement Filter Tape Media

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TEXT SUMMARY

Replacement Filter Tape for the Magee Scientific Model AE33 Aethalometer®

The Magee Scientific Model AE33 Aethalometer measures the light transmitted through a spot of filter tape that is continuously collecting aerosol particles. The rate of decrease of light transmission is proportional to the rate of accumulation of optically-absorbing material. The data is interpreted as a real-time concentration of 'Black Carbon' aerosols in the sampled air stream. Analysis at multiple wavelengths provides the separation of "black" particles (for example, diesel exhaust emissions) from "brown" particles which usually indicate biomass combustion.

This analysis is critically dependent on the nature of the filtration material. The earliest Aethalometers used 25-mm wide quartz fiber tape, Part No. 8010. Quartz fiber has an affinity for water vapor which leads to a 'humidity effect' on the data. In 2012, the Model AE33 Aethalometer was developed using 30-mm wide PTFE-coated glass-fiber tape, Part No. **8020** (originally, "AE33-FT"). This tape had good analytical properties; low affinity for water vapor; but a high lateral leakage. This tape was discontinued by the manufacturer in 2015, leading to its replacement by a different PTFE-glass-fiber tape, Part No. **8050**. This tape had low lateral leakage; low affinity for water vapor; but showed an optical non-linearity at short wavelengths. While the "Black" carbon data was accurate, the calculation of the 'Biomass Burning' fraction was affected. This material in tape form will also become unavailable after 2018.

Consequently, Aerosol Co. performed an extensive programme of testing and evaluation of several candidate filter tapes. These tapes were tested for optical linearity, response to aerosols of different sizes, humidity, transients, etc.: and were also tested by sampling ambient air in parallel with current filter tapes at six locations world-wide.

The outcome of this effort is the selection of a new tape which meets all of our analytical criteria, and has a low lateral leakage. This tape will be made available as **Part Number 8060**. Its data replicates and continues the measurement of "Black" Carbon; and provides a good assessment of "Biomass Burning".

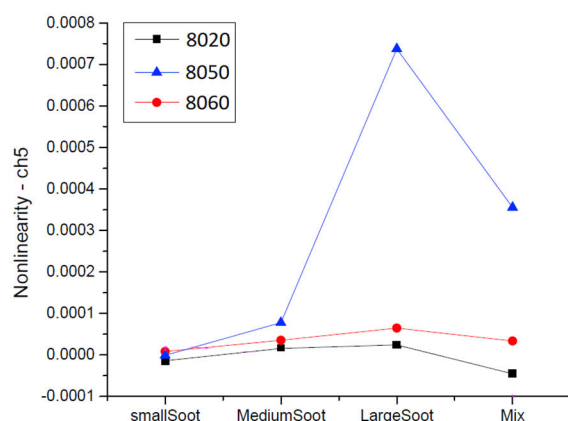
Test Programme

Many different types of filter tape were purchased for testing. Most were eliminated for reasons such as: large adsorption transients when fresh tape is brought into the analytical airflow stream; excessive influence of Relative Humidity; excessive lateral leakage.

In this document, we report on the comparison of the final selected tape '8060' with the original '8020' tape; and the intermediate '8050' tape.

