For more information, please contact:

World Meteorological Organization

Research Department

Atmospheric Research and Environment Branch

7 bis, avenue de la Paix – P.O. Box 2300 – CH 1211 Geneva 2 – Switzerland

Tel.: +41 (0) 22 730 81 11 – Fax: +41 (0) 22 730 81 81

E-mail: AREP-MAIL@wmo.int

Website: http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html

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GAW Report No. 200

WMO/GAW Standard Operating Procedures for In-situ Measurements of Aerosol Mass Concentration, Light Scattering and Light Absorption

Chair, Publications Board
World Meteorological Organization (WMO)
7 bis, avenue de la Paix
P.O. Box 2300
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0) 22 730 84 03
Fax: +41 (0) 22 730 80 40
E-mail: publications@wmo.int

WORLD METEOROLOGICAL ORGANIZATION
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WMO/GAW Standard Operating Procedures for In-Situ Measurements of Aerosol Mass Concentration, Light Scattering and Light Absorption

Edited by John A. Ogren
Chairman, GAW Scientific Advisory Group for Aerosols

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CHAPTER 1

Mass Concentration - Gravimetric Analysis of Teflon Filters

1. PREAMBLE

The mass concentration of atmospheric aerosols is clearly a fundamental parameter in the GAW measurement programme. This standard operating procedure (SOP) builds on the assumption that the aerosol mass measurements use a filter sampling method of collecting aerosol particles at a given GAW monitoring station. Specifically, 47 mm diameter Teflon filters are assumed to be used for the aerosol collection as per the recommendations by the WMO/GAW Programme as contained in the WMO/GAW Report 153, the Aerosol Measurement Guidelines and Recommendations. Furthermore, the filter samples are assumed to have been collected from the station and properly conditioned and stored until they are ready for the mass measurements in a weighing facility as described below.

In WMO/GAW Report 153, it was recommended that aerosol mass measurements at the GAW stations be made gravimetrically on 47 mm diameter Teflon filters. This SOP builds upon the operational guidelines of the US EPA see Reference 1 and the Canadian Air and Precipitation Monitoring Network (CAPMoN) see Reference 2 for gravimetric aerosol mass measurements, and tailors it to make a simplified approach.

For this SOP, specific references are made to certain trade marks and products. It is neither an endorsement of the product nor a requirement at the GAW measurements. Technically equivalent products can be used for the same purpose.

2. APPLICATION

The mass measurement procedure is applicable to TEFLO W/RING 2 mm pore size - 47MM 50/PK R2PJ047 Teflon membranes. It is also applicable to mass measurement using equivalent Teflon filters.

3. METHOD SUMMARY

A microbalance is calibrated using NIST referenced weights under controlled conditions. The mass of the aerosol is based on weighing the filters pre and post sampling under specified temperature and relative humidity conditions. The mass of the aerosol is the difference of pre and post weights.

4. INSTRUMENTATION AND APPARATUS

Micro Balance – Mettler Toledo UMT2 (weighing capacity 2100 mg, readability 0.1 µg), or an equivalent micro balance.

Computer – either a notebook computer or a desktop computer, that runs a data entry software, such as a spreadsheet programme, customized for recording data from the mass measurements. The computer is intended for recording weights of calibration weights, quality control filters, and actual sample filters.

There are specialized software programmes that can be used on the computer to link to the Mettler Toledo micro balance, for the purpose of data capture. The use of such programmes needs to be covered in supplemental standard operating procedures (supplemental SOPs).

A simpler approach is to use spreadsheet software to record the filter weights. For example, CAPMoN has an MS Excel-based spreadsheet template for recording the weighing data, with embedded criteria for accepting or rejecting a weighing result. Quality assurance and quality control plots are contained in the spreadsheet template. Manual input of sample identification is required for the spreadsheet template. This spreadsheet is available for anyone interested (dave.mactavish@ec.gc.ca; shao-meng.li@ec.gc.ca).

Manual input needs some forms of quality assurance, as transcription errors can be a big problem if all data need to be recorded into the data recording software. Double checking upon entry is one way to reduce such errors.

- 200 mg NIST traceable standard calibration weight
- U-Ionizer (Type PRX U) – Haug with power supply (ENC 01 7810.001). Equivalent ionizer can be used
- Polonium-210 antistatic strips ($5x10^{-4}$ μCi) and holder apparatus
- Teflon-tipped forceps (two pairs)
- Polystyrene 50mm Petri dishes
- Tyvek shoe covers, gowns and caps or equivalent
- Powder free, antistatic vinyl or polyethylene gloves
- Clean plastic bags equipped with a closure system such as ziplock or wire (e.g., Whirlpak bags)

Po-210 has a half-life of 138 days. Change the antistatic strips every 6 months and dispose of the old strips according to the manufacturer's recommendations.

5. SAFETY CONSIDERATIONS

- Polonium ionizing strips are radioactive materials that pose minimal hazard to the analyst.
- Radioactive licensing is likely required in most countries. Check national/local regulations on radioactive material handling.
- For most countries radioactive materials must be returned to the originating manufacturer for disposal. Check national/local regulations on radioactive material handling.

6. REAGENTS

Not required.

7. PREPARATION

Use deionized water (18.2 megaohm) for rinsing forceps and cleaning surfaces. Deionized water may be produced in-house from tap water using a Millipore system, a Barnestead system, or other equivalent deionizing system. Deionized water is typically stored in a large reservoir, from which the water is dispensed into smaller squirt bottles for rinsing use in the clean room. All rinse water used in this method must be taken from the reservoir on a per run basis (minimum daily).

8. FACILITIES

NOTE: *A climate-controlled, draft-free room or chamber is assumed to have been setup that complies with requirements for the purpose of aerosol mass measurements. See References **1**, **3** and **4** for recommended criteria for such a room. All the instruments and apparatus are assumed to be inside the clean room for the mass measurements by weighing.*

The conditioning and weighing of the filters are carried out in a climate-controlled clean room. The clean room must meet the following standard conditions for 24 hours prior to weighing:

- The temperature must be controlled at 20°C with a maximum variation of ±1°C
- The relative humidity must be controlled within the range of 45% with a maximum variation of ±5%
- The temperature, atmospheric pressure, and relative humidity of the clean room should be continuously recorded. This should be done on a regular basis. Additional recording should be done for every session of weighing (See Sections 9, 10, and 11)
- Personnel entering this room must wear clean room grade shoe covers, cap, gown, and gloves to minimize dust contamination
- The clean room should not be used for storage of any item
- Wipe all benches in the clean room at least once a week using kimwipes and deionized water. Do not do this when filters are exposed for equilibrium purposes in the room
- HEPA and carbon filters for the clean room must be changed on a scheduled basis, nominally annually. The frequency depends on the local environmental conditions of the clean room; where gas and particle pollutants are high in concentrations, more frequent changes must be made to maintain a good microenvironment for the clean room. During the change, the clean room needs to be closed until the room is restored to its original conditio.
- Access shall be restricted to authorized personnel only

9. CALIBRATION

1. Calibrate using the NIST referenced weight, of 200 mg, once per 50 sample filters.

2. Before calibration starts, the operator must have clean vinyl or polyethylene gloves on. The operator must wear Tyvek (or equivalent) shoe covers, a gown and a cap.

3. Turn on the computer. If no special software is used, a spreadsheet programme needs to be used to record the NIST reference weight. The reference weight data should be recorded in a dedicated spreadsheet file that is used for Quality Control, such as time series QC plots.

4. Clean the ionizing bar with the special brush provided.

5. Using forceps provided with the NIST referenced weights, grasp the 200 mg weight and pass it slowly over the ionizing bar horizontally three times. Pass the weight about 2 to 3 cm from the top and side of the ionizing bar.

6. Slowly pass the weight over the polonium strip three times.

7. Open the Mettler balance draft shield by pressing either the right or left-hand prompt on the front panel of the balance. On other equivalent microbalances, operate the balance according to its manuals.

8. Place the weight on the pan forks of the balance (pan forks recommended for better stability) and close the draft shield using the keypad. On other balances, operate according to its manuals. Allow the reading to stabilize.
9. Record the weight reading in the dedicated spreadsheet file.

10. Wait for the draft shield to open. Using forceps to remove the weight from the weighing cell and place it back in its designated box. Replace the forceps.

10. QUALITY CONTROL FILTERS

- Two 47mm Teflo membranes (part number R2PJ047; or equivalent filters) are kept in the weighing room exposed to room air to be used as reference filters. These are identified as QC1 and QC2. The QC filters are placed in Petri dishes equipped with covers.
- Before reference weighing starts, the operator must have clean vinyl or polyethylene gloves on. The operator should wear Tyvek (or equivalent) shoe covers, a gown and a cap.
- At the beginning and end of each weighing session for sample filters (before and after field samples), and after every 10th sample filter, weigh one of the two control filters. Alternate between the two control filters.
- If the reference filter does not fall within ±3 standard deviations of its average weight over a period of 30 days, all filters weighed since the last reference filter reading must be re-weighed. If this still does not correct the problem, trouble shoot and take appropriate corrective actions, including (1) rectifying the QC control filters against NIST-referenced weights, or (2) service the microbalance by qualified personnel.
- Record the reference filter weight measurements in a dedicated spreadsheet, preferably in the same file as the NIST calibration weight measurements. Plot the reference filter weights as a time series. Plotting should be automatic as the new reference filter weight is entered. Separate the weight data for the QC1 and QC2 reference filters into different spreadsheets.
- Refer to Steps 9.2-9.9 to complete weighing procedure.

11. SAMPLE PREPARATION

1. Filters must be removed from their respective packages for one month prior to weighing. Remove the Teflo (or equivalent) filters from the outer wrap and inner tray. Remove the spacers. Place a stack of 10-20 filters in a single Petri dish. These are then left in the clean room for equilibration.

2. One week prior to weighing, separate the above filters into one filter per Petri dish and leave uncovered on a clean room bench.

3. Before sample preparation, the operator must have clean vinyl or polyethylene gloves on. The operator should wear Tyvek shoe covers, gowns and caps.

4. Avoid contamination and handle filters with Teflon-tipped forceps. Grasp the filters by the plastic ring of the filter edge.

5. Remove the filter from the packaging and inspect each filter visually for integrity before placing in a clean Petri dish. Check for dirt, fibers, holes or tears and discard filters with any imperfections.

6. Place a Petri dish on a clean laboratory bench. Using Teflon tipped forceps place the inspected filter face up in the dish. Place the Petri dish cover face down on the bench next to the dish.

7. After all filters have been placed in Petri dishes, record the time to the nearest minute in a properly identified worksheet. Record the temperature and the humidity of the room in the Calibration sheet, the QC sheets, and the sample sheet.

12. INSTRUMENT SETUP, MAINTENANCE & TROUBLESHOOTING

- Before these activities take place, the operator must have clean vinyl or polyethylene gloves on. The operator should wear Tyvek (or equivalent) shoe covers, a gown and a cap.
- The Mettler Toledo UMT2 (or equivalent) must be turned on prior to weighing for a minimum two-hour warm-up period.
- Check that the balance is not tilted. See that that the balance bubble is in the centre of the inner circle of the viewing window.
- Check the weighing chamber for dust and sweep using a dedicated soft brush.
- Clean the exterior of the balance with isopropanol or deionized water, whichever is more appropriate for the balance.

13. OPERATIONAL REQUIREMENTS

- Before filter weighing measurement starts, the operator must have clean vinyl or polyethylene gloves on. The operator should wear Tyvek (or equivalent) shoe covers, a gown and a cap.

13.1 First pre-weighing of filters

1. Affix an identifying label to the exterior of each Petri cover. Each label will show a unique ID number that will be used to identify the filter. Put on the Petri dish cover.

2. Turn on the computer.

3. Clean the ionizing bar with the special brush provided.

4. On the computer, open a spreadsheet file, preferably the template that has all the necessary headings, formats, and calculation logic built in. Enter the ID number on the Petri dish into the spreadsheet.

5. Check the ID numbers. Does the sample ID number match the Petri dish label? Change the number if necessary.

6. Using Teflon coated tweezers to grasp the Teflo (or equivalent) filter by the plastic ring and pass it slowly through the ionizing bar horizontally three times. Pass the weight about 2-3 cm from the bottom and side-bars.

7. Slowly pass the filter under the polonium strip three times.

8. Open the draft shield of the Mettler balance by pressing either the right or left-hand prompt on the front panel of the balance. On other balances, follow their operational manuals for operating the balances.

9. Place the filter on the pan forks of the balance and close the draft shield using the keypad. On other balances, follow their operational manuals for operating the balances. Allow the reading to stabilize.

10. Record the weight in the spreadsheet.

11. Remove the filter from the weighing cell and place it back in the Petri dish. Put on the Petri dish cover.

12. Repeat steps 6-11 for the rest of the filters. Tare the balance if the readings drift between weights.

13. Weigh all of the filters again starting at the filter at the top of the spreadsheet. Record both the first and second weighing results in two separate columns of the spreadsheet.

14. Save the spreadsheet file.

15. For every 50 filters, the NIST calibration weight must be measured (see Section 9).

16. For every 10 filters, the reference filters must be weighed once. Alternating between the QC1 and QC2 reference filters (see Section 10).

17. The filters are weighed again, 24 hours after the initial weighing. See following section for details. In total, four weights will have been recorded for each filter.

13.2 Second pre-weighings of same filters

A second pre-weighing after the first pre-weighing is necessary to ensure the precision of the weight measurements.

1. Open the same spreadsheet file containing the first pre-weighing results.

2. Continue with steps 5 to 16 in First Pre-Weighings of same filters.

3. If the average duplicate weight of a filter does not fall within 0.01 mg average of the initial weight, the filter is weighed a fifth and sixth time 24 hours later, in a third pre-weighing of the same filter and repeating the steps from 1 to 3. If the third weighing still does not produce consistent results with the first weighing, the filter should be discarded.

4. Place weighed and conditioned filters in their own Petri dishes, and place the Petri dishes in small Whirlpak (or equivalent) plastic bags, 20 Petri dishes per bag. Close the bag tightly.

14. FILTER HANDLING

NOTE: *Filter handling, after pre-weighing, needs to be harmonized with the field sampling operation of any GAW station. The following SOP is generic and needs to be tailored to the needs and operations of a particular GAW station. Where an SOP exists for the field sampling using filters, it should be followed, but with a special effort to record the connection between the ID of the pre-weighed filters with the actual sample ID and start and end date/times for sampling.*

14.1 Filter loading

1. After shipping to the field, the Petri dishes containing the pre-weighed filters are ready to be loaded into filterpacks for sampling at a given GAW station. Make sure that a printout of the ID of the Petri dishes, together with the weights as obtained in Section 13, accompanies the Petri dishes/filters. A copy of the spreadsheet containing this information should also be forwarded to the GAW station operators together with the Petri dish/filters.

2. At the station, the spreadsheet file should be opened up using a local computer. Enter the station ID and record the station sample ID for the lab-generated filter ID. Record the sampling start date/time and end date/time for each filter. Save the file.

3. Load the filters onto filterpacks according to the SOP for the filter sampling programme at the station. Load in a clean area. Wipe down the bench top with deionized water and a Kimwipe before starting.

4. Put on a pair of polyethylene gloves.

5. Using clean Teflon-coasted forceps and grasping the plastic ring of the filter, transfer the filter from its Petri dish into the filterpack. Assemble the filterpack as per the station SOP for the filter sampling programme at the station.

6. Close the empty Petri dish and put it aside. Temporarily store the labelled Petri dishes in a clean sealable polyethelene plastic bag in the order of the pre-weighings in the spreadsheet file, and seal the bag.

7. If multiple filterpacks are loaded at one time, repeat steps 3-6 for each successive filterpack.

14.2 Filter unloading

The following steps are to be conducted in the field at the GAW station as per the station SOP for filterpack handling.

1. After sampling is completed at the station, unload the filters in a clean area at the GAW station. Wipe down a bench top with deionized water and a Kimwipe before starting.

2. Put on a pair of polyethylene gloves.

3. Gently remove the filter from the filterpack using forceps, grasping the plastic ring and taking care not to touch the sample filter area and not to damage the filter.

4. Without turning the filter upside down, examine the filter for defects that may have occurred during sampling, and for evidence of leaks in the filterpack.

5. Record the start and end date/time in the spreadsheet for each filterpack. Add comments specific to the filter and site conditions to the spreadsheet as appropriate. Save the file.

6. Referring to the spreadsheet containing the filter ID number and weights, locate the filter ID number. Select the Petri dish with the accompanying filter number on the lid from the temporary sealable storage bag.

7. Place the filter in its original labeled Petri dish. Close the Petri dish with its lid.

8. Place the Petri dish with the filter in a separate sealable polyethelene plastic storage bag for transport to the clean room for weighing.

9. Field blank filters must be subjected to the same procedures as the true sampled filters.

10. Clean all filterpack stages three times with deionized water.

14.3 Post-weight procedure

Once the Petri dishes are sent back to the clean room for weight measurements, the following procedures need to be followed.

1. The sampled filters must be conditioned in the clean room. The conditioning and weighing of the sampled filters are carried out in the same climate controlled weighing room as the unexposed filters.

2. Place the Petri dishes containing the sampled filters on the bench.

3. Remove the lids of the Petri dishes and place them beside the dishes.

4. Record the filter number, temperature, pressure, relative humidity, date and time. The temperature, pressure, and relative humidity of the weighing room should be continuously recorded separately.

5. Allow the filters to condition for 24 hours.

6. Prepare the Mettler (or equivalent) balance and the computer as for the pre-weight procedure; but the appropriate spreadsheet file needs to be opened for recording the post-weight measurements.

7. Proceed as in Section 9.4 to 9.10.

8. Perform the required quality control following instructions 10.3 to 10.6 with the reference filters; but record the results as post-weighing.

9. Relate the sampled filter ID to station ID information with the Petri dish label and record both IDs for the same sample.

10. Follow the steps in 13.2 to proceed with the post-weighing for the sampled filters.

11. Record the results in the spreadsheet.

12. Post-weights must be more than the pre-weights and duplicate values must be within + 0.025 mg of each other. Post-weighing of sampled filters is done in duplicate once only.

13. Replace filters in corresponding Petri dishes and place in small Whirlpack bags. Freeze in filter archive freezer at –18ºC for later use.

15. AEROSOL MASS CONCENTRATION CALCULATION

The aerosol mass air concentration for a given aerosol sample is calculated as:

$$C = (Wf - Wi)/V$$

where C is the aerosol mass air concentration in µg/m^3 at the standard temperature of 0ºC and 1 atmosphere; Wf and Wi are the final and initial weights averaged from the two repeat weighings, respectively, of the filter used to collect the aerosols sample and given in µg; and V is the total air volume sampled through the filter in m^3 at the standard temperature of 0ºC and 1 atmosphere. If the volume reported from the field sampling station is not at this standard temperature and pressure, then conversion of the reported volume, using the average ambient air temperature and pressure for the particular sample, to the volume at the standard temperature and pressure needs to be made. The converted volume can then be used in the calculation of C as above. The procedures in manipulating the data from the measurements are given below for calculating the *C* values for all filter samples.

- Data manipulation is to be done after the post-weighing is completed. Two files will be at hand for the data manipulation and combination, one for the field data, the other one for the weighing data.
- The field data file, generated as a result of procedures in Section 14.2 at the GAW Station, needs to be combined with the post weighing results to give final aerosol mass concentrations. This file contains detailed information on the sample station name, the ID for the samples that have gone through the weighing procedures, their start and end date and times, and their air volumes sampled. All other metadata must be included in this file to assist subsequent quality controls of the data generated from the weighing room procedures as outlined above.
- It must be emphasized that all necessary quality assurance and quality control checks on the field data must have been performed and that the air volumes at the standard temperature of 0ºC and 1 atmosphere have been properly calibrated with known standards. This is expected from the SOP for filter sampling at the station.
- In the mass weighing data file, quality control the weighing data. After the pre-weighing procedures in Sections 13.1 and 13.2 and the post weighing procedures in Section 14.3 are completed, inspect the weighing data for the two Quality Control filter results (QC1 and QC2) for any large outliers to identify measurement artifacts. Inspect the QC filter results for baseline drifts in the balance (e.g., Section 17.1.4).
- Correction to the weighing data for baseline drift over time, usually quite small compared to the total weights, may be necessary. This is accomplished by carrying out a box-car running mean of the QC data time series; the length of the box-car must ensure a smooth running mean. The time series differentials, of the running means subtracting the long term mean value, are the time-dependent baseline drift corrections, and thus must be added to the pre-weighing and post-weighing results. Since the pre- and post-weighings are conducted at different times, the corrections can be different for both weighings.
- In the same file, calculate the mean weights for each filter from both pre-weighing and post weighing after the baseline drift correction is completed (if such correction is necessary, e.g., for situation shown in Section 17.2). Calculate the differences from the corrected pre- and post-weighings to obtain the net aerosol masses.
- Create a new spreadsheet to handle the weighing data for the field blank filters. Field filter blank masses are handled with the same procedures as the true aerosol samples. For each batch of filters, the mean blank mass is calculated. The standard deviation on the mean is calculated for these field filter blanks. **A method detection limit for the mass determination can be defined as the mean blank plus 3 standard deviation on the mean.**
- The mean field filter blank mass is subtracted from the net aerosol mass of each sample filter. The resulting blank-subtracted net aerosol mass is the true aerosol mass loading for each filter sample.
- In cases where the blank-subtracted net aerosol mass becomes negative, the sampled aerosol mass on the filters is below the method detection limit for mass measurements. In these cases, the mass value for the filters is set to a specified flag for Below-Detection-Limit (BDL).
- Merge the air volume data from the field data file with the blank-subtracted net aerosol mass data. This is done within the field data file by creating a new spreadsheet. Copy the station sample ID, start and end date and time, and air volume for each filter from the existing sheet and paste them into the new spreadsheet. Copy the blank-subtracted net aerosol mass data, together with sample ID, from the weighing spreadsheet file, and paste into this new spreadsheet. **Align the mass data with the air volume data to make sure that the IDs from the field file and from the weighing file match each other.** This

alignment is a critical part of the quality assurance procedure and thus must be done carefully to assure that no mistakes are made.

- In a new column of the spreadsheet, calculate the aerosol mass air concentration in air by dividing the blank-subtracted net aerosol mass with the corresponding air volume for each filter sample as per the equation provided above in Section 15. In cases where the mass is BDL, use specific flags.
- The field data file now contains the air concentrations of aerosol mass. Time series plotting of the aerosol mass concentration is made to inspect for unusual temporal variations, such as unusually high concentrations. As part of further quality control, inspect to see if these unusual variations are related to potential artifacts during sampling and/or sample handling. If yes, flag them with appropriate flag designations.
- At this point, the data will have gone through parts of the most important quality assurance and quality control procedures for the data.

16. REFERENCES

US EPA, *Quality Assurance Guidance Document 2.12: Monitoring PM in 2.5 Ambient Air Using Designated Reference or Class I Equivalent Methods*, November 1998.

CAPMoN, *CAPMoN Laboratory Standard Operating Procedure Manual*, December 2005.

National Conference of Standards Laboratories, *Recommended Practice for Laboratory Design, RP-7, National Conference of Standards Laboratories*, July 25, 1993. This document can be obtained by contacting the National Conference of Standards Laboratories, 1800 30th St., Suite 305B, Boulder, CO 80301.

NIST/NVLAP Handbooks 150: *Procedures and General Requirements, and 150-2: Calibration Laboratories Technical Guide*, June 1996.

ANNEXES

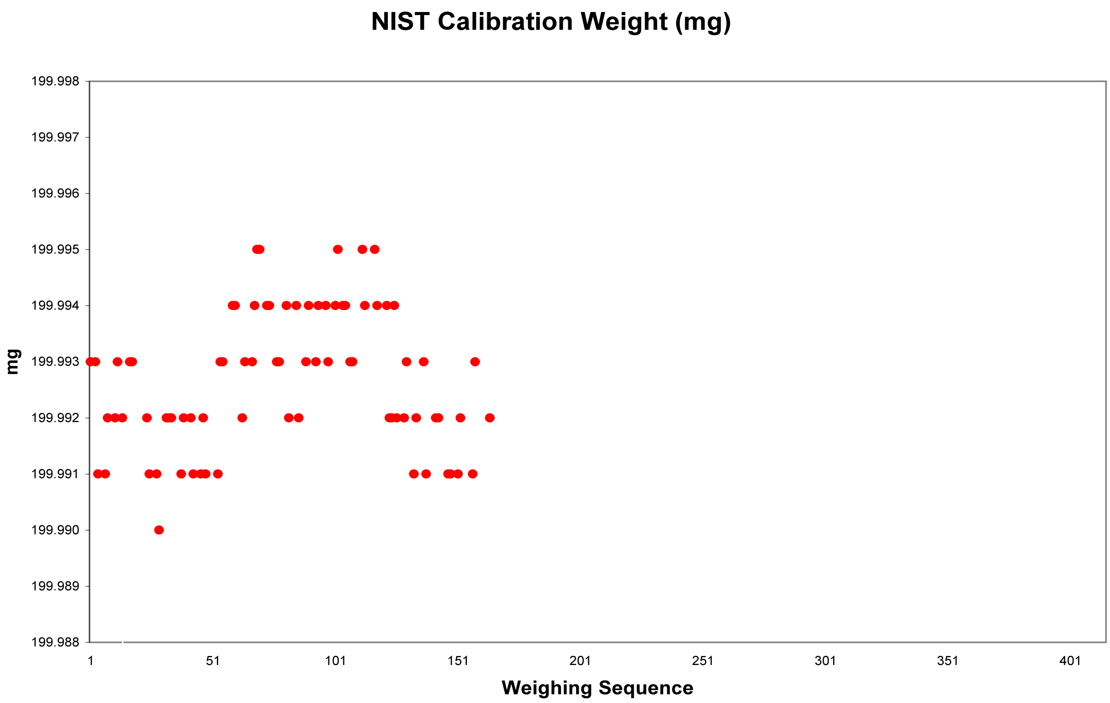
17.1 Spreadsheet Template For The NIST Calibration Weight and Reference Filter QC1 and QC2 Weighings

	A	B	C	D	E	F	G	H	I	J	K
1		REF wt	QC1	QC2							
2	S.D.	0.001	0.003	0.003							
3											
4	UCL	199.996	164.597	162.303							
5	UWL	199.995	164.594	162.300							
6	MEAN	199.993	164.587	162.294							
7	LWL	199.991	164.580	162.288							
8	LCL	199.990	164.577	162.285							
9											
10		NIST REF WT	QC1	QC2	DATE	comments	nist LCL	nistlwl	nistmean	nistuwl	nistucl
11	1	199.993	164.585	162.289	20050704		199.99	199.991	199.993	199.995	199.996
12	2		164.585	162.29			199.99	199.991	199.993	199.995	199.996
13	3	199.993	164.581	162.287	20050706		199.99	199.991	199.993	199.995	199.996
14	4	199.991	164.583	162.288			199.99	199.991	199.993	199.995	199.996
15	5		164.583	162.287			199.99	199.991	199.993	199.995	199.996
16	6		164.583	162.288			199.99	199.991	199.993	199.995	199.996
17	7	199.991	164.583	162.291	20050707		199.99	199.991	199.993	199.995	199.996
18	8	199.992	164.584	162.291			199.99	199.991	199.993	199.995	199.996
19	9		164.585	162.29			199.99	199.991	199.993	199.995	199.996
20	10		164.587	162.288			199.99	199.991	199.993	199.995	199.996
21	11	199.992	164.582	162.29	20050712		199.99	199.991	199.993	199.995	199.996
22	12	199.993	164.585	162.289			199.99	199.991	199.993	199.995	199.996
23	13		164.582	162.291			199.99	199.991	199.993	199.995	199.996
24	14	199.992	164.585	162.291	20050713		199.99	199.991	199.993	199.995	199.996
25	15		164.581	162.292			199.99	199.991	199.993	199.995	199.996
26	16		164.583	162.29			199.99	199.991	199.993	199.995	199.996
27	17	199.993	164.585	162.290	20050714		199.99	199.991	199.993	199.995	199.996
28	18	199.993	164.583	162.287			199.99	199.991	199.993	199.995	199.996
29	19		164.585	162.293			199.99	199.991	199.993	199.995	199.996
30	20		164.585	162.292			199.99	199.991	199.993	199.995	199.996
31	21		164.582	162.290			199.99	199.991	199.993	199.995	199.996
32	22		164.586	162.291			199.99	199.991	199.993	199.995	199.996
33	23		164.585	162.290			199.99	199.991	199.993	199.995	199.996
34	24	199.992	164.586	162.292	20050719		199.99	199.991	199.993	199.995	199.996
35	25	199.991	164.582	162.291			199.99	199.991	199.993	199.995	199.996
36	26		164.584	162.292			199.99	199.991	199.993	199.995	199.996
37	27		164.585	162.291			199.99	199.991	199.993	199.995	199.996
38	28	199.991	164.586	162.291	20050721		199.99	199.991	199.993	199.995	199.996
39	29	199.99	164.586	162.29			199.99	199.991	199.993	199.995	199.996
40	30		164.582	162.292			199.99	199.991	199.993	199.995	199.996
41	31		164.585	162.29			199.99	199.991	199.993	199.995	199.996
42	32	199.992	164.585	162.292	20050725		199.99	199.991	199.993	199.995	199.996
43	33	199.992	164.59	162.293			199.99	199.991	199.993	199.995	199.996
44	34	199.992	164.586	162.291			199.99	199.991	199.993	199.995	199.996
45	35		164.585	162.292			199.99	199.991	199.993	199.995	199.996
46	36		164.585	162.292			199.99	199.991	199.993	199.995	199.996
47	37		164.584	162.29	20050726		199.99	199.991	199.993	199.995	199.996
48	38	199.991	164.586	162.29			199.99	199.991	199.993	199.995	199.996
49	39	199.992	164.586	162.295			199.99	199.991	199.993	199.995	199.996
50	40		164.585	162.293			199.99	199.991	199.993	199.995	199.996

QC Data / NIST Reference / MASS QC1 PLOT / MASS QC2 PLOT

Ready

Example screen shot of the NIST calibration weight measurement results over time



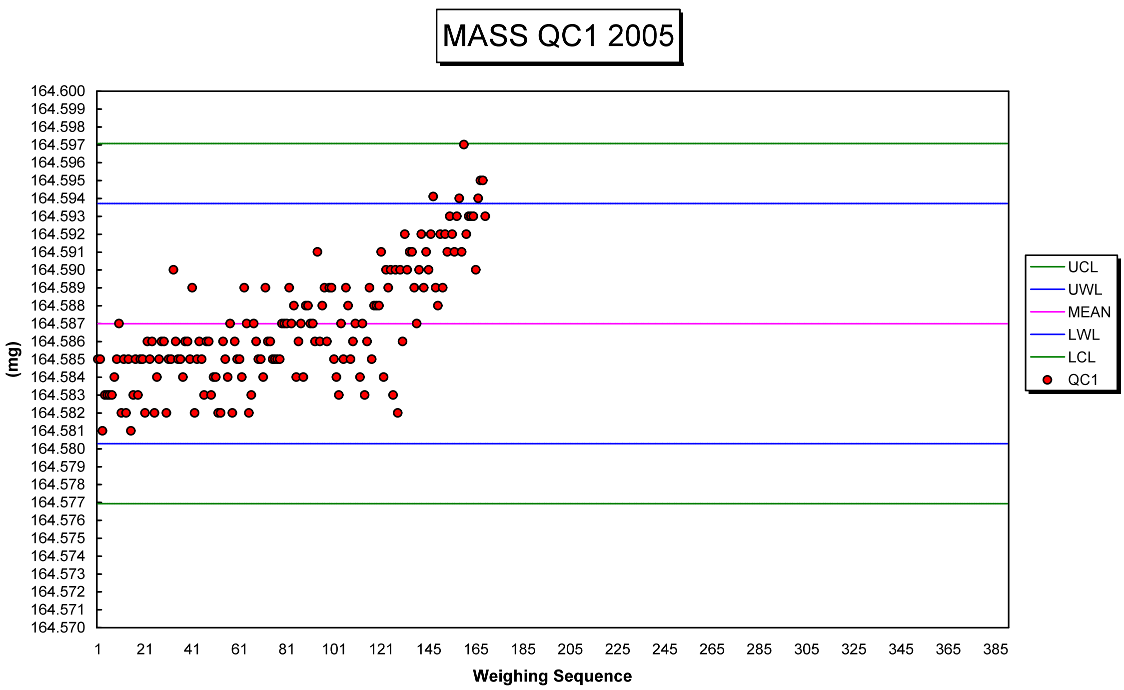
Screen shot of the NIST calibration weight quality control plot

	A	B	C	D	E	F	M	N	O	P	Q	S	T	U	V	W
1		**REF wt**	**QC1**	**QC2**												
2	**S.D.**	0.001	0.003	0.003												
3																
4	**UCL**	199.996	164.597	162.303												
5	**UWL**	199.995	164.594	162.300												
6	**MEAN**	199.993	164.587	162.294												
7	**LWL**	199.991	164.580	162.288												
8	**LCL**	199.990	164.577	162.285												
9																
10		**NIST REF WT**	**QC1**	**QC2**	**DATE**	**comments**	**lclqc1**	**lwlqc1**	**mean qc1**	**uwlqc1**	**uclqc1**	**lclqc2**	**lwlqc2**	**mean qc2**	**uwlqc2**	**uclqc2**
11	1	199.993	164.585	162.289	20050704		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
12	2		164.585	162.29			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
13	3	199.993	164.581	162.287	20050706		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
14	4	199.991	164.583	162.288			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
15	5		164.583	162.287			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
16	6		164.583	162.288			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
17	7	199.991	164.583	162.291	20050707		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
18	8	199.992	164.584	162.291			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
19	9		164.585	162.29			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
20	10		164.587	162.288			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
21	11	199.992	164.582	162.29	20050712		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
22	12	199.993	164.585	162.289			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
23	13		164.582	162.291			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
24	14	199.992	164.585	162.291	20050713		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
25	15		164.581	162.292			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
26	16		164.583	162.29			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
27	17	199.993	164.585	162.290	20050714		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
28	18	199.993	164.583	162.287			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
29	19		164.585	162.293			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
30	20		164.585	162.292			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
31	21		164.582	162.290			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
32	22		164.586	162.291			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
33	23		164.585	162.290			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
34	24	199.992	164.586	162.292	20050719		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
35	25	199.991	164.582	162.291			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
36	26		164.584	162.292			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
37	27		164.585	162.291			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
38	28	199.991	164.586	162.291	20050721		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
39	29	199.99	164.586	162.29			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
40	30		164.582	162.292			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
41	31		164.585	162.29			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
42	32	199.992	164.585	162.292	20050725		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
43	33	199.992	164.59	162.293			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
44	34	199.992	164.586	162.291			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
45	35		164.585	162.292			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
46	36		164.585	162.292			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
47	37		164.584	162.29	20050726		164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
48	38	199.991	164.586	162.29			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
49	39	199.992	164.586	162.295			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303
50	40		164.585	162.293			164.577	164.580	164.587	164.594	164.597	162.285	162.288	162.294	162.300	162.303

QC Data / NIST Reference / MASS QC1 PLOT / MASS QC2 PLOT

Ready NUM

Example screen shot of the QC reference weight results



Screen shot of the QC1 reference filter quality control plot

17.2 Spreadsheet Template for the Pre-Weighing and Post-Weighing of Filters

Lab ID #	Filter ID #	Station ID	Sample ID	Start Date	Start Time	End Date	End Time	pre-weight(1) (mg)	pre-weight (2) (mg)	pre-weight average (mg)	post-weight (1) (mg)	post-weight (2) (mg)	post-weight average (mg)	Difference (mg)
KEC05-187	3467							148.902	148.902	148.902	148.908	148.906	148.907	0.005
KEC05-188	3468							161.564	161.563	161.564	161.602	161.602	161.602	0.039
KEC05-189	3469							155.485	155.485	155.485	155.609	155.610	155.610	0.125
KEC05-190	3470							164.541	164.541	164.541	164.637	164.640	164.639	0.097
KEC05-191	3471							176.073	176.073	176.073	176.180	176.181	176.181	0.107
KEC05-192	3472							163.937	163.937	163.937	164.014	164.010	164.012	0.075
KEC05-193	3615							167.024	167.024	167.024	167.025	167.025	167.025	0.001
KEC05-194	3616							167.744	167.744	167.744	167.866	167.864	167.865	0.121
KEC05-195	3617							165.553	165.553	165.553	165.624	165.625	165.625	0.072
KEC05-196	3618							166.086	166.086	166.086	166.213	166.211	166.212	0.126
KEC05-197	3619							162.966	162.966	162.966	162.992	162.996	162.994	0.028
KEC05-198	3620							153.552	153.552	153.552	153.689	153.671	153.680	0.128
KEC05-199	3811							169.019	169.019	169.019	169.100	169.100	169.100	0.081
KEC05-200	3812							177.819	177.819	177.819	177.819	177.819	177.819	0.000
KEC05-201	3813							158.948	158.948	158.948	159.006	159.004	159.005	0.057
KEC05-202	3814							163.494	163.494	163.494	163.492	163.494	163.493	-0.001
KEC05-203	3815							166.463	166.463	166.463	166.550	166.550	166.550	0.087
KEC05-204	3816							165.051	165.051	165.051	165.110	165.114	165.112	0.061

Mass weights and sampling logs

Example screenshot of the template

CHAPTER 2

Mass Concentration - Beta Attenuation

Met One Instruments BAM-1020

1. AIM

This manual outlines Standard Operating Procedures (SOP) for measurement of aerosol mass concentration using a Met-One BAM-1020 beta attenuation mass monitor. It is intended for use by staff carrying out aerosol mass measurements at WMO GAW stations.

Guidance on setting up the sampling system and measurement and reporting of aerosol mass concentrations can be obtained in GAW 153 (2003). Sample conditioning to standardized relative humidity is particularly important for aerosol mass determination and care is required to achieve this without significant mass loss. Attention to sample conditioning is also required in humid environments where problems with condensation are commonly encountered.

Additional information can be obtained from sag-aero@tropos.de.

2. BACKGROUND

Continuous aerosol mass measurements are part of the suite of aerosol measurements recommended by the WMO Aerosol SAG to better understand climate and air quality impacts of aerosol particles.

3. TERMS AND DEFINITIONS

- WMO GAW = World Meteorological Organization, Global Atmosphere Watch.
- Aerosol SAG = GAW Scientific Advisory Group for aerosol.
- BAM = Beta Attenuation Monitor.

4. SAFETY AND PRECAUTIONS

BAM instruments utilize a low activity beta-emitting radioactive source. Operators should not attempt to access the source. Disposal of an unwanted source should conform with relevant national regulations or legislation.

5. STATEMENT OF TRACEABILITY

All mass measurements are referenced using the internal calibration membrane mass, which is factory calibrated to traceable standards. Flow measurements need to calibrated using a suitable flow measuring device that can traced to a recognized national or international standard, also the reference thermometer and barometer are required to have traceable calibration.

6. EQUIPMENT

- Beta attenuation monitor
- Calibration equipment includes:
  - Inlet adapter
  - Connecting tubing
  - Reference volumetric flow meter
  - Reference thermometer
  - Reference barometer

7. OPERATING PRINCIPLES

Beta Attenuation Mass Monitors (BAM) measure the mass concentration of particulate matter in the atmosphere by attenuation of beta radiation. A ^{14}C source emits beta rays, which are attenuated as they collide with particulate matter (PM) collected on a filter tape. The degree of attenuation of the beta signal is directly proportional to the mass loading of PM of the filter tape. Although highly different attenuating materials have somewhat different mass proportionality constants, in practice a single mass attenuation coefficient is used, and during operation of the instrument this is automatically referenced using an inserted calibrating membrane.

The BAM-1020 has three component sections: the sample inlet system, the controller and sensor assembly, and the sample pump.

8. RESPONSIBILITIES

Each GAW station that utilizes this type of equipment has the responsibility to ensure that the outlined operating procedures are followed. The WMO GAW Aerosol SAG has the responsibility for updating this manual.

9. OPERATION AND MAINTENANCE OF THE MASS MONITOR

A number of options are available for setting up the BAM-1020 flow values used to calculate mass loading; in part this depends on the hardware options for the particular instrument. Flows available are named “metered” (for instruments with manual flow control), “actual” (uses ambient flow) or “STD” (uses flow at 25 °C and 1 atmosphere). In setting up the instrument for GAW operation the STD option should be selected although this requires an additional density correction (x 1.0915, for 25°C to 0°C) to the mass loadings reported by the instrument before reporting these data to the GAW data centre.

9.1 Daily check

Procedure

1. CLOCK CHECK: check BAM clock is correct for Time and Date against a known accurate time, preferably UTC, (or UTC ± fixed time zone adjustment). Adjust if necessary (if greater than 30 seconds).

2. ERROR CHECK. Note any recent error messages recorded by the BAM. Press F3 from the Top Menu to display the last 10 error messages. Review sections 4.16, 5.2, and 9.2 of the Operation Manual for corrective actions.

3. TAPE CHECK. Inspect filter tape for damage and the amount remaining. One filter tape should last for 2 months.

4. REFERENCE CHECK: record and track the density of the Reference Membrane by observing the “LAST m:” value from the main screen. Compare the displayed value with the value given in Annex B of the Operation Manual. A difference of greater than ± 5% indicates instrument drift and corrective action needs to be taken.

5. Record all results in daily check sheet.

9.2 Monthly check

Procedure

1. Perform the daily checks as per Section 9.1 above "Daily checks".

2. Perform a LEAK CHECK as per Section 4.8 of Operation Manual. Record the leak rate displayed on the screen and track for deterioration.

3. Perform the FLOW CHECK as per Section 6.3 of Operation Manual. Typical BAM-1020 configurations have an ambient temperature and barometric pressure sensor to convert Mass flow to Volumetric flows. Perform the Flow Check while in “Normal” Operating Mode, ensuring that the pump is running. Flows should be 16.7 L/min ± 2%. If outside this tolerance then a Flow Calibration should be performed (note, this is the inlet flow at ambient density conditions, this value matches normal size selective inlet device flow requirements and is not the value used for mass concentration reporting (see Section 10). If using a Mass Flow device to check the flows, they will need to be corrected to local temperature and pressure conditions for Volumetric flow.

4. Record all results in Monthly check sheet.

9.3 2-Monthly check and maintenance

Procedure

1. Perform the daily checks as per Section 9.1 above.

2. Perform the Monthly checks as per Section 9.2 above.

3. Replace FILTER TAPE as per Section 4.7 of the Operation Manual. Note that typically the tapes only last for two months. Wrap the end of the new tape about 1½ turns around the take-up spool. Advance the tape about 10 spaces, then reverse about 5 spaces. This helps to position the tape on the rollers and indicates if there are any problems with the tape loading before sampling commences. Check remaining stock of filter tape. Order new tape if needed.

4. Perform FLOW CALIBRATION as per Section 6.3 of Operation Manual. Ensure instrument is in “flow calibration” mode. Flows should be 16.7 L/min ± 2%. If outside this tolerance then an adjustment should be performed. If using a Mass Flow device to check the flows, they will need to be corrected to local temperature and pressure conditions for Volumetric flow.

5. Perform a NOZZLE CLEAN, which cleans the inlet nozzle and nozzle area, as per Section 4.8 of the Operation Manual. Particulate build up on the nozzle may damage the filter tapes. The nozzle should be cleaned each time the filter tape is replaced. Isopropanol (Isopropyl alcohol) may be used as the cleaning solution.

6. Perform an INLET HEAD CLEAN as per Section 10.1.3 of the Operation Manual. Follow the instructions according to the type of Inlet Head in operation. Clean surfaces with a mild soapy solution and rinse with clean water. Pay particular attention that nozzles and impaction surfaces of inlet head are clean from particulate build up. Inspect and replace all O-rings as required. Ensure all Inlet Head components are dry before re-installing head on the sampler.

7. Check instrument zero by attaching a HEPA filter to the inlet (via the inlet flow adapter) and running for a sufficient period to include a full measurement cycle (minimum of one hour).

8. Record all results in 2-Monthly check sheet.

9.4 12-Monthly check and maintenance

Procedure

1. Perform the daily checks as per Section 9.1 above.

2. Perform the Monthly checks as per Section 9.2 above.

3. Perform the 2-Monthly checks as per Section 9.3 above.

4. Perform the complete clean of the Inlet System (including Inlet tube) as per Section 10.1.5 of the Operation Manual.

5. Perform a TEMPERATURE SENSOR CALIBRATION as per Section 6 of Operation Manual. Reference Thermometer should have up-to-date certification. Position Reference Thermometer within close proximity of BAM-1020 Outside Temperature sensor for best results.

6. Perform a PRESSURE SENSOR CALIBRATION as per Section 6 of Operation Manual. Reference Barometer should have up-to-date certification.

7. Record all results in 12-Monthly check sheet.

10. PROFORMAS & PAPERWORK

When completed all check sheets should be collated and kept with the instrument for future analysis. Electronic checklists are recommended instead of paper lists. Backup copies of the electronic files must be kept in a safe place. Electronic checklists should be printed out once every month.