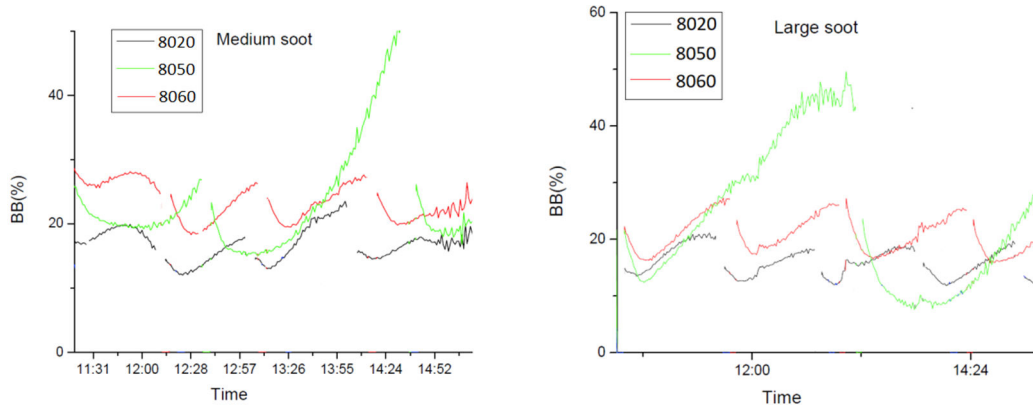
These tapes were tested under controlled conditions in the laboratories of 'TROPOS' in Leipzig, Germany and at Aerosol Co. in Ljubljana, Slovenia; and by sampling outdoor ambient air in Bangalore, India; Paris, France; Beijing, China; Boulder, CO, USA; Berkeley, CA, USA; and Ljubljana, Slovenia.

One set of laboratory tests studied the non-linearity of the optical response, when the filter was loaded with combustor-derived 'soot' particles of controllable size.



This figure shows that the non-linearity for the fundamental Black Carbon measurement is very similar between the '8060' tape and the original '8020' tape.

Other tests studied the reported 'Biomass Burning fraction' for composite particles of different size ranges.



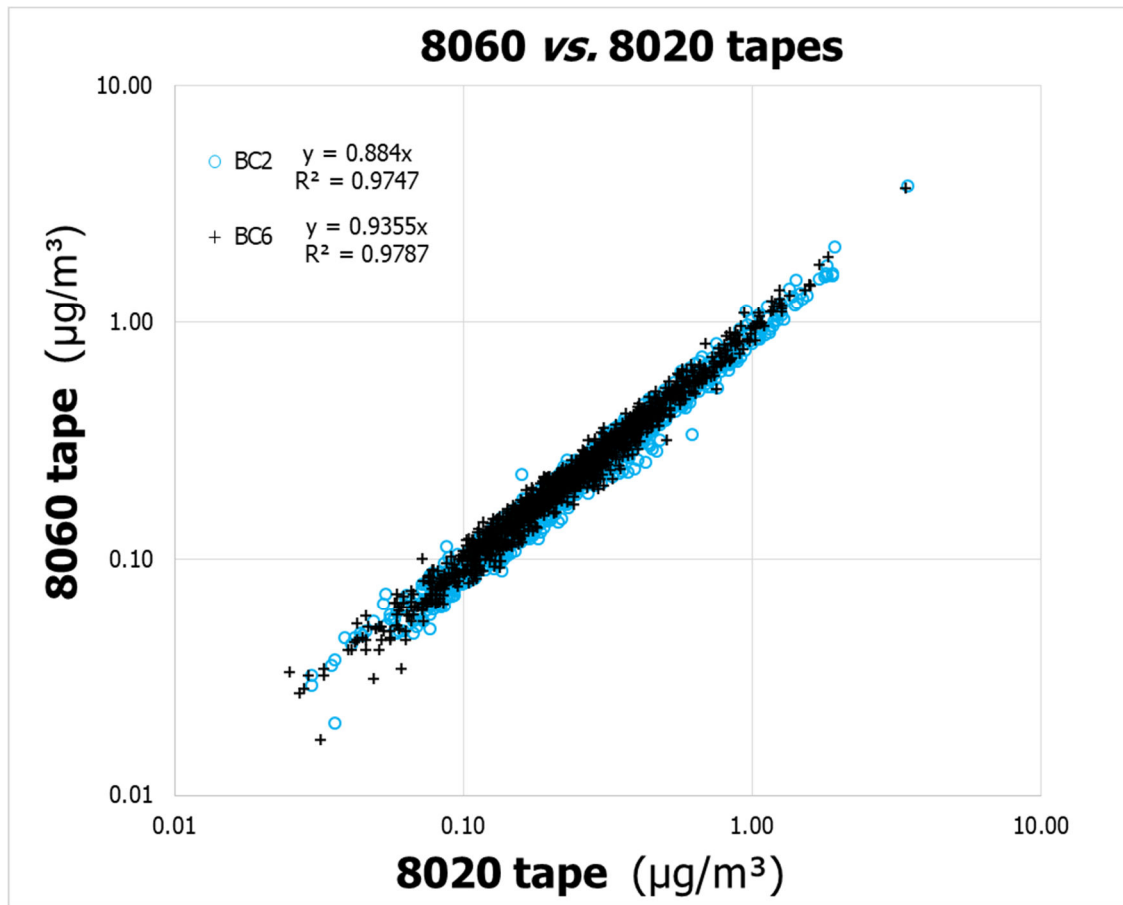
These figures show that the '8060' tape gives a result for the 'Biomass Burning fraction' that tracks the result for '8020' tape, with less discontinuity at tape advances. The discrepancy of '8050' data is clear.