11. BAM-1020 DAILY CHECKLIST

Date / Operator:										
ERROR LOG: any errors recorded?										
TAPE CHECK: Tape OK?										
Reference Check:										
"Last m:" value										
Pass / Fail?										
Comments:										

12. BAM-1020 MONTHLY CHECKLIST

Date / Operator:										
Leak Check:										
Leak rate LPM										
PASS / FAIL ?										
Reference Flowmeter make/model										
Flow Check:										
Reference Flowmeter s/n										
Measured Volumetric flow										
Displayed Volumetric flow										
% difference										
PASS / FAIL?										
Comments:										

13. BAM-1020 2-MONTHLY CHECKLIST

Date / Operator:										
Filter Tape										
Replaced Filter Tape?										
Flow Calibration										

Reference Flowmeter make/model										
Reference Flowmeter s/n										
Measured Volumetric flow										
Displayed Volumetric flow										
% difference										
PASS / FAIL?										
Adjusted?										
Nozzle clean										
Nozzle Cleaned OK?										
Inlet Head Clean										
Cleaned Inlet OK?										
Aerosol zero with HEPA filter										
Comments:										

14. BAM-1020 12-MONTHLY CHECKLIST

Date / Operator:										
Complete Inlet clean										
Cleaned whole of inlet system?										
Temperature Sensor Cal										

Reference Thermometer make/model										
Reference Thermometer s/n										
Measured (REF) temperature										
Displayed (BAM) temperature										
% difference										
PASS / FAIL?										
Adjusted?										
Pressure Sensor Cal										
Reference Barometer make/model										
Reference Barometer s/n										
Measured (REF) Baro.Press										
Displayed (BAM) Baro.Press										
% difference										
PASS / FAIL?										
Adjusted?										
Comments:										

15. DATA HANDLING/PROCESSING

Data can be transferred from the BAM1020 to either a stand-alone PC or central data facility via RS232 communication protocols. The normal mode of operation is to draw sample air through the filter tape for 50 minutes with the remaining time being taken for other instrument functions, giving an overall sample rate of one mass sample per hour. This determines that the only mass data hourly statistic is the mass concentration (together with any flags for indicating corrupt or contaminated data).

Raw data files should be retained and archived at the station or central facility. Data backup and processing at the station or central office should be carried out regularly, with a recommended minimum frequency of weekly.

Mass loading data reported to the GAW data centre should be calculated using flow normalized to STP (0 °C, 1 atmosphere). For the BAM-1020 utilizing the STD option, a density correction of x 1.0915, is required to convert mass concentrations reported by the instrument (using flow referenced to 25°C) to those recommended by WMO (using a flow referenced to 0°C).

Minimum requirements for data examination include plotting the time series of mass concentration data and examination of the station's mass monitor log to identify possible sample contamination or instrumental problems, such as flow problems. Any such episodes should be flagged in the subsequent edited data file and excluded from processing. Any additional corrections, calibrations, or other information, such as time zone, that are required to interpret the data (i.e. meta data) should be recorded in the meta data file for this period and form part of the data submission to the GAW archive. At some stations/locations data are screened using selected wind-sectors or species concentration data e.g. radon, to ensure that measurements represent specifically defined air masses. A description of any selection procedures should also form part of the submitted meta data file. (Some limited information on screening procedures is given in the GAW Aerosol Procedures manual, GAW 153, pg. 6, 2003, and more detailed information can be obtained from the Aerosol SAG).

Edited hourly statistics files, including all relevant meta data should be prepared into the format required by the GAW archive and submitted regularly to the GAW World Data Centre for Aerosols. These data should also be retained and archived at the station or central facility. Details on the archiving procedures and contact details are given in Chapter 7.

16. REFERENCES

Met One Inc. *BAM-1020 Operation Manual*.

WMO/GAW *Aerosol Measurement Procedures: Guidelines and Recommendations*, GAW Report No. 153, TD No. 1178, 2003 http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html

sag-aero@tropos.de

CHAPTER 3

Light Absorption Coefficient - Filter-based –

Thermo 5012 Multi Angle Absorption Photometer (MAAP)

WORK INSTRUCTION MANUAL

1. AMENDMENT RECORD SHEET

This chapter is based on procedures used at the Cape Grim Baseline Air Pollution Station, developed by the Marine and Atmospheric Research Division of the Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

Amendment Officer	Amendment Date	Section Number	Brief description of amendment
J Ward	July-Aug 2008	All	Initial Draft of all sections
JG, JW	Dec 2008	All	Revision

2. INTRODUCTION AND DESCRIPTION

2.1 The 5012 Multi Angle Absorption Photometer (MAAP)

The Thermo Electron Corporation (Teco) Model 5012 Multi Angle Absorption Photometer (MAAP) utilises single wavelength light absorption to infer black carbon (BC) concentration, from the light absorption coefficient at a nominal wavelength of 630 nm. It uses a multi-angle absorption photometer to measure the radiation fields in the forward and back hemisphere of a glass-fibre filter caused by deposited particles. This approach allows use of aerosol radiative transfer theory to essentially remove scattering effects that otherwise impact on the derived light absorption coefficient; the data inversion algorithm takes multiple scattering processes inside the deposited aerosol and between the aerosol layer and the filter matrix explicitly into account.

For more details on the theory of operation, see Section 8 of the MAAP manual.

The Cape Grim 5012 operates with the following configuration:

- 240Vac Line voltage setting
- PM-1 Size Selective Inlet (a BGI VSCC), operated at < 40% RH
- RH controlled inlet heater system set to keep sample RH to <40%

Operational flow rate is controlled to 16.67 Lm-1 (1000 litres per hour at the cyclone), at ambient pressure and cyclone temperature.

Filter advance: Auto with transmission < 20%
Exhaust port exhausted to outside laboratory, via bench-end extractor.

Measurement Interval: RS232: 1-sec, data reported: 1-minute, further processed to 1-h statistics.

Standard conditions for reported concentrations 0 ºC, 1 atm., flow is calibrated at ambient.

During normal operation, the keyboard usually is locked. The majority of the menu points and all displays can be accessed by pressing the **BACK, NEXT** and **YES** keys. Changing operational and calibration parameters are only possible after enabling the keyboard. With the keyboard enabled only operational changes are possible. To calibrate the unit, a code must be entered to access calibration rights.

2.2 Primary reference

Teco Model 5012 MAAP Instruction Manual for v1.2, edition 1 Dec 2003, p/n 100076-00.

2.3 Work instructions

Maintenance, Audit, Calibration	Frequency	Acceptance Criteria	Operating Manual Reference	Responsibility
Daily checks	Daily	Various	Whole manual	CG Staff
Weekly checks	Once per week	Various	Whole manual	CG Staff
Filter tape	As needed	n/a	Chapter 2	CG Staff
Flow Audit	3 monthly	± 0.2 Lm-1	Chapter 4 & 5	CG staff /QA visit by CMAR staff
Temp/Press/RH sensor cal	12 monthly	Temp: ±1 ºC Press: ±10 hPa	Chapter 4 & 5	CG staff /QA visit by CMAR staff
Flow Calibration	12 monthly	± 0.2 Lm-1	Chapter 4 & 5	CG staff /QA visit by CMAR staff
HEPA check	12 monthly	0 ng/m3 BC	Chapter 6	CG staff /QA visit by CMAR staff

3. DAILY CHECKS

Purpose

This procedure describes how to perform the Daily checks.

Scope

This should be performed every day of the working week.

Reference

Teco Model 5012 MAAP Instruction Manual for v1.2, edition 1 Dec 2003, p/n 100076-00.

Equipment

CG BAPS Daily check sheet.

Procedure

1. View the Status LED's next to the Display. A green LED next to "ready" indicates the instrument is operating normally. Red "error" LED's indicated an instrument error that may need to be rectified. Record in check sheet.

2. Observe the instrument display. Check if there are any instrument Status conditions or Errors present. Identifying and interpreting the error codes are described in Chapters 3 and 6 of the manual. Record in check sheet and Particles Logbook.

3. Observe instrument output – check that data are within normal expected ranges. In Baseline typically expect BC < 25 ng m-3 and non-Baseline typically < 100ng m-3, although many mg m-3 is possible during strong pollution, e.g. smoke, events.

4. 3 - MONTHLY CHECKS

Purpose

This procedure describes 3-monthly checks, to be carried out by station staff or by CMAR staff on QA/QC visits.

Scope

The principal 3-monthly check is an audit of the MAAP inlet flow. Flow rate in the MAAP is determined using an orifice plate located after the filter tape. The flow rate is then calculated from the pressure drop measured at the orifice plate (together with pressure and temperature), see Figure 1.

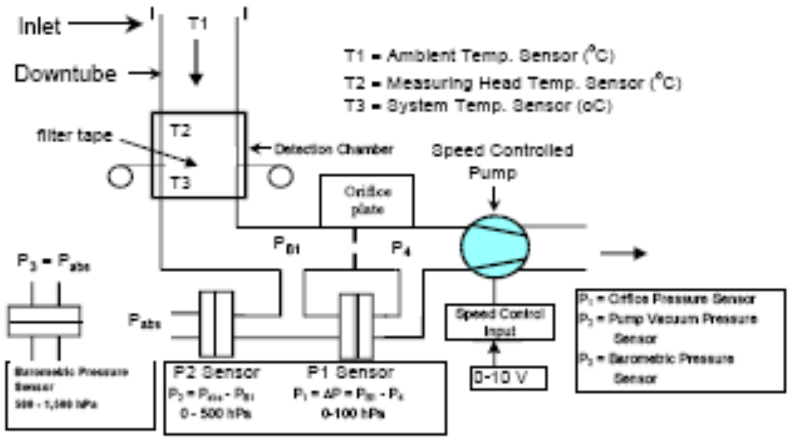


Figure 1

Reference

Teco Model 5012 MAAP Instruction Manual for v1.2, edition 1 Dec 2003, p/n 100076-00.

Equipment

Station flow standard – (Gillibrator).

Procedure

1. Flow check as per Chapter 5 of the manual. Disconnect the inlet line from top of MAAP and attach flow audit connector (5/8" to 3/8" reduction) to enable connection to the Gillibrator. With the MAAP running take a minimum of 10 readings at 10 second intervals on the Gillibrator. Record the average reading in the particle log, the value should be 16.7 L m-1. If the measured flow diverges more than ± 0.2 L m-1 from 16.67 L m-1 a flow calibration should be initiated (this will require temperature and pressure checking/calibration first).

2. Clean the grit-pot on the in-line cyclone and regrease lightly with silicone grease. Re-tighten "finger-tight".

3. Record all test details in Particles Logbook.

5. 12-MONTHLY CHECKS

Purpose

This procedure describes annual checks, to be carried out by station staff or by CMAR staff on QA/QC visits.

Scope

The principal additional annual checks are an audit of the MAAP environmental sensors (temperatures and pressure), with recalibration if necessary, (manual also recommends check/replace pump vanes) a filter check for zero and check of the set point humidity for the SSI humidity control heater.

Reference

Teco Model 5012 MAAP Instruction Manual for v1.2, edition 1 Dec 2003, p/n 100076-00.

Equipment

Reference Thermometer with an accuracy of ±0.5 ºC.

Reference Barometer with an accuracy of ±5 hPa (or station barometric pressure).

Humidity Salt Solutions.

Reference manometer.

Procedures

1. Temperature and pressure calibration are described in Section 4.3.1 of the manual. Put MAAP into calibration mode (will require the access code: 147), scroll down to Outside temperature, measure temperature of SSI temperature sensor using the transfer thermometer. If the difference in temperatures exceeds ±1 ºC, proceed to the recalibration. Record details in the Particles log.

2. Scroll down to Barometric Pressure, record pressure indicated by MAAP and either station level pressure (from Obs) or from a traceable barometric sensor. If the difference in pressures exceeds ±10 hPa, proceed to the recalibration. Record details in the Particles log.

3. Carry out flow audit, and then a zero check, also perform differential pressure sensor calibration if the flow calibration has shifted appreciably. For the zero check attach a Hepa cartridge filter to the inlet, scroll down to the Service menu, enable the keys and proceed to open the head and advance the filter, stop the motor and close the head. Scroll back to normal operation. Leave the filter in place for sufficient time to determine the zero level, this can be read by scrolling down the display to give last hour, 3 hour and 24 hour averages. It is desirable to run for at least 3 hours with filtered air to assess the noise level. Record all information in the Particles log.

4. Calibrate the Humidity Sensor in the Inlet Heater system over several points encompassing 40% RH, and set to the Controller to activate at 40% RH. Record initial and final readings in the Particles Logbook.

5. If required, replace the carbon vanes in the vacuum pump as per chapter 5 and 7 of the manual. Service the pump outside of the laboratory so that carbon dust does not contaminate the airspace.

6. INSTALLING THE FILTER TAPE

Purpose

This procedure describes how to install a new Filter Tape.

Scope

This should be performed when the instrument is first installed and/or when the previous filter tape finishes.

Reference

Teco Model 5012 MAAP Instruction Manual for v1.2, edition 1 Dec 2003, p/n 100076-00.

Equipment

New Filter Tape, Teco p/n: FH111.
Double-sided sticky tape.

Procedure

1. Follow the steps under "Filter Tape Installation" on page 2-7 of the manual, which refer to the Front View diagramme on page 2-2.

2. Be sure to check correct rotation of the spools and correct spool tension. Follow the checks in the last paragraph on page 2-7.

3. Record in Logbook that a filter change has occurred.

7. REFERENCES

By John Gras and Jason Ward.

Teco Model 5012 MAAP Instruction Manual for v1.2, edition 1 Dec 2003, p/n 100076-00.

CHAPTER 4

Light Absorption Coefficient - Filter-based - Radiance Research

Particle/Soot Absorption Photometer (PSAP)

1. PURPOSE

This document outlines the standard operating procedures for the measurement of aerosol light absorption coefficients using a Particle Soot Absorption Photometer (PSAP, Radiance Research, Inc., Seattle, WA, USA). There is a need for the standard operating procedures applicable to all WMO/GAW sites. The aerosol light absorption measurement has been recommended by Scientific Advisory Group on Aerosols for long-term measurements in the Global Atmospheric Watch global network, as a subset of essential core variables (GAW Report 153, 2003). Having a common guideline for the operation and maintenance of PSAP instruments at all GAW sites ensures a similar quality for light absorption measurements and to reduce potential systematic biases in the data due to differences in methodologies, set-up and maintenance.

2. PRINCIPLE OF PSAP OPERATION

PSAP is used to measure high time-resolution aerosol light absorption coefficient, σap. This measurement is based on the rate of change of light transmission through a fiber filter, as particles deposit and accumulate onto the filter. There are two types of PSAP instruments commercially available at Radiance Research Inc.; a single-wavelength PSAP that measures light absorption at the wavelength of 565 nm and a 3-wavelength PSAP (3W PSAP) that measures light absorption at wavelengths of 467, 530 and 660 nm respectively.

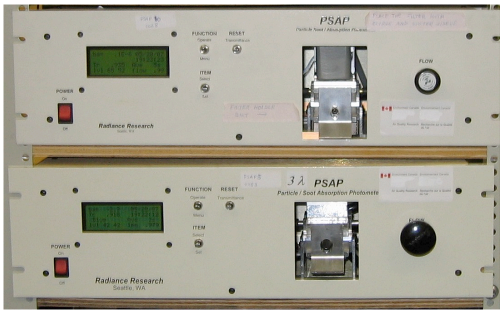


Figure 1 - 1W & 3W PSAP (Radiance Research Inc.) as installed at Alert GAW station

Air is drawn through two identical glass fiber filters in series and an aerosol sample is collected on the exposed area (~ 0.5 cm in diameter) of the first filter. Light is transmitted through the aerosol sample on the first filter (sample filter) and through the clean second filter (reference filter). The light intensities detected are compared between the sample side and the clean reference side. As aerosols accumulate on the sample filter with time the light transmittance drops and light absorption coefficients are determined by the Beer's-law:

$$\sigma_{ap} = \frac{Area}{Vol} \times \log\left(\frac{I_0}{I}\right)$$

where *Area*=exposed sample spot, *Vol* is volume of air sampled, I_0 is filter transmittance in average period *i* and *I* is transmittance in period *(i+1)*. The software within the instrument has an algorithm which corrects for the filter loading non-linearity. This transfer function *f(τ)* is incorporated in the software and is based on filter loading for Pallflex filters (Pall Life Sciences, E70-2075W). The function is defined by Equation 2:

$$f(\tau) = (1.0796\tau + 0.71)^{-1}$$

where τ is filter transmission (set to unity in the software for unloaded filter). It should be noted that Equation (2) is applicable only to Pallflex filters. If other filters are to be used, Equation (2) must be re-evaluated. At this time, the PSAP manufacturer has only recommended the use of the Pallflex filters.

3. INSPECTION AND SET-UP OF PSAP

3.1 Initial inspection and checks

A new instrument as received from the company should go through an initial inspection as some electrical components might become loose in transportation.

1. Remove the top panel and ensure all the electrical connections are in place and there are no loose cables.

2. Ensure that the tube connections follow the actual flow schematic. In particular, make sure that the flow path permits air flow from the outlet (bottom) of the sample cell to the inlet (top) of the reference cell. The flow through the PSAP instrument should be in the order as shown below.

Sample inlet→ Sample cell→ Reference cell→ Flow meter

Needle valve→ Outlet→ Pump

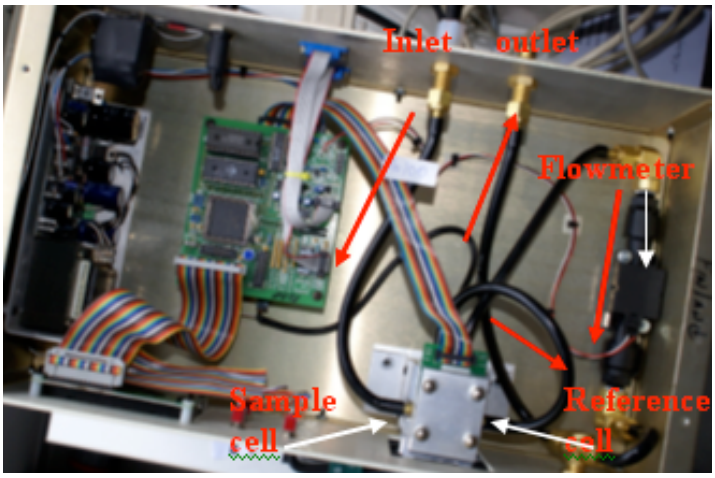


Figure 2 - This picture shows the electronics and tubing connections inside the PSAP. Red arrows indicate the direction of the flow in a correct orientation

3. Conduct a leak test. Turn the instrument on. Leak test must be performed as follows before putting the instrument into operation:

Put a filter in the filter-holder. Cap off the sample inlet, connect and turn on the pump on the vacuum side. The flow on the PSAP display (or in data captured via the serial port) should be close to zero if there are no leaks in the system. This can also be done by a handheld leak checker, if available, with a vacuum gauge. The leak rate should be low and should not exceed a few millibars per minute.

4. Overnight zero test must be performed on a new PSAP by connecting a HEPA filter to the sample inlet to remove the particles. This will determine the sensitivity (noise level) of the instrument. This test is especially important for instruments that are being installed in pristine environments.

5. Make record of the range of photo-detector current (1873 nA) and make sure that the signal and reference values are in the range of 200,000 to 600,000.

6. PSAP has positive interference from the relative humidity. Ensure either the sample stack has a heated inlet which is relative humidity controlled or install a small heater inside the PSAP so that the inlet is gently heated by a few degrees.

7. Calibrate the flow meter in the PSAP by using a proven method. For example, a Gilibrator (Sensidyne, Gilian) can be used to calibrate the volume flow through the PSAP inlet, but an accurate measure of temperature and pressure at the time of calibration will be required to convert the flow to that at the standard temperature and pressure (STP) of 25oC and 1 atmosphere. The calibration of the flow meter is necessary to ensure that the volume used in equation (1) and used in the calculation by the firmware is correct.

8. An accurate measure of the spot size of the exposed area on the sample filter is needed in the calculation shown in equation 1. Use a hand held reticle with scale accurate to 0.05 mm to measure the diameter of the spot size. Take the average of spot size diameter taken by at least 3 people on at least 10 samples on a monthly basis.

9. It is advised that data should be collected at a highest reasonable time resolution so that fast changes in the aerosol response to absorption are recorded. However, there is an option to choose the desired time-step for data averaging in the PSAP software. This could be exercised at the sampling locations depending on how polluted the air-mass is?

10. For a 3W PSAP, go through the PSAP set-up windows and check that initial parameters (default values) with the measured parameters as follows:

If using NOAA software as a data collection platform then adjust the parameters as follows:

- *The default flow parameters are 1000 for 0, 1240 for 0.3 and 2600 for 2*
- *The parameters A=0.814, B=1.237 and Area should be set to 17.81 mm2*
- *The spot-size and 5-point flow corrections are applied in the software as data is processed*

If using your own software for data collection then adjust the parameters as follows:

- *The default flow parameters are 1000 for 0, 1240 for 0.3 and 2600 for 2 and these should be changed to corrected measured flow*
- *The parameters A=0.814, B=1.237 and Area should be set to the measured value in mm2*

3.2 Sample inlet

The sampling set-up, which includes a common aerosol sampling inlet for all instruments, size-cuts and sample conditioning, is described in GAW report # 153 (2003). According to the report the aerosol sample inlet must be set-up to ensure transmission of particles between 0.1 to 10 µm size ranges.

Determine the operational detection limit for the PSAP as installed in the sampling system. This can be done by placing a HEPA filter on the entrance of sample intake if possible or in-line to the PSAP and collect data in this orientation for at least 24 hours to determine the changes in the zero absorption. The detection limit of the instrument is determined as 3 times the standard deviation above the mean absorption measurements.

3.3 Data collection

The difference in the data collection between the single wavelength (1W) and the 3W PSAPs is that the 1W PSAP has serial and analog output options but the 3W PSAP has serial output only. Serial data are transmitted once every second and are easily collected using a computer. The absorption data are updated at the end of the averaging period selected in the firmware. Any software capable of capturing a serial data-stream can be used as data collection platform. The data transmission rate of the PSAP (baud rate=9600 for new PSAPs; some old models require baud rate of 4800), specified in the PSAP setup, needs to be used in the software to collect the data properly. A data-logger is required for capturing the analog data-stream. Similar to the 1W PSAP, the initial sample and reference intensities are also available in the 3W PSAP data stream but these raw readings are embedded in a hexadecimal format in the end column. If needed, a programme is available from the supplier to extract these raw data for changes to absorption at a later date.

4. CALIBRATION AND RAW DATA ADJUSTMENTS

The filter-based optical methods for the determination of aerosol light absorption coefficients have limitations and artifacts as changes in light attenuation depend on the nature of the filter matrix and light scattering constituents of the aerosols deposited onto the filter. A calibration method devised by Bond et al. (1999) has been used widely to correct for the filter loading and light scattering artifacts.

Prior to such correction is applied to the data, the raw light absorption coefficient data must be adjusted for the spot size and flow corrections post data collection procedure. There is a discrepancy in the reported spot size by Bond et al. (1999) to derive their correction scheme and spot size that PSAP firmware uses to calculate the absorption coefficient. The spot area of 17.83 mm2 is used in the 1W PSAP firmware but the manufacturer's reference of 20.43 mm2 of area has been used to derive the Bond et al. (1999) correction scheme. Thus, an adjustment of 0.873 must be applied to compensate for this discrepancy in the areas (Ogren, 2010). Equation 3, below, is used to do this adjustment:

$$\sigma_{adj} = \left(\frac{Q_{psap}}{Q_{meas}}\right) \times \left(\frac{D_{meas}}{D_{calib}}\right)^2 \times \sigma_{PSAP}$$

where Q_{psap} is the flow used by PSAP, Q_{meas} is the flow obtained after calibration, D_{meas} is the spot size measured, and D_{calib} = 5.1 mm is a reference used in the PSAP calibration by the manufacturer (Bond et al., 1999). However, for the 3W PSAP, there is an option in the set-up menu where the spot area can be preset before measurements are started as mentioned in Section 3.1 (10).

The technique for light scattering corrections suggested by Bond et al (1999), which requires light scattering measurements, should be implemented to correct the PSAP data at all GAW sites as shown in Equation 4:

$$\sigma_{ap} = \frac{(\sigma_{adj} - K_1 \times \sigma_{sp})}{K_2}$$

where *σadj* is obtained from Equation 3, K_1=0.02±0.02 and K_2=1.22±0.20 have been derived by Bond et al. (1999), σ_{sp} is the light scattering coefficient at 550 nm as measured by a nephelometer. Bond et al. (1999) suggested that for large scattering aerosols (e.g., sea salt, dust, etc.), the K_1 value could be as low as 0.01, although no specific guidance is given on the relationship between particle size and K_1.

5. DATA PROCESSING AND ARCHIVE

The following procedures must be applied to the raw light absorption data as recorded by the acquisition programme:

1. When processing raw data stream, it is advisable to take certain steps in maintaining the integrity of the measurements. The quality control procedures must be followed with proper

flagging procedures. Data must be flagged invalid if one or more of the following conditions are met:

(i) There is no flow through the filter due to broken pump or a major leak
(ii) Transmittance values decrease below 0.6; the measurements may now have artifacts from aerosol shadowing
(iii) There are spikes in the data due to local contamination from nearby sources. The contamination sector should be determined. Aerosol number concentrations could be used, if available, as a measure to determine the local contamination when the winds are from the contamination sector
(iv) When the values for absorption are negative. This can happen when absorption values are small, and in Equation (1) the transmittance I in the current averaging period is nominally smaller than the I_0 in the previous averaging period due to uncertainties in the transmission measurements

2. Check the time-step to identify any data-gaps in the data-set.

3. Apply the spot size and flow corrections to the light absorption data as described in Section 5.

4. Light absorption data must be merged with light scattering data after the initial quality control process is achieved. Apply Bond et al. (1999) correction for the effect of light scattering, as described in Section 5, to the light absorption data to compensate for scattering by particles. Use the light scattering data at 550 nm.

5. Report hourly and daily averages of light absorption coefficients time series in the final data set as per the guidelines of the GAW, or as required by the local needs.

6. Procedures for submission of data to the World Data Centre for Aerosols are given in Chapter 7.

6. MAINTENANCE AND REPAIRS

6.1 Daily checks

1. Check that the pump is running and there is flow through the PSAP as set between 1 to 2 standard litres per minute.

2. Check that the filter is placed in the correct orientation with whiter & brighter side up in the filter holder.

3. Check that the filter is changed before the transmittance value reaches 0.6.

4. Check that the o-rings are still in place before and after the filter is changed.

5. While changing the filter, examine the exposed area and ensure that it is sharp and does not appear dispersed or fuzzy at the edges. If it is dispersed, there is a leak, i.e., the o-rings are not making a good seal. Examine the o-rings and replace if necessary.

6.2 Monthly checks and cleaning

1. Cleaning of the sample cavity is important on a regular basis to maintain low detection limits for the absorption measurements. The sample cavity must be cleaned once a month with a swab dipped in methanol. Ensure that fibers from the swab are not left behind in the cavity. Record the raw signal value on the monthly log sheet before the cleaning by flicking the up switch until you get to the signal and reference window. Record the signal value after cleaning. Do the same with reference cavity.

2. Check the performance of the lamp by recording the sample and reference readings (between 200,000 to 600,000) as well as lamp voltage and current on a regular basis.

3. Inspect the inside of the enclosure box and make sure all tubings are still firmly connected and all electrical connectors are securely in place.

4. Check to see if the o-rings are still in place, determine the integrity of the o-rings and make sure that there are no breaks in the o-rings. Replace the o-rings if they are missing or damaged.

5. Measure the spot size accurately on 10 filters per month.

6.3 Lamp change

For the 1W PSAP, the lamp is an ultra-brite green LED. There is a spare taped to the inside of all instrument case. Remove the rubber cap, and cut or de-solder the leads from the lamp. The lamp is press fitted with a small amount of glue to hold it in place. This seal could be broken with a pair of pliers. Install the new lamp and re-solder the power leads to the lamp leads. The long lead on the LED is positive and should be connected to the centre lead of the shielded wire. The shield connects to the short LED lead (as described in page 8 of the PSAP manual).

For the 3W PSAP, changing the light source should left to experienced operators or to be performed by the factory.

Table 1 - Daily Check Sheet

Sample Filter ID#	*Sample Start* Date	Time (UTC)	*Sample Stop* Date	Time (UTC)	*Trans. Value (end time)*	*Flow check*	*O-ring Check*	*Spot size appearance check*

Table 2 - Monthly Maintenance Logsheet

Date	*Time (UTC)*	*Sample Cavity Cleaning*		*Reference Cavity Cleaning*		*Lamp Voltage*	*Lamp Current*	*o-rings condition*	*Spot size diameter*

7. REFERENCES

Bond, T.C., T. L. Anderson & D. Campbell (1999), Calibration & intercomparison of filter-based measurements of visible light absorption by aerosols, *Aerosol Science & Technology* 30, 582-600.

WMO/GAW *Aerosol Measurement Procedures: Guidelines and Recommendations*, GAW Report No. 153, TD No. 1178, 2003.

PSAP manual, Radiance Inc.

Ogren, J.A. (2010). Comment on "Calibration and Intercomparison of Filter-Based Measurements of Visible Light Absorption by Aerosols". *Aerosol Science & Technology* 44, 589-591, doi:10.1080/02786826.2010.482111.

CHAPTER 5

Light Scattering Coefficient - Integrating Nephelometer - Ecotech M9003

1. AIM

This manual outlines Standard Operating Procedures (SOP) for measurement of aerosol light scattering coefficient using an Ecotech M9003 integrating nephelometer. It is intended for use by staff carrying out aerosol light scattering measurements, using such instruments at WMO GAW stations.

Guidance on setting up the sampling system and measurement and reporting of aerosol properties can be obtained in GAW 153 (2003). Sample conditioning to standardized relative humidity is particularly important for aerosol light scattering coefficient determination and particular care is required to achieve this without significant mass loss, or in humid environments problems with condensation.

Additional information can be obtained from sag-aero@tropos.de.

2. BACKGROUND

Continuous measurements of aerosol light scattering coefficient is a high priority component of the suite of aerosol measurements recommended by the WMO Aerosol SAG to better understand the global climate and air quality impacts of aerosol particles.

3. TERMS AND DEFINITIONS

WMO GAW = World Meteorological Organization, Global Atmosphere Watch.

Aerosol SAG = GAW Scientific Advisory Group for aerosol.

NARSTO DES = North American Research Strategy for Tropospheric Ozone, Data Exchange Standard.

Nephelometer = The integrating Nephelometer used to determine aerosol scattering coefficient.

σ_{sp} = The coefficient of aerosol scattering as displayed by the M9003.

Mm^{-1} = Unit of measure for σ_{sp} , inverse megameters (1 Mm^{-1} = 10^{-3} km^{-1} = 10^{-6} m^{-1}).

Reference Thermometer = A traceable reference thermometer must be used for the calibration of the temperature compensation sensor and must have an accuracy of ± 0.1 degrees Celsius (°C).

Reference Barometer = A traceable reference barometer must be used for the calibration of the pressure compensation sensor and must have an accuracy of ± 1 kiloPascals (kPa).

CO_2 = Typical gas used for span calibration.

FM200 = (1,1,1,2,3,3,3) heptafluoropropane, alternative gas used for span calibration. Gives a signal response closer to the full-scale output than CO_2.

DFU = Disposable Filter Unit.

HEPA = High efficiency particulate aerosol (filter).

SSI = Size selective Inlet.

4. SAFETY AND PRECAUTIONS

Calibration of nephelometers usually involves the use of inert pressurized gases; appropriate safety precautions for safe handling of gas cylinders including bottle restraint, use of regulators in good working condition need to be observed. Venting of calibration gases into poorly ventilated or small enclosed spaces must be avoided to prevent asphyxiation hazards. Venting should also be carried out in a manner that minimizes impact on other measurements. Ozone depleting and high greenhouse potential calibration gases (e.g chlorofluorocarbons) should be avoided.

5. STATEMENT OF TRACEABILITY

Light scattering measurements are referenced to pure calibration gases for which accepted light scattering coefficient values have been published in the scientific literature. Temperature and pressure calibrations need to be traceable to an appropriate national or international standard.

6. EQUIPMENT

- Integrating nephelometer
- Calibration equipment includes:
  - High efficiency filters (e.g. HEPA cartridge, high grade DFU - e.g. Balston AQ)
  - Connecting tubing
  - Flow indicator (for calibration gases)
  - Reference gases
  - Pressure regulator or other devices for reducing the calibration gas flow to a steady low flow rate
  - Reference thermometer
  - Reference barometer

7. OPERATING PRINCIPLES OF THE M9003 INTEGRATING NEPHELOMETER

In its most common configuration, an integrating nephelometer measures the amount of light scattered by a sample of air at one or more wavelengths, using a small near-Lambertian, diffuse, light source. The sample air is drawn into a blackened sample chamber where it is illuminated by a very bright LED array (light source). The light scattered by the sample of air is detected by a photomultiplier operating in photon-counting mode. The fraction of the scattering due to particles is separated from that due to air. It is scaled in the instrument's controller using stored calibration factors, and then logged in the data memory. The instrument is calibrated by introducing filtered air, to give an aerosol zero, and a gas with a known scattering coefficient, typically CO_2 to give the span.

The Ecotech M9003 integrating nephelometer displays the aerosol scattering coefficient as σ_{sp} in Mm^{-1} (inverse Mega meters). It can be operated stand-alone with its own internal data logger or connected to an external data logger. It can condition incoming sample air to provide a fixed upper relative humidity level. Calibration sequences can be initiated manually or automatically.

8. RESPONSIBILITIES

Each GAW station that utilizes this type of equipment has the responsibility to ensure that the outlined operating procedures are followed. The WMO GAW Aerosol SAG has the responsibility for updating this manual.

9. OPERATION AND MAINTENANCE OF THE NEPHELOMETER

9.1 Procedures covered

This document describes the procedures used to perform routine maintenance, audits and calibrations on the Nephelometer at weekly, 3-monthly, and 6-monthly intervals. Because many of the maintenance activities are performed jointly with the calibrations and audits all are contained within this document.

9.2 Setting up the instrument for operation

The M9003 nephelometer may be mounted on a table top, bench or wall mounted. It should be located at a level that is convenient for calibration and arranged so that the inlet is as direct as possible, preferably with no bends or changes in tubing diameter. The inlet should have a rain hood or shroud to prevent rain entering the sample line. The M9003 should preferably use a dedicated inlet to prevent back flow of calibration gas during (automatic) calibration interfering with other measurements. Further details on inlet characteristics are given in the WMO report GAW 153 (p4). If the laboratory operates at a temperature lower than ambient and the humidity is high, an inlet heating system (and/or other drying device) will be necessary, also the inlet line inside the laboratory will need thermal insulation (using regular air conditioner foam insulation) and possibly additional heating. The nephelometer inlet can operate to maintain the sample RH at less than 40%, which is the recommended way to operate. For further details see the Ecotech M9003 manual.

- *Size selective inlet* – the GAW aerosol programme recommends use of a size selective inlet, although it is also common practice to operate nephelometers looking at the total scattering coefficient (with no size selection, or Total Suspended Particulate, TSP). For GAW a size cut of 1 µm diameter at low RH for sampling the submicrometer diameter aerosol fraction is recommended (see GAW153, pg 26); the GAW Programme also suggests use of a 10 µm diameter cut or switched inlets. In its standard configuration using an internal pump the M9003 cannot be operated with a SSI (e.g cyclone), use of a SSI requires modification of the flow system. Information on the type of inlet used should be included as part of the meta-data provided together with the observations to the data repository.

9.3 Set-up for calibration

See Figure 1 below (and Ecotech M9003 Users Manual).

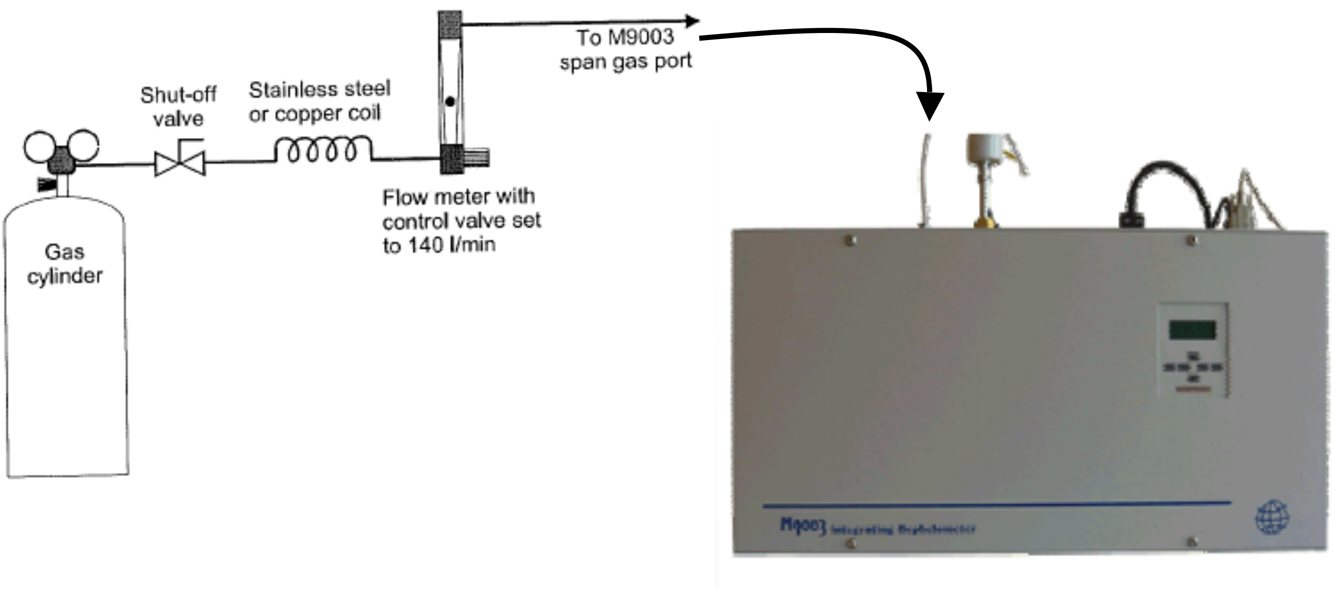


Figure 1 - Calibration Set-up

- *Calibration gas* - pure gas (~100% v/v) and regulator or an adjustable valve for lower pressure gases. Refrigerant gas, fire retardant gas (eg FM200) or CO2 may be used ('food grade' is acceptable) – additional filters for zero air and cal gas are recommended. Configure Settings as per Section 3.6 of this work instruction.
- *Length of copper tubing* - around 5 to 6 m long is needed for the calibration gas to warm up to room temperature after it leaves the gas bottle.
- *Flow indicator* - ball flowmeter etc (around 0-5 l/min).
- *Zero air line* – install minimum 1 meter of ¼" tubing into 'Zero Air' port and place additional filter on end of tubing. Keep tubing away from calibration gas cylinder.

Note: Span Calibrations are typically initiated *manually* at 1 to 3 month intervals. If calibrations are to be initiated *automatically* then the gas lines must be pressurized and flows checked first. The line will stay pressurized when the cal cycle is off.

9.4 Default configuration

All instrument operating parameters can be accessed through the keypad and a simple menu that is displayed on a LCD display. Default parameters are included for a typical operating situation.

Settings on the menu screen – these are the recommended normal settings

Report preferences Screen:

Date:	D/M/Y
Temp:	ºC
Press:	mB (milliBar =hPa)
Normalise to:	0 ºC (the Standard Temperature to which to normalize)

Calibration Screen:

Zero check:	24 hrs
Wavelength:	520 nm
Span Gas	CO_2 (or whichever gas is used)
Min cal time:	10 min
Max cal time:	20 min
% stability:	97%

Control Screen:

Cell Heater:	yes
Inlet heater:	yes
Desired RH:	40%
RH buffer:	2%

Analog out Screen: Not used here

Serial I/O Screen:

Baud:	9600 (but depends on Logging system)
Parity:	none

Adjust Clock Screen: Adjust clock as necessary (see manual) normally operate UTC, with the time zone used reported as part of metadata file

Data Logging Screen:

Log period:	5 min
Clear Datalg:	(only when you need to)
Log data now:	(only when extra readings are wanted at a particular time)

Remote menu: No

9.5 Summary of work instructions

Maintenance, Audit, Calibration	Frequency of task	Acceptance Criteria
Weekly check	Once per week	various
3 monthly check	3 monthly	various
6 monthly check	6 monthly	various
12 monthly check	12 monthly	various
Manual Zero/Span Calibration	3 monthly or as needed	Zero: ±1 Mm-1 Span : ±2% of span (e.g. ± 4 Mm-1 for FM200
Temp/Pressure/RH Calibration	12 monthly	Baro.Press.: ± 10 hPa Temps: ±1°C RH: ±1%

9.6 Daily check

Purpose

A daily manual check of the instrument, comprising examination of data on the instrument display will ensure that instrument malfunction is discovered quickly and that corrective action can be taken without delay.

9.7 Weekly check

Purpose

This procedure describes how to check that the regular (every 24 hours) zero measurement has been made and that operating parameters are within acceptable tolerances.

Frequency

This should be performed at weekly intervals.

Equipment

M9003 Weekly check sheet.

Procedure

1. Confirm Instrument is powered up and operational. Confirm Sample Fan is operational by placing hand over exhaust grill.

2. Enter READINGS screen from MAIN MENU and record following parameters into C.

i. Heck sheet:

Readings Screen:

Scattering Coefficient	xxx
Atm Pressure	xxxx
Air Temp	xx
Cell Temp	xx

Rel Humidity xx

ii. Enter CALIBRATION Screen from the MAIN MENU and record the following parameters in the Check sheet:

Calibration Screen:

Wavelength:	520 nm.
Last Zero check:	x.xxx
Zero Check stability:	xx%
Wall signal:	xx

iii. Enter the CONTROL screen from the MAIN MENU and record the following parameters in the Check sheet:

Control Screen:

Cell Heater:	yes
Inlet heater:	yes
Desired RH:	40%
RH buffer:	2%

6. Enter the HIDDEN MENU by pressing on the FIRST "C" in the ECOTECH label below the keypad, and record the following parameters in the check sheet:

Hidden Menu ® Counts Screen:

Dark count:	xxxxx (within 0-10, >20 is BAD!)
LED Set point:	xx (within 0-40, typically 5-25)

The DARK count gives the PMT signal with the light source (LEDs) OFF. A high value indicates a light leak into the cell.

The SHUTTER count gives the PMT signal during the Reference cycle (every 15 seconds). It should approximate 1,200,000 counts.

7. Confirm Nephelometer clock time against UTC time and adjust if necessary. If adjustment is necessary, report both the old and the new setting of the clock.

8. Enter any additional comments into Comments Box of Check Sheet.

9.8 3-Monthly check

Purpose

This procedure describes how to perform the 3-monthly checks and calibrations.

Frequency

This should be performed every 3 months.

Equipment

- Monthly check sheet
- Calibration gas

Procedure

1. Perform the Weekly checks (as per this Work Instruction: 9.7).

2. Perform the Manual Zero/Span Calibration (as per this Work Instruction: 9.11).

3. Inspect and clean inlet (remove trapped dust, bugs, etc).

9.9 6-Monthly check and maintenance

Purpose

This procedure includes more frequent checks plus checking the DFUs.

Scope

This should be performed at least twice per year.

Equipment

- Monthly check sheet
- Calibration gas
- New DFU's

Procedure

1. Perform the Weekly checks (as per this Work Instruction: 9.7).

2. Perform the 3-Monthly checks (as per this Work Instruction: 9.8).

3. Inspect and replace Zero Air Pump DFU by following Maintenance Section of Users Manual. Replace only if necessary (noticeable particle loading).

4. Inspect and replace Zero/Span Air DFU by following Maintenance Section of Users Manual. Replace only if necessary (noticeable particle loading).

5. Add entry into Comments Section of Weekly check sheet if replaced DFU's.

9.10 12-Monthly check & maintenance

Purpose

This procedure includes more frequent checks plus checking the nephelometer temperature and pressure calibration.

Scope

Temperature and pressure checks should be carried out at least every 12 months.

Equipment

- Reference thermometer
- Reference barometer
- Audit sheet No. 4

Procedure

1. Perform the Weekly checks (as per this Work Instruction: 9.7).

2. Perform the 3-Monthly checks (as per this Work Instruction: 9.8).

3. Perform the 6-Monthly checks (as per this Work Instruction: 9.9).

4. Replace the two AA back-up batteries by following Maintenance Section and page 7 (diagram) of Users Manual.

5. Add entry into Comments Section of Weekly Check sheet if replaced batteries.

6. Carry out temperature and pressure checks (as per this Work instruction: 9.12).

9.11 Manual zero/span calibration

Purpose

This work instruction describes how to perform manually initiated zero & span calibrations.

Equipment

- Calibration Gas

Procedure

1. Use the M9003 calibration proforma located at the end of this procedure to record calibration information.

2. Ensure the **Span gas** type is set in the CALIBRATION Menu (e.g to FM 200).

3. Follow instructions in Section 3.5 of this Work Instruction for connecting the calibration gas to the span port of the M9003.

4. From the CALIBRATION menu select the DO SPAN CHECK and press <enter>. The instrument span port will open with an audible “click”. When the span gas solenoid is heard to click open, open the calibration gas cylinder valve, set the regulator to 50 kPa and the gas flow to 1.8 – 2.0 L/min on the rotameter. After the 20-minute cycle is complete enter the CALIBRATION menu and record the instrument response to the cal gas under LAST SPAN CHECK. Record this value into the proforma.

5. From the CALIBRATION Menu select the DO FULL CAL command and press <enter>. The message “Full calibration will commence within 30 seconds” will appear on the display, and the instrument span port will open with an audible “click”.

6. The DO FULL CAL command is a fully automatic process and the operator need not do anything during the calibration. The span portion of the calibration will run for 20 minutes.

7. When the span calibration is completed the instrument will automatically close the span port, open the zero port for zero calibration, and update the **last span check** and **span check stability** fields in the calibration menu.