A very important test is to compare the 'sensitivity' – i.e. the instrumental response per unit mass of aerosol – between the reference '8020' material and the test '8060' material, across a wide range of laboratory and ambient atmospheres. These results are as follows:

Relative sensitivities between test filter (8060) and reference (8020)

| | 8060/8020 slope | |
|--------------------------------|--------------------|------|
| | BC2 | BC6 |
| Laboratory combustor | 0.88 | 0.86 |
| India | 0.90 | 0.87 |
| Paris | 0.95 | 0.93 |
| China | 0.80 | 0.82 |
| Boulder | 0.96 | 0.88 |
| Berkeley | 0.88 | 0.94 |
| MEAN | 0.89 | 0.88 |
| STD.DEV. | 0.06 | 0.05 |
| Relative proportional variance | 6% | 5% |

The result shows that the mean instrumental response factor for '8060' tape is 0.885 times that for '8020' (AE33-FT) tape; and that the variation across geographic locations and aerosol types is about 6%. Each of these tests was performed by shipping three instruments to the distant location, and instructing them to be used exactly as received. Minor issues of a few percent differences in relative flow calibration may be responsible for some part of this range of variation.



This figure shows an example of the correlation of ambient-air data between '8060' and '8020' tape from Berkeley, California. The period covered two months of testing and the 1,246 one-hour average data values span more than 2 orders of magnitude, from 'very clean' to 'moderately polluted' air.

The main results of the tape intercomparison for the ‘8060’ product may be summarized as follows:

| Parameter | Metrics | 8020 | 8050 | 8060 |
|-----------------------|-------------------------------|----------------|------------------------------|----------------|
| Leakage | % at 5 LPM | 5.5% | 1.0% | 1.5% |
| Flow resistance | Pressure drop at 5 LPM (hPa) | 40.8 | 84.4 | 58 |
| Spot shape | Spot edge | sharp | smudged | sharp |
| Non-uniformity | Spot inhomogeneity | yes | yes | no |
| Sensitivity BC6 | Relative to 8020 | 1 | 0.7-1 | 0.82–0.94 |
| Sensitivity BC2 | Relative to 8020 | 1 | 0.75-1 | 0.80–0.96 |
| Transients (BC6) | 1, 3, 10 mins after advance | 50/30/10 | 60/0/0 | 0/0/0 |
| Adsorption (BC1) | 1, 3, 10, 60 m. after advance | 150/100/100/20 | -260/80/100/40 | -200/-25/50/20 |
| Humidity dBC/dRH | transients | 1 | 1 | NA |
| Filter loading effect | Non-linearity | 1 | 10 | 3 |
| Filter loading effect | Magnitude | 1 | Much bigger | Bigger |
| %BB calc. jumps | Across tape advance | 10% | 10-40% | 10% |
| k2 | ambient air, Ljubljana | 0.005 | 0.009 | 0.005 |
| k6 | ambient air, Ljubljana | 0.004 | 0.011 | 0.006 |
| %BB value | relative to 8020 | 1 | Much bigger | 1.1 |
| SSA effect | (albedo dependence) | | Similar for all filter types | |

Based on these results, we are pleased to announce the availability of the replacement filter tape for the Magee Scientific Model AE33 Aethalometer, as our **Part Number 8060**.