8. The zero portion of the calibration will run for 20 minutes. After the zero calibration is finished the instrument will update **last zero check** and **zero check stability** fields in the calibration menu.

9. Enter the **analyser zero, zero stability, span check and span check stability** information to the M9003 calibration proforma.

9.12 Temperature, pressure, and RH calibration

Purpose

This work instruction describes how to check the temperature and pressure measured by the nephelometer

Scope

Temperature and pressure checks should be carried out at least every 12 months.

Equipment

- Reference thermometer
- Reference barometer
- Audit sheet No. 4

Procedure

9.12.1 Remove the Casing of the Integrating Nephelometer M9003

i. Ensure M9003 integrating Nephelometer is in a stable environment and has been operating for a period of > 1 hour.
ii. Remove 4 black screws on the front of Nephelometer and remove case, taking care to remove the earth trap as well (refer to Figure 2 for locations). Your view should be as shown below in Figure 2.

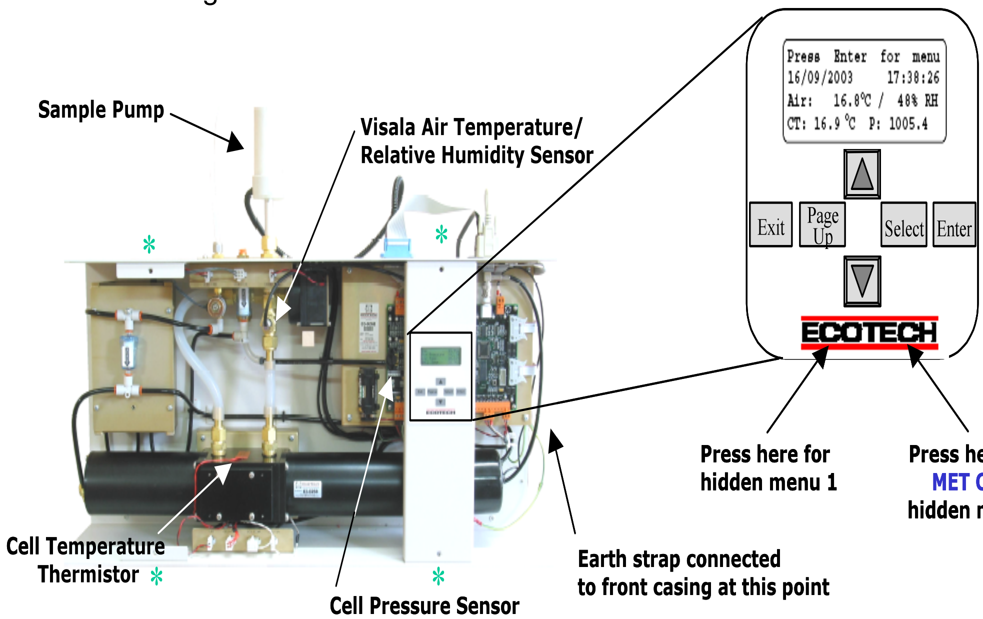


Figure 2 - Photo of the inside of the Integrating Nephelometer M9003 showing positioning of the Air Temperature/Humidity Sensor, Cell Pressure Sensor, Cell Temperature Thermistor and Sample Pump. The 4 screw positions are denoted by *. The inset shows the display and keypad in Environmental Cal Mode on the Integrating Nephelometer M9003. The location of the hidden MET Calib menu is also shown

9.12.2 Place the M9003 Nephelometer in Environmental Calibration Mode

The calibration procedure for **all** the internal sensors requires the M9003 Integrating Nephelometer to be in Environmental Calibration Mode. Before doing this, ensure that the M9003 Integrating Nephelometer is in a stable environment and has been operating for a period of >1 hour.

To place the M9003 in Environmental Calibration Mode:

i. Access the **MET Cal** hidden menu by pressing the 2nd C in **ECOTECH** on the keypad. (Refer to Figure 2).
ii. Then select **MET Calib** from the menu (1st item on the menu) and press enter.
iii. On opening this menu, the display should look similar to that shown in Figure 3. Scroll down the menu to **Enter Env Cal**, click enter. The M9003 is now in Environmental Calibration Mode.
iv. Press exit on the keypad. All the M9003 internal sensors (**RH**, **CT**, **P**, and **Air**) should now

be displayed on the screen (this may take 30 seconds). Measurements displayed are updated continuously as they are read.

* Cal Pres X	1013.2	Displays the air pressure reading in mb at calibration point
* Cal Pres Y	26768	Displays the A2D reading at Pressure calibration point
* Cal Therm	18089	Displays the Cell Thermistor (A2D) offset reading at 25°C
* Cal VaisTO	234.25	Displays the Air Temp sensor min temperature offset
* Cal RH Gra	1.0000	Displays the RH sensor Gradient
* Cal RH Off	0.0000	Displays the RH sensor Relative Humidity offset
Enter EnvCal	-->	Activates Environmental Calibration mode
Exit EnvCal	-->	Exits Environmental Calibration mode and returns to Normal operating mode

Table 1– MET Calibration Hidden Menu

Note: the values used in the above menu are Factory Default values. Each M9003 after calibration will have different values.

Figure 3 - Screen display on activation of the MET Calib menu. Refer to manual for further instructions

9.12.3 Calibration of the Barometric Pressure Sensor

i. Place the M9003 Integrating nephelometer in Environmental Calibration Mode (refer to Section 9.12.2).
ii. Disconnect the sample pump and allow the pressure reading on the M9003 display to stabilize.
iii. Determine the current barometric pressure using the Calibrated Barometric Pressure Sensor.
iv. Read off the pressure displayed on the M9003 screen and calculate the difference between this pressure and that measured using the Calibrated Barometric Pressure Sensor.
v. Access the **MET Calib** hidden menu (refer to Section 9.12.2 and Figure 2).
vi. Scroll down the menu (refer to Figure 3) and verify that the parameter **Cal Press Y=26768**
vii. If the difference between the pressure measured using the calibrated standard and the M9003 is >**1hPa**, adjust the **Cal Press X** value by the difference calculated in step (v) in this section (e.g. If Pressure (Calibrated Sensor) **-** Pressure (M9003) = **+**2.0 hPa, then **increase** the **Cal Pres X** value by 2.0 hPa (e.g. from **1013.2** to **1015.2**)).
viii. Return to the main menu by pressing **Exit** on the keypad and check the new pressure reading.
ix. If M9003 does not read within **1 hPa** of the value measured using the Calibrated Barometric Sensor, repeat steps (v) to (viii) of this section.

9.12.4 Calibration of the Cell Temperature (Thermistor)

i. Place the M9003 Integrating Nephelometer in Environmental Calibration Mode (refer to Section 9.12.2).
ii. Place the Calibrated Temperature Probe on the cell housing near the Cell Temperature Thermistor, and temporarily attach in order to ensure good thermal contact (refer to Figure 2 for location).
iii. Measure the temperature at this position (allowing sufficient time for the reference thermometer to stabilize)
iv. Calculate the difference in this temperature and the one shown on the M9003 display for the Cell Temperature (i.e. **CT**).

v. If the difference is >**0.1°C**, Access the **MET Calib** hidden menu (refer to steps in users manual and **Figure 2**) and scroll down to **Cal Therm.**
vi. If Cell Temperature (Calibrated Sensor) – Cell Temperature (M9003) = **+**0.2°C, then **increase** the **Cal Therm** value by **100** units (e.g. from **18089** to **18189**). If Cell Temperature (Calibrated Sensor) – Cell Temperature (M9003) = **-** 0.2°C, then **decrease** the **Cal Therm** value by **100** units (e.g. from **18089** to **17989**). **NOTE:** This works out to be a change of 50 units per 0.1°C.
vii. Return to the main menu by pressing **Exit** on the keypad and check the new cell temperature reading.
viii. If M9003 value does not read within **0.1°C** of the value measured using the Calibrated Temperature Probe, repeat steps (ii) to (vii) of this section until this is the case.

9.12.5 Calibration of the Ambient Temperature Sensor (Vaisala)

i. Place the M9003 Integrating Nephelometer in Environmental Calibration Mode (refer to Section 9.12.2).
ii. Remove Vaisala Temperature/Humidity Sensor by unscrewing the bolt at brass T section (refer to **Figure 2** for location).
iii. Place the Calibrated Temperature Probe close to the sensor (such that good thermal coupling is obtained).
iv. Allow the sensors to stabilise in the ambient environment (at least 1 minute).
v. Record the ambient temperature from the Calibrated probe and the M9003.
vi. Calculate the difference between these 2 values.
vii. If the difference is > **0.1°C**, access the **MET Calib** hidden menu (refer to steps in users manual and **Figure 2**), scroll down to **Cal VaisTO** and adjust this value accordingly. e.g. If Ambient Air Temperature (Calibrated Sensor) – Ambient Air Temperature (M9003) = **+**2°C, then **increase** the **Cal VaisTO** value by **2 units** (e.g. from **234.**25 to **236.**25). If Ambient Air Temperature (Calibrated Sensor) – Ambient Air Temperature (M9003) = **-**2°C, then **decrease** the **Cal VaisTO** value by **2 units** (e.g. from **234.**25 to **232.**25).
viii. Return to the main menu by pressing **Exit** on the keypad and check the new Ambient Air Temperature reading.
ix. If M9003 value does not read within **0.1°C** of the value measured using the Calibrated Temperature Probe, repeat steps (iii) to (vii) of this section until this is the case.

9.12.6 Calibration of the Relative Humidity Sensor

i. Place the M9003 Integrating Nephelometer in Environmental Calibration Mode (refer to Section 9.12.2).
ii. Remove Vaisala Temperature/Humidity Sensor by unscrewing the bolt at brass T section (refer to **Figure 2** for location).
iii. Allow Vaisala Temperature/Relative Humidity Sensor to stabilise in the ambient environment.
iv. Access the **MET Calib** hidden menu (refer to steps (i) & (ii) in Section 9.12.2 and **Figure 2**) and scroll down the menu to **Cal RH Gra.**
v. Check **Cal RH Gra**=1.0000.
vi. Press **Exit** to return to the main menu.
vii. Measure the Relative Humidity of the ambient air using the Calibrated Sensor and record value (if using a psychrometer to do this, refer to users manual for instructions).
viii. Record the **RH** measured by the M9003 as shown on the display.
ix. Calculate the difference between these 2 values. If the difference is >1% select **MET CALIB** and adjust **Cal RH Off** accordingly**.** (e.g. If the difference between the calibrated sensor and the **RH** displayed by the M9003 is **+**3%, increase **Cal RH Off** from **0.0000** to **3.0000**.
x. Press **Exit** to return to the main menu and check the **RH** reading on the M9003 display.

xi. Repeat steps (iii) to (x) until the reading is within 1% of the calibrated sensor value.
xii. When this is the case, replace Visala Temperature/Relative Humidity sensor back into the T-piece fitting on the inlet.

10. PROFORMAS & PAPERWORK

When completed, all log sheets and audit sheets are to be filed in a dedicated folder at the station or central office facility.

Weekly Check sheets may be kept in a folder with instrument.

Use of electronic checklists instead of paper-based lists is recommended. Backups of electronic checklists are to be kept with backups of the data at a different location from the primary storage place. Checklists should be printed out once per month and kept in a safe place.

Ecotech M9003 weekly checklist

Date / Operator:										
Time (stopwatch)										
Time (instrument)										
Sample Fan operational?										
Main Menu ® READINGS screen										
Scattering coefficient										
Atm Pressure (mB)										
Air Temperature (°C)										
Cell Temperature (°C)										
RH (%)										
Main Menu ® CALIBRATION screen										
Wavelength *(520 nm)*										
Wall signal *(<95%)*										
Last zero check										
Zero check stability *(>97%)*										

Main Menu ® CONTROL screen										
Cell Heater										
Inlet Heater										
Desired RH										
Hidden Menu ® COUNTS screen										
Dark Count *(0-10 counts)*										
Shutter Count *(~1.2 million)*										
LED set point *(within 0-40)*										
Comments:										

Nephelometer Audit Sheet No. 1

Calibration

Date ________________ Operator ____

M9003 s/n: ____

Time
Zero value before adjustment
Zero value after adjustment
Span value before adjustment
Span value after adjustment
Zero value
Calibrate again?

Nephelometer Audit Sheet No. 2

Date ________________ Operator ____

M9003 s/n: ____

Reference Thermometer
Make:
Model:
s/n:
Last calibrated:

Reference Barometer
Make:
Model:
s/n:
Last calibrated:

Reference Psychrometer
Make:
Model:
s/n:
Last calibrated:

PRE CAL check

Date/Time		Reference	Neph.	Difference	Pass/Fail
Cell Temperature					
Ambient Temperature					
Barometric Pressure					
Relative Humidity					

POST CAL check

Date/Time		Reference	Neph.	Difference	Pass/Fail
Cell Temperature					
Ambient Temperature					
Barometric Pressure					
Relative Humidity					

11. DATA HANDLING/PROCESSING

Light scattering, instrument and environmental parameter data from the Ecotech nephelometer may be retrieved continuously, via the communication port, using an external data system (e.g. a station's central data system) or logged internally by the nephelometer's controlling system and then periodically downloaded to a central or stand-alone system, e.g. a PC. In the latter case Ecotech software is available (from www.ecotech.com.au) to facilitate data downloading; this software will allow the data to be saved in a format that is suitable for use in a spreadsheet.

In either case the raw data files should be retained and archived at the station or central facility. Data backup and processing at the station or central office should be carried out regularly, with a recommended minimum frequency of weekly.

Minimum requirements for data examination include plotting the time series of light scattering data and examination of the station's nephelometer log to identify possible sample contamination or instrumental problems, such as zero drift. Any such episodes should be flagged in the subsequent edited data file and excluded from processing in the hourly statistics. Other levels of processing may be applied, for example zero and span drift correction if appropriate. If these procedures are carried out, this information should be added to the metadata file for this period and form part of the metadata submission to the GAW archive. At some stations/locations data are screened using selected wind-sectors or species concentration data e.g. radon, to ensure that measurements represent specifically defined air masses. A description of the selection procedures should also form part of the submitted metadata file. (Some limited information on screening procedures is given in the GAW Aerosol Procedures manual, GAW 153, p 6, 2003, and more detailed information can be obtained from the Aerosol SAG). Higher level processing, for example to include truncation errors may also be carried out using the relevant instrument transfer function when this is known, any such processing should be indicated in the metadata file.

The GAW aerosol sampling manual recommends minimum sampling rates of 1 to 3 minutes and the minimum statistics for light scattering data are arithmetic mean and standard deviation, median, 5 and 95 percentiles for each hour (GAW 153, pg. 28). These hourly data statistics should also include a flag to indicate corrupt or contaminated data.

Edited hourly statistics files, including all relevant metadata should be prepared into the format required by the GAW archive (Chapter 7) and submitted regularly to the GAW aerosol data centre. These data should also be retained and archived at the station or central facility.

12. REFERENCES

Australian Standard 3580.12.1:2001 *Methods of sampling and analysis of ambient air. Method 12.1: Determination of light scattering-Integrating nephelometer method.*

WMO/GAW *Aerosol Measurement Procedures: Guidelines and Recommendations*, GAW Report No. 153, TD No. 1178, 2003. http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html

Ecotech M9003 Nephelometer Users Manual.

Contact for further information: sag-aero@tropos.de

CHAPTER 6

Light Scattering Coefficient - Integrating Nephelometer - TSI 3563

1. OVERVIEW

1.1 Summary

The integrating nephelometer measures the scattering component of the aerosol light extinction coefficient. This variable, also called the scattering coefficient or the volumetric scattering cross-section, is directly related to the climate forcing and visibility reduction caused by aerosols, and consequently is one of the core aerosol variables recommended for GAW stations. The scattering coefficient has dimensions of cross-sectional area per unit volume, i.e., $m^2\ m^{-3}$, which is often reported as inverse meters (m^{-1}) or inverse megameters (Mm^{-1}, 1 Mm^{-1} = $10^{-6}\ m^{-1}$.)

Most integrating nephelometers, including the TSI model 3563, operate by illuminating a volume of air with a diffuse light source. A photomultiplier tube views a conical section, with its axis perpendicular to the light source, of the illuminated volume. This special geometry provides the angular integration of the scattered light needed to provide a signal that is proportional to the scattering coefficient. The instrument is calibrated by filling the sample volume with gases of known scattering cross-section, commonly CO_2 and air. Internal temperature, pressure, and relative humidity sensors measure the environmental state of the sample. More information on the theory of operation of the instrument is given in Chapter 7 of the instrument operating manual. Theory and applications of the instrument are described further in Heintzenberg and Charlson (1996).

The TSI model 3563 measures the scattering coefficient at three wavelengths (450, 550, and 700 nm) and for two ranges of angular integration ("total" scatter 7-170º, "back" scatter 90-170º). The operating characteristics of the instrument, including the wavelength and angular response, were characterized in detail by Anderson et al. (1996). The total scattering coefficient is frequently written as σ_{sp} or B_{sp}, although B_{scat} is sometimes used. Likewise, the hemispheric backscattering coefficient is often written as σ_{bsp}.

1.2 Applicability

This document describes specific procedures that apply to the TSI model 3563 integrating nephelometer. The specific procedures are also applicable to other versions of the TSI nephelometer, which may operate at a single wavelength and do not have a backscatter shutter. Many of the general operating procedures can also be applied to integrating nephelometers from other manufacturers, but those instruments may differ in the specific operating procedures.

This manual was written specifically for users of TSI Model 3563 integrating nephelometers. Its purpose is to ensure the quality of nephelometer measurements by advising users of ways to optimize nephelometer performance, to recognize instrument problems, and to perform simple maintenance and repair procedures. This is not meant to be a comprehensive document in that all potential instrument problems are not addressed here. Most of the common preventative maintenance procedures are discussed in detail in the Instruction Manual that comes with Model 3550/3560 Series Integrating Nephelometers. The most commonly encountered problems and maintenance procedures, however, are discussed here. This manual was written for field technicians of the World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) programme, so that a field reference document for instrument maintenance, repairs, and performance checks at remote field sites would be available. The hope is that comparable care for the instruments at different sites will lead to a similar high quality of nephelometer performance and reduced instrument down time for unscheduled maintenance and repairs.

2. OPERATIONS

2.1 Sampling conditions

Sampling techniques for the TSI model 3563 are described in Chapter 2 of GAW Report 153. Basically, a sample from undisturbed ambient air must be brought to the instrument with minimal losses of particles in the size range that typically dominates aerosol light scattering (0.1-10 µm diameter). The instrument response is independent of flow rate, and flow rates of 10-30 lpm are typically used to give an adequate time response (1/e-response times of 5-15 seconds). Heating from the lamp causes a warming of 4-5 ºC, but additional heating, drying, or insulation may be needed in humid environments, particularly in air conditioned laboratories, to achieve the desired sample relative humidity of 30-40%.

2.2 Instrument configuration

The nephelometer should be configured using the following commands (these are described in Chapter 6 of the Nephelometer Instruction Manual):

UE
STA60
STB61 *(sufficient for a high flow rate like 30 lpm, should be longer for lower flow rates)*
STP3600
STZ300
SMZ1
SP75
UD1
UZ1
UB

In this configuration, the nephelometer measures the scattering coefficient of filtered air for 54 minutes of each hour and reports 1-minute average values. There is a 5 minute zero period, and two 61-second blanking periods at the start and end of each zero check.

Under extremely clean conditions, such as at the South Pole, with aerosol scattering coefficients frequently below 1 Mm^{-1}, it may be desirable to average the results of multiple zero checks. This can be accomplished by issuing the "SMZ" command with a larger value than 1, e.g., "SMZ4" would cause the nephelometer to use the average the last four zero checks.

2.3 Data recording

The time resolution of nephelometer measurements should allow calculation of hourly statistics (mean, standard deviation, selected percentiles), which implies that the data be logged as averages over 1-3 minutes. The primary parameters needed for using and interpreting data from the TSI integrating nephelometer include all six scattering channels, temperature, pressure, and relative humidity. Supporting data should be recorded regularly (at least hourly) to allow data quality assessments, including the instrument status flags, lamp voltage and current, background signals from zero-air checks, and reference calibrator count rates.

2.4 Routine checks

In order to track the performance of a nephelometer, records should be kept of diagnostic measurements over time. This is the best way to determine if the performance of the nephelometer has changed. Span gas and overnight noise checks (discussed below) document the stability of instrument calibration and performance over time. Zero background checks show when the instrument background changes, and are especially useful in showing when the inside of a nephelometer is getting dirty. The monitoring of lamp current and voltage is necessary because lamps draw more current as they age. If the lamp draws too much current, the analog circuit board could be damaged. We recommend replacing the lamp when the lamp current rises above about 6.5 amps, as experience has shown that lamp failure is likely within about a week. Temperature, pressure and relative humidity measurements are required for interpretation of nephelometer measurements, and are also useful in diagnosing many potential instrument problems.

Measurements and checks that should be recorded and monitored over time include:

- *Daily* - Review measurements of scattering coefficient, instrument temperature, pressure, relative humidity, lamp voltage and lamp current for indications of abnormal operation (spikes, level jumps, drift). Review hourly zero background checks for stability. Abnormal operation should be noted in the instrument log and may require data flagging, editing, or removal prior to archival; such notes should be filed with other instrument metadata.

- *Weekly to Monthly* - Span gas checks and leak checks should be conducted at least monthly, and more frequently if excess variability is noted in the monthly results.
- *Annually* - Overnight noise checks should be performed at least annually.

2.5 Calibrations

The nephelometer is calibrated by measuring the scattering by two different gases with know scattering coefficients, typically air (low) and CO_2 (high). Detailed instructions on how to calibrate the nephelometer are given in the TSI operating manual. Normally, the instrument calibration is checked by measuring the scattering by air and CO_2 as if they were sample air, following the "span check" procedure in the Annex. A full calibration, including adjustment of the internal calibration constants, should be performed only when a span check or instrument comparison suggests that a nephelometer’s calibration has shifted. Routine re-calibration is not recommended as long as regular span checks are performed. The TSI nephelometer software displays the K2 and K4 constants determined in each calibration. The K2 constant is a measure of how much light is being detected by each PMT during the calibration portion of each chopper cycle. This value can vary over a fairly wide range depending on the thickness or on the presence of scratches in the finish of the reflective coating on the chopper shutter. Typical values for K2 for all three wavelengths in a properly functioning nephelometer are 2E-3 to 8E-3, although it is possible that values for a particular nephelometer could lie slightly outside this range. The K4 constant is related to the fraction of the scattering volume illuminated during the backscatter measurement. Typically, the value of this constant is near 0.5.

After a calibration has been performed, it is always a good idea to perform a span gas check to verify that the calibration results are reproducible. If the span check errors are large, a repeat of the calibration may be necessary. Alternatively, the full calibration procedure can be repeated until reproducible values of the K2 and K4 constants are achieved.

2.6 Independent audits

The GAW World Data Center for Aerosol Physics (http://gaw.tropos.de/WCCAP/index.html) includes a review of nephelometer operation during station audits. The audit checks the inlet system, instrument logbooks, physical instrument condition, and calibration (or span check) procedures. If time permits, the instrument noise level is determined by operating the instrument with a filter on the inlet for several hours.

3. DATA MANAGEMENT

Light scattering, instrument and environmental parameter data from the nephelometer may be retrieved continuously, via the communication port, using an external data system (e.g. a station’s central data system) or the data logging application provided by the manufacturer.

In either case the raw data files should be retained and archived at the station or central facility. Data backup and processing at the station or central office should be carried out regularly, with a recommended minimum frequency of weekly.

Minimum requirements for data examination include plotting the time series of light scattering data and examination of the station’s nephelometer log to identify possible sample contamination or instrumental problems, such as zero drift. Any such episodes should be flagged in the subsequent edited data file and excluded from processing in the hourly statistics. Other levels of processing may be applied, for example zero and span drift correction if appropriate. If these procedures are carried out, this information should be added to the metadata file for this period and form part of the metadata submission to the GAW archive. At some stations/locations data are screened using selected wind-sectors or species concentration data e.g. radon, to ensure that measurements represent specifically defined air masses. A description of the selection procedures should also form part of the submitted metadata file. (Some limited information on screening procedures is given in the GAW Aerosol Procedures manual, GAW 153, p 6, 2003, and more detailed information can be obtained from the Aerosol SAG). Higher level processing, for example to include truncation errors may also be carried out using the relevant instrument transfer function when this is known, any such processing should be indicated in the metadata file.

The GAW aerosol sampling manual recommends minimum sampling rates of 1 to 3 minutes and the minimum statistics for light scattering data are arithmetic mean and standard deviation, median, and selected percentiles for each hour (GAW 153, p 28; Chapter 7, this report). Light scattering data should be adjusted to standard temperature and pressure (0ºC, 1013.25 hPa) prior to submission. The hourly data statistics should also include a flag to indicate corrupt or contaminated data.
Edited hourly statistics files, including all relevant metadata should be prepared into the format required by the GAW archive and submitted regularly to the GAW aerosol data center. These data should also be retained and archived at the station or central facility.

4. MAINTENANCE AND REPAIR

4.1 New instrument checkout

4.1.1 Initial inspection and tests

Initial inspection

A Model 3563 nephelometer arriving new from the TSI factory will most likely be in excellent condition. TSI ships these nephelometers in large wooden crates which are form-fitted with blown-in foam. Even with careful packing, however, some instrument components can loosen if the crate is handled roughly. Upon receipt of a new instrument, the following items should be inspected. This inspection will require the removal of the nephelometer photomultiplier and top covers.

- Photomultiplier Tubes (PMTs) - ***With the power cord disconnected***, open the PMT housing by removing the four PMT cover screws and remove the PMT cover. Reseat each PMT, wiggling the tube to ensure a good firm fit into the socket. TSI now puts a dab of silicone adhesive at the base of the PMT housings to fix them to the optical block base and prevent them from falling out during shipment. Older nephelometers did not have this adhesive applied. Even with the dab of adhesive on the PMT housings, however, they can still move sideways so that the light path might not be fully centered on the PMT window. ***Afterwards, be sure to replace the PMT housing before connecting the power cord to the nephelometer.*** **Applying power to the photomultiplier tubes with the PMT housing removed may permanently damage the PMTs.**

- Electrical and tubing connections - It is unlikely that any of the electrical or tubing connections would come loose during shipping, but it is a good idea to check them anyway. All of the cable-to-cable and cable-to-circuit board electrical connectors should be checked to make sure they are not loose. In addition, check for a firm connection on the electrical connector that joins the two circuit boards. The 1/2-inch nylon Swagelok nuts between the HEPA zero air filter and the instrument body should be checked for tightness and the 1/4-inch silicone tubing at the vent ports should also be checked to ensure that it is securely connected.

Performance Checks

Model 3563 nephelometers are calibrated just before they leave the factory so it is not recommended to recalibrate the instrument unless a performance check suggests a problem with either the instrument or the calibration. There are two performance checks that can be done upon receipt of a new nephelometer. The first is a span gas check, described in detail in the Annex (6.1).

In a span gas check, the scattering coefficients of a low span gas (typically filtered air) and a high span gas (for example, CO_2) are measured under instrument conditions of temperature and pressure. The results are used to derive the measured scattering coefficient of CO_2 under conditions of standard temperature and pressure (STP; 273.15K and 1013.25 hPa). The measured value of scattering by pure CO_2 is compared with the published value [*Anderson et al., 1996; Anderson and Ogren, 1998*] for each measurement wavelength. The mean error in the CO_2 measurement (i.e., the difference from the CO_2 target value), calculated from each of the six nephelometer channels (three wavelengths each with a total and hemispheric backscatter measurement) should be within a few percent, with no individual channel's error being larger than 10%. If observed errors are larger than this, it suggests an instrument problem and/or a poor calibration. A span check algorithm is provided in Section 6.2 of this chapter so that users can perform these calculations. As discussed below, span gas checks should occur at regular intervals (e.g., weekly to monthly) so that instrument performance can be tracked over time.

Span checks that show large negative values are often caused by CO_2 either not entering the nephelometer as expected or not staying inside the instrument. If the CO_2 is delivered under elevated pressure, hoses can be blown off fittings inside the nephelometer cover. Check to make sure no tubes have been disconnected or ruptured and that CO_2 is in fact flowing through the nephelometer. Since the CO_2 measurement is made relative to the measurement of filtered air, large negative errors will also be encountered if the filtered air measurement is compromised. This can happen if the zero filter ball valve is not completely sealing off the inlet and directing all air through the HEPA filter. If this turns out to be the case, either adjust the ball valve so that it completely seals off the inlet, or else replace it if necessary.

The second performance check is an instrument noise check. For this check, a second HEPA filter is required and should be mounted on the instrument inlet. Nephelometer data should be recorded using the Logging feature in the Data Collection module of the TSI Nephelometer software, or with any terminal emulation software. The noise check should be run for 12-24 hours to determine variability in the background values.

A programme can then be run on this log file that calculates means and standard deviations for the 1-minute filtered air and zero background measurements. A Perl version of this programme is included in the Annex (6.1). As with the span gas checks, a noise check should be done periodically (at least once a year) to check that instrument background values remain low and consistent. Typical ranges of the nephelometer performance statistics for the TSI 3563 nephelometers operated by the Global Monitoring Division of NOAA/ESRL (13 instruments) are shown below.

Parameter	Mean (Mm^{-1})	St. Dev. (Mm^{-1})
Filtered Air, Total Scatter (all wavelengths)	0.01-0.10	0.10-0.40
Filtered Air, Backward Scatter (all wavelengths)	0.01-0.05	0.07-0.30
Neph. Background, Total Scatter (all wavelengths)	2-8	0.02-0.12
Neph. Background, Backward Scatter (all wavelengths)	1-9	0.01-0.12

Values observed that are far beyond the upper end of these ranges suggest an instrument problem; additional inspection of nephelometer is suggested.

4.1.2 Shipping

Most users ship their TSI model 3563 nephelometers in the original wooden crate, although as the crates age it may be necessary to build a new crate or purchase an appropriate shipping container. With use the blown-in foam becomes broken, so some additional cushioning may also be required. The major criteria for fabricating a replacement shipping box for the nephelometer are:

- Protection - This is the most important criterion. The nephelometer is a rather heavy instrument with hard metal edges that can break through a flimsy shipping container. The shipping box should be made of a sturdy material; for example, wood, metal, or heavy plastic have all been used successfully. The box should have form-fitting or blown-in foam so that the instrument does not shift position in the box during transport or lifting. Cardboard and light plastic boxes should not be used because they provide a lesser degree of protection, they are easily damaged, and they require frequent replacement. Pieces of foam, newspaper, styrofoam peanuts, and other types of loose packing material should be avoided because they can allow the instrument to shift position inside the box.
- Weight and Dimensions - The wooden crates that the nephelometers are shipped from TSI in weigh approximately 61 kg (134 lbs.) when loaded with the nephelometer and accessory kit. If new shipping containers are constructed, keep in mind that several international delivery services (e.g., FedEx) have limits of 150 lbs. (68 kg) for standard air freight service. Larger packages are considerably more expensive to ship.

Finally, when shipping a TSI nephelometer make sure that the inlet and outlet are tightly sealed. This will eliminate the possibility of dust, packing debris, insects, etc., getting into the nephelometer and minimize the need for taking apart the instrument for cleaning. Also, it is wise to make sure the top and bottom covers and the PMT cover are tightly secured to protect sensitive and fragile instrument components.

After an instrument is shipped, the same initial inspection and performance checks as for new instrument arrival should be performed, except that some additional maintenance and recalibration may be required. Refer to the Instruction Manual for calibration instructions. For possible maintenance required, see Routine Maintenance and Special Maintenance sections.

4.1.3 Instrument modifications

NOAA typically makes several modifications to the standard TSI nephelometer before deployment at field sites. These include:

- Installing plastic clips to hold the circuit boards together
- Replacing fan covers with a large speaker grill, and removing the metal strip down the middle of the cutout so the lamp can be changed without removing the nephelometer cover
- Installation of a small solenoid valve on the 1/4-inch port fitting next to the lamp shield, to control injection of CO_2 for span checks
- Installation of a second BNC-style connector on the power/communications panel so that the solenoid valve can be controlled for automated span gas checks. A coaxial cable connects the new connector to the existing BNC connector, so that the nephelometer command 'SX 5000' opens the solenoid valve and 'SX 0' closes the valve
- Cutting the nephelometer top cover lengthwise so that it can be removed without having to remove inlet and outlet plumbing

Further details are available from the authors of this report.

4.2 Scheduled maintenance

Maintenance procedures for the nephelometer are described in Chapter Eight of the TSI Nephelometer Instruction Manual. Most of these procedures are recommended to be done "as needed" or "periodically". Some need to be performed when the diagnostic measurements suggest it is time for maintenance. Routine maintenance procedures are relatively simple to perform and include:

- Replacement of particulate filters (yearly, more frequently at very dusty or polluted sites)
- Replacement of the fan filter (inspect yearly)
- Replacement of lamp (as needed, generally 2-3 times per year)
- Checking for instrument leaks (yearly)
- Cleaning the main cavity of the nephelometer (as needed, if instrument background goes above ~ 10 Mm^{-1})
- Cleaning or changing the flocked paper (when main cavity is cleaned)
- Cleaning the light pipe lens (when main cavity is cleaned)
- Calibration or replacement of the T, P, and RH sensors (check annually)

4.3 Special maintenance

Special maintenance procedures should be performed on an "as needed" basis. These procedures are often on sensitive components of the nephelometer, so extra care should be exercised when working on these procedures. Special maintenance procedures include:

- High voltage adjustment or replacement of PMTs
- Cleaning or replacement of aged bandpass filters
- Replacement of old/scratched chopper shutter
- Replacement of EPROM chip
- Replacement of motor control microprocessor
- Replacement of chopper and backscatter shutter motors.
- Adjustment/replacement of IR reflective diodes
- Cleaning of the backscatter shutter
- Replacement or realignment of the zero filter ball valve

Over time, the photon count rates of TSI nephelometers will decrease. This is usually due either to aging of the optical glass filters that pass each wavelength of light to the photomultiplier tube detectors or to the degradation in sensitivity of the PMTs themselves. If span gas calibration checks are noisy from one check to the next, it may be that too few photons are being detected to get good counting statistics. In this case, the performance of the optical filters and PMTs should be checked.

Using the TSI software in Data Collection mode, check the raw photon counts on filtered air. Under "Total Scatter" there are nine photon count rates (in Hz) to monitor. These are "CAL", "MEAS", and "DARK" for the blue, green, and red channels. CAL measures the count rate on the calibrator, or fixed brightness section of the chopper shutter. MEAS is a measurement on the open sector of the chopper, so it is essentially a measurement of the photon count rate from the Rayleigh scatter of the filtered air in the scattering volume. DARK is a measure of the dark counts; i.e., the detected count rate with no light being passed from the scattering volume of the instrument. A general strategy is to increase a PMT's voltage as long as the change increases the CAL and MEAS count rates without significantly increasing the DARK count rate.

It is difficult to recommend specific photon count rates because they are dependent on the interaction between the lamp-colour filter-detector system, and lamp brightness, bandpass efficiency, and PMT sensitivity all come into play. Still, we can come up with some minimum measure of count rate acceptability based on experience in maintaining many nephelometers. These should be viewed as guidelines rather than firm thresholds of acceptability.

Under Total Scattering, the blue channel should show a count rate of at least 60-70 kHz on the CAL and at least 500 Hz on the MEAS. The green channel should be a little higher on the CAL, with a count rate of at least 100 kHz, and a minimum MEAS count rate of 500 Hz. Remember that these are recommended minimum values, and that a properly functioning nephelometer may have counts rates 2 or 3 times higher than this. If count rates are below those suggested here, statistical noise from low count rates will affect the measurements. The DARK counts for the blue and green channels are typically quite low, often below 10 Hz.

The red Total Scattering channel always shows a much higher DARK count rate than the corresponding blue or green channels, often in the several hundred Hz range. The CAL Total Scatter count rate should be at least 150 kHz, and the MEAS count rate should be at least 800 Hz. If the nephelometer photon count rates are below the minimum acceptable guideline values listed above, there are several things to try in order to increase them. If the lamp is old, you can try replacing that. A new lamp is often a bit brighter than an old one. If the lamp is OK, then try increasing the voltage on the PMT for the low count rate channel. If increasing the voltage does not increase difference between the MEAS and DARK counts, then turn the voltage back to where it was and try replacing the PMT with a new one. Note the photon count rate before proceeding.

To replace the PMT, it is important to ***disconnect the power cord from the neph. Normal room-intensity light will damage an energized PMT****!* Then remove the PMT housing and replace the PMT. Make sure the PMT cover is well seated before reconnecting the power cord and turning on the power. If the photon count rate is significantly higher than it was before at the same voltage, then it was probably a wise move to replace the PMT.

If replacing the PMT does not increase the count rate, you can try cleaning or replacing the optical bandpass filter for that channel. Over time, these filters can become cloudy or hazy, especially in very humid environments. To remove the optical filters, again cut power to the instrument and remove the PMT housing cover. Extract the correct colour filter by removing the two small screws and nylon washers holding it in place in the optical assembly. To clean an optical filter, use lens paper if available and a very clean alcohol like spectrophotometer-grade methanol. Impure alcohols will leave a deposit that will itself have to be cleaned. Very gently pull the lens paper across the optical surface to remove the alcohol. Do not apply pressure to the lens paper as the optical coating can scratch, and then light other than the correct wavelength can pass the filter. If the optical filter looks less cloudy, then the haze deposit may have been successfully removed. The only way to be sure is to replace it in the optical assembly and check the photon count rate using the same PMT voltage. If it did not increase, the only other option is to replace the suspect optical bandpass filter with a new one. Generally, some combination of cleaning and/or replacing components of the lamp-filter-detector system will increase the count rates into the acceptable range. If it does not, the nephelometer may have to be sent back to the factory for an overhaul.

We recommend replacement of an old chopper shutter, rather than cleaning. We have found through experience that it is very difficult to clean one of these shutters without leaving a dull deposit or imparting additional scratches on the reflective surface. The TSI Nephelometer Instruction Manual recommends cleaning a dirty chopper shutter with isopropyl alcohol and cotton swabs. Feel free to try this, but don’t be surprised if you end up needing a new chopper shutter anyway.

The two IR reflective diodes are used to detect when the zero valve and the chopper shutter are in the appropriate positions. The lenses for these diodes can get dirty and may need to be cleaned periodically. These diodes have been found to fail over time, so when cleaning or adjustment does not make these perform better, it is time for a new diode. If the diode needs to be replaced, note the distance between diode and shutter and try to match that with the new installation. Generally, these diodes should be 1-3 mm from the surface of the shutter to ensure position detection.

The backscatter shutter should be cleaned so that dirt or dust on the shutter does not lead to additional scattering of light from the lamp. Care should be taken not to change the orientation of the backscatter shutter (i.e., the angle at which it rotates above its base plate). If this orientation is changed, the K4 constant will change and a new calibration will be required.

Over time, the ball valve assembly can cause problems either by developing a misalignment or by becoming more difficult to turn. These problems can cause background measurements that are off by varying degrees, or in the extreme case of a ball valve that will not turn a nephelometer unable to calculate its own backgrounds. A misaligned ball valve lets ambient air into the instrument during the zero air background measurement, which obviously compromises the background measurement. This can be observed by shining a flashlight into the nephelometer inlet when the valve is supposed to be in the zero air position. Seeing a gap where air can get directly into the nephelometer confirms the problem.

A misalignment of the ball is usually caused by one or more of the four set screws that hold the couplers in place becoming loose. This permits the shaft to rotate relative to the aluminium flange that is used a positioning device. The way to correct this problem is to loosen all of the set screws so that the ball can be turned by hand. Position the ball so that it is as far open as possible; i.e., that it allows air to enter the nephelometer as efficiently as possible. Then position the flange so that its edge is directly over the IR reflective diode sensor that determines flange (and valve) position. The metal should be 1-3 mm away from the sensor. If the distance is greater than that, adjust the position of the IR reflective diode closer to the aluminium flange. Make sure to rotate the valve over 360 degrees because the flange is often tilted slightly and could move too close or far away from the diode for position detection. After aligning the ball and getting the flange in the correct position, tighten the set screws to lock the assembly in place. Make sure when the ball valve changes position during background checks that the ball is also in the proper (sealed) position at that time.

In the extreme case, an aged ball valve can become locked in position and the shaft will either break or the motor or coupling will be damaged. Replacement of the ball valve is discussed in the Section "Troubleshooting and Repair".

4.4 Materials required

4.4.1 Consumables

During normal operation, the only consumable parts are the internal filters (TSI #1602051 and #1602080) and the lamp (TSI #2201111). Filters should be replaced annually, although more frequent changes may be needed in very dusty or polluted environments. Lamps should be replaced when the current exceeds 6.5 amps, which typically occurs after 4-6 months of operation.

4.4.2 Calibration

A supply of pure (>99.9%) CO_2 is required for calibration and span checks. The calibration gas must be filtered; a suitable choice is a second blue DQ filter (TSI #1602080). The calibration gas should enter the nephelometer at room temperature; a coil of copper tubing between the CO_2 tank and the instrument will achieve this.

4.5 Troubleshooting and repair

Nephelometer repairs can be tricky and in general are best left to the factory. Repairs of this type include electronic repairs, circuit board repairs, motor repairs, etc. There are a few repairs that can usually be made by a competent end user. These include:

- Replacement of broken zero filter motor, ball valve, or coupler
- Repair or replacement of ribbon cables and connectors
- Replacement of white rectangular plastic AMP connectors and attached cables
- Replacement of various chips and microprocessor on the IC cards

If the ball valve is not turning easily, it probably needs to be replaced. This ball valve can be ordered from TSI, but can also be ordered directly from the manufacturer. The manufacturer is Georg Fischer Piping Systems. The valve is a “Ball Valve Type 346” with a 1-inch bore. See the web page at:
http://www.us.piping.georgefischer.com/index.cfm?6330B9B99D5F474C87D47549DE959C77.

This valve is now out of production, but the manufacturer states that it will be supported with parts until 2013. If you have a broken ball and/or stem, you can simply order another ball set. The part number you will need is 161.482.877. If you need a new ball valve (including the valve body), you will need part number 161.483.943.

To replace the broken valve, loosen the 4 large hex-head bolts that secure the valve and inlet housing to the nephelometer body. Remove the broken valve, inlet housing, and HEPA filter. Remove the coupling and flange from the shaft of the broken valve and install it on the shaft of the new valve. Make sure to align the set screws with the groove in the shaft so that the ball position will be correct. Place the new ball valve in position, making sure that the couplers fit together and that the flange is close to the IR reflective diode sensor. Tighten the four hex-head bolts down to secure the ball valve. CAUTION: The ball valve body has o-ring seals at each end, so the bolts do not have to be tightened really tight. The o-rings have to be compressed, but over-tightening the bolts can impede the turning of the ball in the valve.

Replacement of the zero filter motor assembly should be straightforward – just a one-for-one replacement. Again, make sure that the couplers fit together and that the ball is aligned after the replacement.

If chips on the IC boards are suspect, they are fairly easy to remove, reseat, or replace. Simple care is required so that pins are not damaged. If corrosion is detected on the pins, a very light abrasive like emory paper or a pencil eraser can be used to improve the contacts. The microprocessor pins are very small and probably can not be cleaned successfully with an abrasive. Special corrosion remover liquids must be used to clean the pins on the microprocessor, and special care is needed in the re-insertion of the microprocessor into its socket.

A description of tools and equipment needed for nephelometer maintenance is given in the instrument operator's manual.

5. REFERENCES

5.1 Manufacturer's Operating Manual

A detailed operating manual is supplied with each instrument. An electronic copy is available at http://www.tsi.com/particledocs/3563-Integrating-Nephelometer-1933563g.pdf. Login credentials (provided with permission from TSI) for accessing this page are:

username: tsi-particle
password: W3bP4rt1cle

5.2 International and national procedures

WMO/GAW Aerosol Measurement Procedures: Guidelines and Recommendations, GAW Report No. 153, TD No. 1178, 2003 (http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html)

5.3 Scientific Publications

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ANNEXES

6.1 EVALUATION OF NEPHELOMETER NOISE LEVELS FROM OVERNIGHT ZERO-AIR RUNS

Instrument performance can be assessed by running for 12-2 hours with a HEPA filter on the inlet to the nephelometer. This Perl programme will calculate and display the means and standard deviations of the filtered air and zero background measurements for all six channels. The following configuration commands should be issued prior to the run:

UE
STA60
STB61 (sufficient for a high flow rate like 30 lpm, should be longer for lower flow rates)
STP3600
STZ300
SMZ1
SP75
UD1
UZ1
UY1
UT1
UB

6.2 SPAN CHECK ALGORITHM FOR TSI 3563 NEPHELOMETER

6.2.1 Overview

In a span gas check, the scattering coefficients of a low span gas (typically filtered air) and a high span gas (for example, CO_2) are measured under instrument conditions of temperature and pressure. The results are used to derive the measured scattering coefficient of CO_2 under conditions of standard temperature and pressure (STP; 273.15K and 1013.25 mb). The measured value of scattering by pure CO_2 is compared with the published value [Anderson et al., 1996; Anderson and Ogren, 1998] for each measurement wavelength. The mean "error" in the CO_2 measurement (i.e., the difference from the CO_2 target value), calculated from each of the six nephelometer channels (three wavelengths each with a total and hemispheric backscatter measurement) should be within a few percent, with no individual channel's error being larger than 10%. If observed errors are larger than this, it suggests an instrument problem and/or a poor calibration. A span check algorithm is provided below so that users can perform these calculations. As discussed below, span gas checks should occur at regular intervals (e.g., weekly to monthly) so that instrument performance can be tracked over time.