Accommodation for the “mean value” of 0.885 for the relative sensitivity simply requires an adjustment of the ‘C’ parameter in the Aethalometer advanced setup menu. In place of the ‘C’ value of 1.57 used for ‘8020’ and ‘8050’ tapes, a value of $\{1.57 * 0.885 = \mathbf{1.39}\}$ should be entered as shown on the next page. In this way, the Black Carbon mass concentration data will be calculated correctly. Additionally, the leakage parameter ‘Z’ should be set to **0.01** to represent the 1% leakage of this tape.

The full suite of results will be presented at scientific conferences and submitted for publication. For further information, please contact us as shown on the end-pages of this report.

References

(copies available on request)

L. Drinovec et al., (2015), "The "dual-spot" Aethalometer: an improved measurement of aerosol black carbon with real-time loading compensation", *AMT* **8**, 1965-1979

A. D. A. Hansen et al., (1982), "Real-time measurement of the absorption coefficient of aerosol particles", *Appl. Opt.* **21**, 3060-3062

H. Rosen and T. Novakov, (1983), "Optical transmission through aerosol deposits on diffusely reflective filters: a method for measuring the absorbing component of aerosol particles", *Appl. Opt.* **22**, 1265-1267

H. Rosen et al., (1978), "Identification of the optically absorbing component In urban aerosols", *Appl. Opt.* **17**, 3859-3861

Parameter Change Required to use '8060' tape

The parameters "Z" (leakage) and "C" (sensitivity) are shown on the Operation / Advanced screen. After installing '8060' tape, change Z to **0.01** and C to **1.39**.

| HOME | | OPERATION | | DATA | | ABOUT | |
|--------------------------------------|----------------|----------------------|-------|-------------------------|-----------------------------|---|---|
| GENERAL | | ADVANCED | | LOG | | MANUAL | |
| Status | 0 | Flow Σ (mlpm) | 3007 | Sigma_Air (λ) | LED err | Detector err | |
| Controller status | 0 | Flow1 (mlpm) | 1814 | Ch1 | 18.47 | 0 | 0 |
| Detector status | 10 | Pump (ref.val.) | 449 | Ch2 | 14.54 | 0 | 0 |
| LED status | 10 | Flow sensor Σ | 450 | Ch3 | 13.14 | 0 | 0 |
| TA status | 0 | Flow sensor 1 | 355 | Ch4 | 11.58 | 0 | 0 |
| Tape sensor left | 121 | Chamber status | 10 | Ch5 | 10.35 | 0 | 0 |
| Tape sensor right | 173 | Chamber position | 302 | Ch6 | 7.77 | 0 | 0 |
| TapeAdvance left | 181 | Valve status | 00000 | Ch7 | 7.19 | 0 | 0 |
| ATNf1 | 10 | Z | 0.07 | Kmax | 0.015 | Date format: | <input checked="" type="checkbox"/> US <input type="checkbox"/> EU |
| ATNf2 | 30 | C | 1.57 | Kmin | -0.005 | Measure time stamp: | <input type="checkbox"/> Before <input checked="" type="checkbox"/> After |
| Warm up interval (min) | 3 | Aff | 1 | Home display | | <input type="checkbox"/> UVPM | <input checked="" type="checkbox"/> Proc BB |
| Firmware version | 513 | Abb | 2 | Display: | <input type="checkbox"/> ON | <input checked="" type="checkbox"/> Saver | <input type="checkbox"/> Auto OFF |
| Software version | 1.1.3.0 | | | FlowCal | TapeSenAdj | LED adjust | |
| IP address | 127.0.0.1 | | | Change Tape | External device | Update | |
| Server IP address | | | | | | | |
| <input type="checkbox"/> AutoConnect | | | | | | | |
| Serial number | AE33-S00-00033 | | | | | | |

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