Span checks that show large negative values are often caused by CO_2 either not entering the nephelometer as expected or not staying inside the instrument. If the CO_2 is delivered under elevated pressure, hoses can be blown off fittings inside the nephelometer cover. Check to make sure no tubes have been disconnected or ruptured and that CO_2 is in fact flowing through the nephelometer. Since the CO_2 measurement is made relative to the measurement of filtered air, large negative errors will also be encountered if the filtered air measurement is compromised. This can happen if the zero filter ball valve is not completely sealing off the inlet and directing all air through the heap filter. If this turns out to be the case, either adjust the ball valve so that it completely seals off the inlet, or else replace it if necessary.

6.2.2 Configuration commands

UE
STA60
STB61 (sufficient for a high flow rate like 30 lpm, should be longer for lower flow rates)
STP3600
STZ300
SMZ1
SP75
UD1
UZ1
UY1
UT1
UP3
VZ
UB

6.2.3 Procedure

- Flush with air for 3-5 minutes at ~ 30 lpm
- Turn off blower, close off output, restrict input if possible
- Flush with CO_2 for 10 minutes at ~ 5 lpm
- Measure with CO_2 for 5 minutes at ~ 5 lpm
- Record average values during CO_2 measurement
- Open input and output fully, turn on blower
- Flush with air for 3-5 minutes at ~ 30 lpm
- Measure with air for 10 minutes at ~ 30 lpm
- Record average values during air measurement
- Perform a zero.

6.2.4 Data logging

Average values of the following nephelometer parameters should be recorded for the CO_2 and AIR measurements. Separate values are recorded for the blue, green, and red channels [λ] in most cases.

Photon Count Records (B, G, R):	
NTCAL[λ]:	photon counts from calibrator (total scatter)
NTMEAS[λ]:	photon counts from measure (total scatter)
NTDARK[λ]:	photon counts from dark (total scatter)
REVT:	revolutions of chopper for total scatter measurement
NBCAL[λ]:	photon counts from calibrator (back scatter)
NBMEAS[λ]:	photon counts from measure (back scatter)
NBDARK[λ]:	photon counts from dark (back scatter)
REVB:	revolutions of chopper for backscatter measurement
Data Records (D):	
BSP[λ]:	total scattering coefficient (m^{-1})
BBSP[λ]:	back scattering coefficient (m^{-1})
Auxiliary Status Records (Y):	
PRES:	barometric pressure (hPa)
TEMP:	sample temperature (K)
T-IN:	inlet temperature (K)
RH:	relative humidity (percent)
VLAMP:	lamp voltage (V)
ALAMP:	lamp current (A)

6.2.5 Data reduction

The calculations use the following constants:

Chopper rotation rate = 22.994 revolutions per second
Chopper gate widths = (40, 60, 140) degrees for (calibrate, dark, signal) sections

Standard temperature and pressure:

T_STP = 273.15 K
P_STP = 1013.25 hPa

Rayleigh scattering coefficient of air at STP:

BSGAIR[λ] = (27.89, 12.26, 4.605) Mm^{-1} for (450, 550, 700) nm wavelength
BBSGAIR[λ] = BSGAIR[λ] / 2

Rayleigh scattering coefficient of CO_2, relative to air:

RAYCO2 = 2.61

Rayleigh scattering coefficient of CO_2 at STP:

BSGCO2TRUE[λ] = BSGAIR[λ] * RAYCO2
BBSGCO2TRUE[λ] = BSGCO2TRUE[λ] / 2

Calculate average gas density and lamp power:

DENAIR = PRES[AIR] / TEMP[AIR] *273.15 / 1013.25
DENCO2 = PRES[CO2] / TEMP[CO2] *273.15 / 1013.25
POWER = VLAMP * ALAMP

Convert photon counts to count rates in Hz (eq. 7-15 in TSI manual), for CO2 and AIR measurements separately:

HZTCAL[λ] = NTCAL[λ] * (360/40) * 22.994 / REVT
HZTMEAS[λ] = NTMEAS[λ] * (360/140) * 22.994 / REVT
HZTDARK[λ] = NTDARK[λ] * (360/60) * 22.994 / REVT
HZBCAL[λ] = NBCAL[λ] * (360/40) * 22.994 / REVB
HZBMEAS[λ] = NBMEAS[λ] * (360/140) * 22.994 / REVB
HZBDARK[λ] = NBDARK[λ] * (360/60) * 22.994 / REVB

Don't bother with dead time correction (eq. 7-16 in TSI manual), because count rates on CO2 and air are too low for dead time to matter.

Calculate CO2 Rayleigh scattering at STP, as measured by nephelometer:

BSGCO2[λ] = BSPCO2[λ] / DENCO2 - BSPAIR[λ] / DENAIR + BSGAIR[λ]
BBSGCO2[λ] = BBSPCO2[λ] / DENCO2 - BBSPAIR[λ] / DENAIR + BSGAIR[λ]/2

Calculate percentage error in measured CO_2 Rayleigh scattering:
ERRTS[λ] = (BSGCO2[λ] / BSGCO2TRUE[λ] - 1) * 100
ERRBS[λ] = (BBSGCO2[λ] / BBSGCO2TRUE[λ] - 1) * 100

Calculate nephelometer sensitivity factor, defined as the photon count rate (Hz) attributable to Rayleigh scattering by air at STP:

$$\mathrm{SENSTS}[\lambda] = \left((\mathrm{HZTMEASCO2}[\lambda] - \mathrm{HZTDARKCO2}[\lambda]) / \mathrm{DENCO2} - (\mathrm{HZTMEASAIR}[\lambda] - \mathrm{HZTDARKAIR}[\lambda]) / \mathrm{DENAIR} \right) / (\mathrm{RAYCO2} - 1)$$

$$\mathrm{SENSBS}[\lambda] = \left((\mathrm{HZBMEASCO2}[\lambda] - \mathrm{HZBDARKCO2}[\lambda]) / \mathrm{DENCO2} - (\mathrm{HZBMEASAIR}[\lambda] - \mathrm{HZBDARKAIR}[\lambda]) / \mathrm{DENAIR} \right) / (\mathrm{RAYCO2} - 1)$$

Absolute values of ERRTS[λ] and ERRBS[λ] larger than a few percent indicate a potential problem with the nephelometer or with the calibration parameters stored within the nephelometer. If larger errors are encountered, the span check should be repeated. If the errors persist, the full calibration procedure recommended by TSI should be performed.

Long-term trends in SENSTS[λ] and SENSBS[λ] should be monitored for degradation of phototube sensitivity.

6.3 Document authors and history

Patrick J. Sheridan and John A. Ogren
National Oceanic and Atmospheric Administration (NOAA)
Earth System Research Laboratory (ESRL)
Global Monitoring Division (GMD)
325 Broadway
Boulder, CO, 80305
USA
Email: Patrick.Sheridan@noaa.gov and John.A.Ogren@noaa.gov

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2010-03-01 add content

CHAPTER 7

Data Reporting to the WMO GAW World Data Centre for Aerosol (WDCA)

1. INTRODUCTION

The WMO Global Atmosphere Watch (GAW) World Data Centre for Aerosol (WDCA) serves as link between the GAW network of ground-based stations for monitoring of atmospheric aerosol properties on the one hand, and the data user community on the other. The user receives quick and efficient access to the data stored at one location instead of needing to contact the stations individually. While contacts between data users and providers are facilitated, encouraged, and, in case data are used in publications, mandatory, the metadata provided with the data allow for an interpretation of the data even if the provider should not be available. Since the objectives of the GAW aerosol programme have been oriented towards the aerosol effects on climate, WDCA-hosted data have so far largely been used by the climate modelling and prediction community for attribution and verification purposes. More recently, the communities working on the aerosol climate, air quality, and health effects became more aware of their common observational needs. This has led to a closer collaboration between the UN programmes in WMO GAW and the Convention on Long-Range Transport of Air Pollution (CLRTAP), and further collaborations are anticipated.

The WDCA has originally been set up to collect the observations of atmospheric aerosol parameters determined by the GAW Scientific Advisory Group for Aerosol (SAG aerosol) from GAW stations by annual (regular) data submissions. Subsequently, this framework has been extended to any volunteering regional or contributing station that has been registered in the GAW Station Information System GAWSIS (http://gaw.empa.ch/gawsis/). The whole list of parameters recommended for observation by the SAG aerosol, and therefore accepted by the WDCA, can be found in the current WMO GAW strategic plan for 2008 – 2015 (WMO, 2007), of which this SOP only covers a few. Furthermore, this guideline for data submissions to WDCA includes only regular submissions, i.e. fully, manually quality assured data, submitted normally once per year for the preceding year. While WDCA also offers near-real-time data collection and dissemination services, these are not covered here. For more information about these services, please refer to the WDCA homepage (http://www.gaw-wdca.org).

2. DATA POLICY

The data associated with GAW-WDCA, i.e. data reported to WDCA regularly on an annual basis, are available free of charge for non-commercial and scientific use. By using this data, the data user accepts that an offer of co-authorship will be made through personal contact with the data providers or owners whenever substantial use is made of their data. In all cases, an acknowledgement must be made to the data providers or owners and to the project name when these data are used within a publication. Public data are available in without login.

3. DATA SUBMISSION TO WDCA

3.1 General Considerations

The guidelines on submitting data to the WDCA given here reflect the status at the time this report was printed. By their very nature, the data formats and instructions will always take into account new research, updated regulations, and advances in scientific understanding. The latest version of these instructions will therefore always be the online version available at the WDCA website (http://www.gaw-wdca.org) in the "Submit Data" Section.

The procedure of submitting data to WDCA is designed for the data submitter to provide the data in a specified format. Some other GAW World Data Centres (WDCs) will accept data in any format, and reformat the data into a common data format. WDCA has consciously decided not to use this approach for several reasons:

- **Avoiding of errors**: It has turned out that reformatting the data for the provider increases the number of errors in the data. The reformatting process involves often lengthy correspondence between data provider and centre on how to interpret the data, and is prone to misunderstanding and information loss. A clearly defined format as interface between data provider and centre avoids this information loss.

- **Work load at data centre**: WDCA collects over 6000 datasets per year, including data from networks GAW is co-operating with. With reformatting this amount of data, the number of other services WDCA could offer was rather limited. Together with data providers and users, it was decided to free these resources in favour of data interpretation and dissemination.

- **Scientific standard of data provider**: GAW is a research network, and the annual data submission represents the essence of a year's scientific work at the station. It is part of most data providers' standard and their own wish to assemble this part of their work themselves.

While all of the above is true, the annual data reporting is often perceived as cumber- and burdensome by data providers. The data format used by WDCA emphasizes simplicity and reduces the involved overhead to the minimum necessary for archiving and documenting the data meaningfully. On the other hand, data providers often associate data reporting with data quality assurance. While data quality assurance is a necessary prerequisite for reporting data to WDCA, it is a separate step in data processing and needs to be done before the data can be used for any further purpose. In practise, data quality assurance often isn't done before the data is reported, and is far more time consuming than putting the data into the WDCA format, which, apart from first submissions, doesn't take more than a few hours. To put it short, data reporting may force the data provider to do things like quality assurance at a time when it should be done anyway.

The WDCA uses an augmented version of the NASA Ames 1001 format for data submissions, termed EBAS NASA-Ames. This format consists of a metadata header sections and a data section, is backwards compatible with the original NASA Ames 1001 format, but contains additional specifications. The reasons for choosing and keeping this format are:

- **Simplicity**: The format consists of a pure ASCII text that may be assembled and used with numerous, readily available spreadsheet applications, plotting applications, and numerical libraries. It is readable and understandable for a human reader. It is streamlined enough to make the instructions on assembling it fit on a few pages, which is rarely matched by other formats, but still contains the essential information for efficient data archiving, discovery, and documentation.

- **Reduce format confusion**: Some features and specifications of NASA Ames 1001 and EBAS NASA-Ames are certainly outdated and targeted at older IT environments. However, as long as necessary new features can be implemented within the existing format, defining an only slightly optimised new format would only add to the format confusion and limit the use of existing routines and libraries.

- **Keep threshold low**: Other formats like NetCDF or HDF have come into use in the modelling and satellite communities, respectively. However, these are binary formats, not plainly readable for a human, and special applications or routines and a steep learning curve are required for assembling them. For WDCA, it is the intention to keep the threshold for data providers as low as possible. EBAS NASA-Ames has been in use for well more than a decade, and is used also by countries with less developed atmospheric monitoring infrastructures.

3.2 Step-by-Step Guideline

1. **Deadline**
The WMO GAW Programme is built on voluntary contributions. However, many users of the data provided by the WMO GAW Programme depend on the data being available within a reasonable period of time after the measurement has been taken. The GAW SAG aerosol has therefore adopted a **deadline** for data submission. Data collected during a given year should be reported by the end of the following year, i.e. within **one year after the last measurement of that year was taken,** one file per instrument covering the whole year. Please plan your schedule accordingly.

2. **Registration with GAWSIS**
The GAW Station Information System (GAWSIS) is a directory of the stations that contribute observation data to the WMO GAW network. It carries information about a station's location, setting, and network affiliations, and maintains a list of parameters measured at the station along with the contact details of the principal investigators responsible for each parameter. Since GAW data is distributed over several data centres, GAWSIS serves to connect the data centres by linking to the data archived from a station at the individual data centres. GAWSIS is also the authority for assigning the GAW station ID, a unique three letter identifier for a station. You need a GAW station ID for reporting data to WDCA. If you haven't reported data to any GAW data centre before, please register your station with GAWSIS first and obtain your GAW station ID.

3. **Initial contact with WDCA**
Please establish the initial contact with WDCA by writing an e-mail to ebas@nilu.no. In your mail, please indicate the station you are intending to report data for, the GAWSIS station ID, and the aerosol parameters you intend to report. In return, you will receive two additional IDs, the EBAS station code and the EBAS platform code, which you will need for the metadata in your submission. The reason for having several station codes lies in GAW and CLRTAP collaborating. The three letter GAW IDs and the IDs used in the CLRTAP EMEP database EBAS were introduced independently and are maintained for consistency.

4. **Quality assure your data**
This step will probably take longest of all steps in this data submission guideline, and is prerequisite for any further use of the data. Please make sure that you followed the respective SOP valid for your instrument given in this document, both during data collection and data processing and evaluation. There will likely be periods for which the data is invalid due to calibrations or malfunctions, and there may be additional conditions (activity around the station, etc.) you will want to convey to the data user. WDCA uses a system of flags for this purpose. Each flag is assigned a three digit integer number. A list of these flags can be found at: http://tarantula.nilu.no/projects/ccc/flags/flags.html. The list of flags is comprehensive, but may not be complete. If there is a condition you think is not covered, please send an e-mail to ebas@nilu.no for guidance or an extension of the list of flags.

5. **Assemble / Update metadata header**
In assembling the header with metadata for a first-time data submission, it is probably easiest just to copy the respective template valid for the parameter to be reported from the example section, and adapt it to the station and protocols used for data collection and processing. Each line in the template has a line number pointing to an explanation of the content. The explanation always begins with a specification of the syntax used. Items enclosed in "<>" mark a place holder to be replaced with content or key words as described. Please follow the syntax exactly since many lines contain a keyword identifying the content, and these keywords are recognised by string comparison. Green line numbers mark header items common for all parameter types. These are explained at the very end of the template section. Red line numbers mark header items specific for a parameter, and are explained in the respective section. Please note that the line numbers are NOT part of the

actual file to be submitted.

If you have submitted data for a given parameter to WDCA before, you can copy the header from the previous year to start with. Some header fields are mandatory to be updated, but please take the time to go through the whole header and check whether your procedures changed, which needs to be reflected in the header.

6. Format data, join header and data

The data section of an EBAS NASA-Ames file consists of a fixed width, fixed number format ASCII table, with the number formats specified in the file header. Please refer to the parameter specific sections for examples. Once the data section is constructed, please join header and data section into one file, and name the file using the file name stated in the header.

7. Submit Data

The files containing the data submissions are uploaded to WDCA's anonymous FTP-site, which is accessible at:

ftp://gaw-wdca.nilu.no/incoming

To prevent abuse of this server, it is configured in "blind-drop" mode. It accepts uploads only and ignores directory requests, i.e. you won't be able to see the files you just uploaded, and you won't be able to delete them once they are uploaded. If you uploaded a file in error, please send an e-mail to ebas@nilu.no and specify the details. Currently, you won't receive an automated acknowledgement of receipt, but this service is due to be added.

4. RETRIEVING YOUR DATA FROM THE DATABASE

The WDCA is hosted by the EBAS database, which was originally established for the CLRTAP. The EBAS web-interface is accessible at:

http://ebas.nilu.no

EBAS allows you to search for data geographically, by measured parameter, or by project association. Some projects require a login to access their associated data. Datasets may be listed, graphically displayed, or downloaded in EBAS NASA-Ames format. The data reported to WDCA by regular, annual submission are identified in EBAS by the project association *GAW-WDCA*. Please observe that the data format you receive on download may differ slightly from the format specified for submitting data while preserving the information. A number of frameworks and commissions were involved in defining the details of the data reporting and submission formats with in parts conflicting specifications. These cannot be reflected in a complex database infrastructure.

5. INSTRUMENT SPECIFIC TEMPLATES AND INSTRUCTIONS

5.1 Particle Mass Concentration Obtained by Gravimetric Filter Analysis

5.1.1 Example and Template

```
1:    80 1001
2:    Fiebig, Markus; Someone, Else
3:    NO01L, Norwegian Institute for Air Research, NILU,, Instituttveien 18,, N-2027, Kjeller, Norway
4:    Fiebig, Markus
5:    GAW-WDCA
6:    1 1
7:    2008 01 01 2008 06 24
8:    1.000000
9:    Days from the file reference point (start_time)
10:   7
11:   1 1 1 1 1 1 1
12:   9999.999999 9999 9999 9999.99 9999.99 999999.999999 9.99999999999999999999999999999999999999999999
13:   end_time of measurement, days from the file reference point
14:   start_time of measurement, year
15:   end_time of measurement, year
16:   internal instrument pressure, hPa
16:   internal instrument temperature, K
16:   pm10_mass, ug/m3
100:  numflag, no unit
101:  0
102:  59
201:  Data definition:              EBAS_1.1
202:  Set type code:                TU
203:  Station code:                 NO0001R
204:  Platform code:                NO0001S
205:  Timezone:                     UTC
206:  Startdate:                    20080101000000
207:  Timeref:                      00_00
208:  Revision date:                20080624000000
210:  Component:                    pm10_mass
211:  Unit:                         ug/m3
212:  Matrix:                       pm10
```

```
213: Period code:                    1y
214: Resolution code:                1d
215: Sample duration:                1d
216: Laboratory code:                NO01L
217: Instrument type:                low_vol_sampler
218: Instrument name:                Derenda_LVS3.1_BIR_pm10
219: Instrument serial number:       70810508
220: Method ref:                     NO01L_pm10_lvs
221: Ext. lab. code:                                [this line is optional]
222: Ext. meth. ref:                                [this line is optional]
223: Add. qualifier:                 1d
224: File name:                      NO0042R.20080101000000.20080624000000.pm10_mass.pm10.1y.1d.nas
226: Station WDCA-ID:                GAWANO__BIR
227: Station WDCA-Name:              Birkenes Atmospheric Observatory
228: Station GAW-ID:                 BIR
229: Station AIRS-ID:                               [this line is optional]
230: Station other IDs:              201(NILUDB)
231: Station state/province:                        [this is line optional]
232: Station latitude:               58.380
233: Station longitude:              8.250
234: Station altitude:               220m
235: Station land use:               Forest
236: Station setting:                Rural
237: Station GAW type:               R
238: Station WMO region:             6
239: Originator:                     Fiebig, Markus, Markus.Fiebig@nilu.no, Norwegian Institute for Air Research, NILU, Atmosphere and Climate
                               Department, Instituttveien 18,, N-2027, Kjeller, Norway
239: Originator:                     Someone, Else, Someone@somewhere.no, Some nice Institute, WOW, Super interesting division, Street 18,, X-9999,
                               Paradise, Noway
240: Submitter:                      Fiebig, Markus, Markus.Fiebig@nilu.no, Norwegian Institute for Air Research, NILU, Atmosphere and Climate
                               Department, Instituttveien 18,, N-2027, Kjeller, Norway
241: Data level:                     2
242: Version:                        1
243: Version description:            initial revision
244: Height AGL:                     4m
245: Medium:                         Teflon
247: Inlet type:                     Impactor--direct
248: Inlet description:              PM10 at ambient humidity inlet, deliverd with sampler, flow 2.3 m3/h
249: Humidity/temperature control: None
250: Humidity/temperature control description: filter kept at ambient conditions together with sampling head.
```

```
251: Volume std. temperature:      273.15K
252: Volume std. pressure:         1013.25hPa
253: Detection limit:              0.33 ug/m3
254: Detection limit expl.:        Determined by taking 3 times standard deviation of ensemble of field blanks
255: Zero/negative values:         Zero/negative value reported with detection limit and flagged as below detection limit
256: Standard method:              SOP=CEN12341:1998
257: Sample preparation:           Temperature and humidity equilibration
258: Blank correction:             Not blank corrected
259: Comment:                      filter face velocity: 0.48 m/s; conditioning: T = 293.15 K, RH = 50%
260: Acknowledgement:              Request acknowledgement details from data originator
261:  start_time    end_time st_y ed_y   p_int   T_int          pm10 numflag
301:    0.333333    1.333333 2008 2008  839.40  299.80      7.352200 0.000000000000000000000000000000000000000000000
302:    1.333333    2.333333 2008 2008 9999.99 9999.99 999999.999999 0.999000000000000000000000000000000000000000000
303:    2.333333    3.333333 2008 2008  839.40  299.80      0.330000 0.781000000000000000000000000000000000000000000
```

5.1.2 Instrument Type Specific Line-by-Line Instructions

Line Nr.	Explanation of content
16	**Full titles of dependent data columns, gravimetric particle mass specific columns** syntax: internal instrument pressure, hPa internal instrument temperature, K pm10_mass, ug/m3 Expl.: These lines contain the titles of the dependent data columns, one each up to the total number specified in line 10. The titles of the dependent data columns (and thus the content type) are fixed for each instrument type. The titles should match the specification exactly to allow for column identification by string comparison. All properties referring to a volume of air (such as the particle mass concentration per volume of air) are to be stated for standard conditions of temperature and pressure (273.15 K, 1013.25 hPa). The temperature and pressure stated are the ones measured inside the instrument and included to allow to calculate the concentrations back to the original measurement conditions.
210	**Component name identifying dataset type** syntax: Component: <size fraction specific tag> Expl.: Component names are fixed for and identify the type of the reported data. For filter based gravimetric measurements of particle mass concentrations, the component name depends on the size fraction sampled: pm1_mass: if a system sampling the PM1 aerosol particle fraction was used, i.e. the fraction of particles with aerodynamic diameter smaller than 1.0 µm. pm25_mass: if a system sampling the PM2.5 aerosol particle fraction was used, i.e. the fraction of particles with aerodynamic diameter smaller than 2.5 µm. pm10_mass: if a system sampling the PM10 aerosol particle fraction was used, i.e. the fraction of particles with aerodynamic diameter smaller than 10.0 µm.
211	**Unit of reported main variable** syntax: Unit: ug/m3 Expl.: The unit of the reported main variable is determined by the component name. For particle mass concentration data measured by gravimetric filter sampling, the unit always needs to be ug/m3 (as ASCII version of µg/m³). The unit stated here doesn't rule out that the file contains auxiliary variables that are given in other units as specified in the respective column headers.
217	**Instrument type** syntax: Instrument type: <instrument type> Expl.: The instrument type is defined to refer to the measurement principle. For observations of PM mass, this strict definition had to be slightly softened in order to acknowledge terminology grown over several decades for this traditional type of observation. There are 2 options of instrument type for PM mass measurements: low_vol_sampler: A low volume sampler is a filter sampler with a flow rate of 2.3 m³/h (38 l/min) for the samplers following the European standards for PM10 and PM2.5, while in the U.S. Environmental Protection Agency (EPA) specified a flow rate of 1 m³/h (16.7 l/min). Lower flow may also be used for some samplers. The filter size is most commonly 47mm (circular). high_vol_sampler: A high volume sampler is a filter sampler with a flow rate of 68 m³/h (1133 l/min; 40 CFM) for PM10, and 30.0 m³/h (500 l/min; 17.7 CFM) for PM2.5 and PM1. Common filter sizes include 150 mm (circular) or 20.3 cm x 25.4 cm (rectangular). If your instrument is not represented by the above definition, please send an e- mail to ebas@nilu.no.

Line Nr.	Explanation of content
218	**Instrument name** syntax: Instrument name: <manufacturer>_<model>_<additional ID> Expl.: The instrument name field serves 3 purposes: • identify instrument manufacturer • identify instrument model • logically identify instrument uniquely within the network A change in the instrument name will be registered as start of a new time series, even if the same parameter has been measured before at the station. This is meant to ensure that a time series is internally comparable. The instrument name must not contain spaces. Its manufacturer and model parts need to be selected from the list of allowed combinations below. The "additional ID" is supposed to make the ID unique within the GAW network and the WDCA database. Please choose a logical ID, e.g. the style "BIR_pm10" identifying the instrument sampling the pm10 aerosol at Birkenes Observatory (Norway). That way, the instrument name won't need to change if you swap the instrument with one having a different serial number which is otherwise identical. The additional ID also allows to distinguish several instruments of the same type and model that may be run in parallel at a station for different purposes or intercomparison. The choice of instrument manufacturer and model has to correspond to the instrument type stated in header line 217. If you are using an instrument not listed below, please send an e- mail to ebas@nilu.no.

high volume filter sampler

<manufacturer>	<model>
Derenda	HVS30.2
Derenda	HVS60.2
DIGITEL	DHA-80
DIGITEL	DH-77
DIGITEL	DS-02
ECOTECH	HiVol3000
HI-Q	HVP-2000
HI-Q	HVP-3000
HI-Q	HVP-4000AFC
HI-Q	HVP-4300AFC
ISAP	3000e
Thermo	MFC-PM-2.5
Thermo	MFC-PM10
Thermo	VFC-PM-2.5
Thermo	VFC-PM10

low volume filter sampler

<manufacturer>	<model>
Derenda	LVS3.1
Derenda	MVS6.1
DIGITEL	DPA02
DIGITEL	DPA96
ECOTECH	MicroVol1100
ISAP	1050e
ISAP	1050-31e
Leckel	LVS3
Leckel	MVS6
Leckel	SEQ47/50
Thermo	Partisol2000-FRM
Thermo	Partisol2000-D
Thermo	Partisol2000i
Thermo	Partisol2000i-D
Thermo	Partisol2025
Thermo	Partisol2025-D
Thermo	Partisol2025i
Thermo	Partisol2025i-D

Line Nr.	Explanation of content
245	**Filter Medium** syntax: Medium: <filter medium tag> Expl.: The medium states the substrate onto which the targeted substance is adsorbed from the sample. For samples of PM, this is the filter substrate material. The filter substrate is usually specified in the standard method used to acquire the sample. The appropriate medium tag may be chosen from the list of allowed keywords below. For those keyword including a "see metadata", the appropriate information should be stated in the comment line (line 259). Allowed keywords: Cellulose; Cellulose+nylon; Glass fiber Nylazorb; Nylon; PUF (Polyurethane foam) Quartz; Quartz+glass fiber; Teflon Teflon-coated glass; Teflon-coated quartz; Teflon membrane Teflon+nylon; Filter—other Charcoal; Coating or absorbing solution; Gold Impaction surface; PUF (Polyurethane foam); Silica Tenax; XAD Filter(s)+PUF (Polyurethane foam) Filter(s) and impaction surface Filters--multiple not impregnated (see metadata) Filters--multiple impregnated (see metadata) Filters--multiple--combination of impregnated and non-impregnated (see metadata)
256	**Standard method** syntax: Standard method: <standard method tag> Expl.: The standard method refers to one of the standard operating procedures (SOPs) for gravimetric measurements of PM mass recognised by the GAW Scientific Advisory Group for aerosol. Please use one of the keywords for recognised SOPs listed below only if your observations are in fact conducted following this SOP. If not, you may and should still report your observations, and fill in this field with "None". **SOP=EN12341:1998**: This method is only applicable for measurements of PM 10 mass. The measurements were obtained adhering to the specifications of the European CEN norm EN12341 in its version of 1998. The text of the norm is commercially available through the National Standards Organisations of the CEN member countries. For obtaining a copy, please browse to http://esearch.cen.eu/, enter "12341" into the "Standard reference" field of the form, and find your way to your preferred national sales point. **SOP=EN14907:2005**: This method is only applicable for measurements of PM 2.5 mass. The measurements were obtained adhering to the specifications of the European CEN norm EN14907 in its version of 2005. The text of the norm is commercially available through the National Standards Organisations of the CEN member countries. For obtaining a copy, please browse to http://esearch.cen.eu/, enter "14907" into the "Standard reference" field of the form, and find your way to your preferred national sales point. **None**: None of the above standard operating procedures is used. Please use a few keywords to describe your method as comment in line 259.

Line Nr.	Explanation of content
257	**Sample preparation** syntax: Sample preparation: <sample preparation tag tag> Expl.: The sample preparation field states how the PM filter sample was conditioned prior to analysis. Please select the appropriate tag from the list of allowed values below. If the standard operating procedure referenced in the Standard method field leaves room in the details of conditioning, e.g. a range of temperature and humidity for temperature and humidity equilibration, please state the values used in the comment line (line 259). List of allowed sample preparation tags: Acid digestion; Acid extraction Base extraction; Filtration Fractionation by sequential extraction; Organic extraction Temperature and humidity equilibration; Thermal desorption Total digestion; Water extraction Water+base extraction; Not applicable
258	**Blank correction** syntax: Blank correction: <blank correction tag> Expl.: This line states whether the measurement was blank corrected or not. Please select the appropriate tag from the list of allowed tags: Blank corrected; Not blank corrected
259	**Comment** syntax: Comment: <freetext comment> Expl.: This line allows to convey any additional information on how the data was processed, e.g. parameters used for processing the data according to the stated Standard method. For gravimetric samples of PM mass, please state at least the filter face velocity in your sampler, and the exact values for temperature and humidity conditioning. If the filter medium used requires additional specifications, please include them here also. E.g.: Comment: filter face velocity: 0.48 m/s; conditioning: T = 293.15 K, RH = 50%
303	Third data section example line syntax: <DOY start time> <DOY end time> <1st data value> <2nd data value> ... <flags column> Expl.: This line exemplifies how values below the detection limit can be reported. The "781" flag (Value below detection limit, data element contains detection limit) is set, the data column contains the detection limit.

5.2 Particle Mass Concentration Obtained with Equivalent Online Method (e.g. Beta Attenuation)

5.2.1 Example and Template

```
1:    79 1001
2:    Fiebig, Markus; Someone, Else
3:    NO01L, Norwegian Institute for Air Research, NILU,, Instituttveien 18,, N-2027, Kjeller, Norway
4:    Fiebig, Markus
5:    GAW-WDCA
6:    1 1
7:    2008 01 01 2008 06 24
8:    0.041667
9:    Days from the file reference point (start_time)
10:   9
11:   1 1 1 1 1 1 1 1 1
12:   9999.999999 9999 9999 9999.99 9999.99 999999.999999 999999.999999 999999.999999 9.999999999999999999999999999999999999999999999
13:   end_time of measurement, days from the file reference point
14:   start_time of measurement, year
15:   end_time of measurement, year
16:   internal instrument pressure, hPa
16:   internal instrument temperature, K
16:   pm10_mass, ug/m3
16:   pm10_mass, ug/m3, Statistics=percentile:15.83
16:   pm10_mass, ug/m3, Statistics=percentile:84.17
100:  numflag
101:  0
102:  56
201:  Data definition:              EBAS_1.1
202:  Set type code:                TU
203:  Station code:                 NO0001R
```

```
204:  Platform code:               NO0001S
205:  Timezone:                    UTC
206:  Startdate:                   20080101000000
207:  Timeref:                     00_00
208:  Revision date:               20080624000000
210:  Component:                   pm10_mass
211:  Unit:                        ug/m3
212:  Matrix:                      pm10
213:  Period code:                 1y
214:  Resolution code:             1h
215:  Sample duration:             1h
216:  Laboratory code:             NO01L
217:  Instrument type:             optical_particle_counter
218:  Instrument name:             Grimm_190_BIR_dry
219:  Instrument serial number:    70810508
220:  Method ref:                  NO01L_pm10_Grimm190
221:  Ext. lab. code:                             [this line is optional]
222:  Ext. meth. ref:                             [this line is optional]
223:  Add. qualifier:              5s
224:  File name:                   NO0042R.20080101000000.20080624000000.pm10_mass.pm10.1y.1h.nas
226:  Station WDCA-ID:             GAWANO__BIR
227:  Station WDCA-Name:           Birkenes Atmospheric Observatory
228:  Station GAW-ID:              BIR
229:  Station AIRS-ID:                            [this line is optional]
230:  Station other IDs:           201(NILUDB)
231:  Station state/province:                     [this is line optional]
232:  Station latitude:            58.380
233:  Station longitude:           8.250
234:  Station altitude:            220m
235:  Station land use:            Forest
```

```
236:  Station setting:              Rural
237:  Station GAW type:             R
238:  Station WMO region:           6
239:  Originator:                   Fiebig, Markus, Markus.Fiebig@nilu.no, Norwegian Institute for Air Research, NILU, Atmosphere and Climate
                                      Department, Instituttveien 18,, N-2027, Kjeller, Norway
239:  Originator:                   Someone, Else, Someone@somewhere.no, Some nice Institute, WOW, Super interesting division, Street 18,, X-9999,
                                      Paradise, Noway
240:  Submitter:                    Fiebig, Markus, Markus.Fiebig@nilu.no, Norwegian Institute for Air Research, NILU, Atmosphere and Climate
                                      Department, Instituttveien 18,, N-2027, Kjeller, Norway
241:  Data level:                   2
242:  Version:                      1
243:  Version description:          initial revision
244:  Height AGL:                   4m
247:  Inlet type:                   Hat or hood
248:  Inlet description:            inlet as delivered with instrument, incl. dryer and hat
249:  Humidity/temperature control: Nafion dryer
250:  Humidity/temperature control description: Sample heated to lab temperature and dried to RH < 40%.
251:  Volume std. temperature:      273.15K
252:  Volume std. pressure:         1013.25hPa
253:  Detection limit:              0 ug/m3
254:  Detection limit expl.:        Determined only by instrument counting statistics, no detection limit flag used
255:  Zero/negative values:         Zero values may appear due to statistical variations at very low concentrations
256:  Standard method:              None
259:  Comment:                      Instrument installed and operated according to manual, drier switch-on threshold set to 40% RH
260:  Acknowledgement:              Request acknowledgement details from data originator
261:   start_time    end_time st_y ed_y   p_int   T_int          pm10   pm10pc15.83   pm10pc84.17 numflag
301:     0.333333    1.333333 2008 2008  839.40  299.80      7.352200      6.616600      8.087700 0.000000000000000000000000000000000000000000000
302:     1.333333    2.333333 2008 2008 9999.99 9999.99 999999.999999 999999.999999 999999.999999 0.999000000000000000000000000000000000000000000
```

5.2.2 Instrument Type Specific Line-by-Line Instructions

Line Nr.	Explanation of content
16	**Full titles of dependent data columns, gravimetric particle mass specific columns** syntax: internal instrument pressure, hPa internal instrument temperature, K pm10_mass, ug/m3 pm10_mass, ug/m3, Statistics=percentile:15.83 pm10_mass, ug/m3, Statistics=percentile:84.17 Expl.: These lines contain the titles of the dependent data columns, one each up to the total number specified in line 10. The titles of the dependent data columns (and thus the content type) are fixed for each instrument type. The titles should match the specification exactly to allow for column identification by string comparison. All properties referring to a volume of air (such as the particle mass concentration per volume of air) are to be stated for standard conditions of temperature and pressure (273.15 K, 1013.25 hPa). The temperature and pressure stated are the ones measured inside the instrument and included to allow to calculate the concentrations back to the original measurement conditions. As measure of the atmospheric variability, the format includes not only the averages (arithmetic mean) of the mass concentration for the hourly averaging period, but also the 15.87 and 84.13 percentiles . The hourly averages should preferably be based on at least 60 values, i.e. minute averages of raw data. Especially in case of fewer values or poor coverage, it is recommended to interpolate between adjacent percentile values to calculate the specified percentiles. These percentiles were chosen because they correspond to average value plus one standard deviation and average value minus one standard deviation in case the data has a normal (Gaussian) probability distribution.
210	**Component name identifying dataset type** syntax: Component: <size fraction specific tag> Expl.: Component names are fixed for and identify the type of the reported data. A list of all allowed values can be found here. For online observations of particle mass concentrations, the component name depends on the size fraction sampled: **pm1_mass**: if a system sampling the PM1 aerosol particle fraction was used, i.e. the fraction of particles with aerodynamic diameter smaller than 1.0 µm. **pm25_mass**: if a system sampling the PM2.5 aerosol particle fraction was used, i.e. the fraction of particles with aerodynamic diameter smaller than 2.5 µm. **pm10_mass**: if a system sampling the PM10 aerosol particle fraction was used, i.e. the fraction of particles with aerodynamic diameter smaller than 10.0 µm. If an instrument measures the PM mass in more than one size fraction, please submit one data file for each size fraction.
211	**Unit of reported main variable** syntax: Unit: ug/m3 Expl.: The unit of the reported main variable is determined by the component name. For particle mass concentration data measured by online methods, the unit always needs to be ug/m3 (as ASCII version of µg/m³). The unit stated here doesn't rule out that the file contains auxiliary variables that are given in other units as specified in the respective column headers.

Line Nr.	Explanation of content

217 **Instrument type**

syntax: Instrument type: <instrument type>

Expl.: The instrument type is defined to refer to the measurement principle used in the instrument. For online observations of PM mass, there are 3 options of instrument type:

TEOM: The acronym TEOM stands for "Tapered Element Oscillating Microbalance", and refers to a class of instruments formerly produced by Rupprecht & Patashnick Co., Inc. and, since 2005, by Thermo Fisher Scientific, Inc. The instrument infers the mass of particles deposited on a filter by monitoring the resonance frequency of the filter. The particle size fraction is determined by an impactor or cyclone in the inlet system.

beta_gauge_particulate_sampler: This instrument type refers to devices that infer the mass of particles deposited on a filter by monitoring the filter's capacity to attenuate a ray of β-particles. The particle size fraction is determined by an impactor or cyclone in the inlet system.

optical_particle_counter: This instrument type refers to devices that infer the mass of particles in a sample by optically measuring the particle size distribution and integrating over it in the desired size range.

If your instrument is not represented by the above definitions, please send an e- mail to ebas@nilu.no.

218 **Instrument name**

syntax: Instrument name: <manufacturer>_<model>_<additional ID>

Expl.: The instrument name field serves 3 purposes:

- identify instrument manufacturer
- identify instrument model
- logically identify instrument uniquely within the network

A change in the instrument name will be registered as start of a new time series, even if the same parameter has been measured before at the station. This is meant to ensure that a time series is internally comparable.

The instrument name must not contain spaces. Its manufacturer and model parts need to be selected from the list of allowed combinations below. The "additional ID" is supposed to make the ID unique within the GAW network and the WDCA database. Please choose a logical ID, e.g. the style "BIR_dry" identifying the instrument sampling the dry-state aerosol at Birkenes Observatory (Norway). That way, the instrument name won't need to change if you swap the instrument with one having a different serial number which is otherwise identical. The additional ID also allows to distinguish several instruments of the same type and model that may be run in parallel at a station for different purposes or intercomparison. The choice of instrument manufacturer and model has to correspond to the instrument type stated in header line 217. If you are using an instrument not listed below, please send an e- mail to ebas@nilu.no.

TEOM

<manufacturer>	<model>	<manufacturer>	<model>
Rupprecht&Patashnick	1400	Thermo	1400a
Rupprecht&Patashnick	1400a	Thermo	1400ab
Rupprecht&Patashnick	1400aa	Thermo	1405
Rupprecht&Patashnick	1400ab	Thermo	1405D

beta_gauge_particulate_sampler

<manufacturer>	<model>	<manufacturer>	<model>
Eberline	FH62I-R	Thermo	5014i
MetOne	BAM1020	Thermo	FH62C14
		Thermo	FH62I-R

optical_particle_counter

<manufacturer>	<model>	<manufacturer>	<model>
Grimm	180	Grimm	190

Line Nr.	Explanation of content
256	**Standard method** syntax: Standard method: <standard method tag> Expl.: The standard method refers to a standard operating procedure (SOP) for online measurements of PM mass recognised by the GAW Scientific Advisory Group for aerosol. The instrument types listed in the instructions for header line 217 are usually certified as equivalent to their respective gravimetric counterparts. However, there currently exist no independent SOPs describing proper instrument installation, maintenance, and data reduction for any of these instruments apart from the individual instrument manuals. The list of available standard methods therefore contains only one entry, and will be continuously updated: **None**: No recognised standard operating procedures is used, since none is available. Please use a few keywords to describe your method as comment in line 259. If you have suggestions for SOPs to be considered by the GAW aerosol Scientific Advisory Group, please send an e- mail to ebas@nilu.no.
259	**Comment** syntax: Comment: <freetext comment> Expl.: This line allows to convey any additional information on how the data was processed, e.g. parameters used for processing the data according to the stated Standard method. For online samples of PM mass, please state some keywords on the SOP used, e.g.: Comment: Instrument installed and operated according to manual, drier switch-on threshold set to 40% RH

5.3 Light Absorption Coefficient Obtained by Filter Absorption Photometer (e.g. Thermo 5012 MAAP or Radiance Research PSAP)

5.3.1 Example and Template

```
1: 84 1001
2: Fiebig, Markus; Someone, Else
3: NO01L, Norwegian Institute for Air Research, NILU,, Instituttveien 18,, N-2027, Kjeller, Norway
4: Fiebig, Markus
5: GAW-WDCA
6: 1 1
7: 2008 01 01 2008 06 24
8: 0.041667
9: Days from the file reference point (start_time)
10: 16
11: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
12: 9999.999999 9999 9999 9999.99 9999.99 9999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999
    999999.999999 999999.999999 9.999999999999999999999999999999999999999999
13: end_time of measurement, days from the file reference point
14: start_time of measurement, year
15: end_time of measurement, year
16: internal instrument pressure, hPa
16: internal instrument temperature, K
16: number of wavelengths
16: absorption coefficient at 470 nm, 1/Mm
16: absorption coefficient at 520 nm, 1/Mm
16: absorption coefficient at 660 nm, 1/Mm
16: absorption coefficient at 470 nm, 15.87 percentile, 1/Mm
16: absorption coefficient at 520 nm, 15.87 percentile, 1/Mm
16: absorption coefficient at 660 nm, 15.87 percentile, 1/Mm
16: absorption coefficient at 470 nm, 84.13 percentile, 1/Mm
16: absorption coefficient at 520 nm, 84.13 percentile, 1/Mm
16: absorption coefficient at 660 nm, 84.13 percentile, 1/Mm
100: numflag, no unit
```

```
101: 0
102: 54
201: Data definition:            EBAS_1.1
202: Set type code:              TU
203: Station code:               NO0001R
204: Platform code:              NO0001S
205: Timezone:                   UTC
206: Startdate:                  20080101000000
207: Timeref:                    00_00
208: Revision date:              20080624000000
210: Component:                  aerosol_absorption_coefficient
211: Unit:                       1/Mm
212: Matrix:                     pm10
213: Period code:                1y
214: Resolution code:            1h
215: Sample duration:            1h
216: Laboratory code:            NO01L
217: Instrument type:            filter_absorption_photometer
218: Instrument name:            Radiance-Research_PSAP-3W_BIR_dry
219: Instrument serial number:   70810508
220: Method ref:                 NO01L_abs_coef_PSAP_v1
223: Add. qualifier:             6mn
224: File name:                  NO0042R.20080101000000.20080624000000.aerosol_absorption_coefficient.pm10.1y.1h.nas
226: Station WDCA-ID:            GAWANO__BIR
227: Station WDCA-Name:          Birkenes Atmospheric Observatory
228: Station GAW-ID:             BIR
229: Station AIRS-ID:                           [this line is optional]
230: Station other IDs:          201(NILUDB)
231: Station state/province:                    [this is line optional]
232: Station latitude:           58.380
233: Station longitude:          8.250
```

```
234: Station altitude:              220m
235: Station land use:              Forest
236: Station setting:               Rural
237: Station GAW type:              R
238: Station WMO region:            6
239: Originator:                    Fiebig, Markus, Markus.Fiebig@nilu.no, Norwegian Institute for Air Research, NILU, Atmosphere and Climate
                                      Department, Instituttveien 18,, N-2027, Kjeller, Norway
239: Originator:                    Someone, Else, Someone@somewhere.no, Some nice Institute, WOW, Super interesting division, Street 18,, X-9999,
                                      Paradise, Noway
240: Submitter:                     Fiebig, Markus, Markus.Fiebig@nilu.no, Norwegian Institute for Air Research, NILU, Atmosphere and Climate
                                     Department, Instituttveien 18,, N-2027, Kjeller, Norway
241: Data level:                    2
242: Version:                       1
243: Version description:           initial revision, Adis_PSAP_lev0_2_lev1 v.0.0_2, Adis_PSAP_lev1_2_lev2 v.0.0.3
244: Height AGL:                    4m
247: Inlet type:                    Impactor--direct
248: Inlet description:             PM10 at ambient humidity inlet, Digitel, flow 140 l/min
249: Humidity/temperature control: None
250: Humidity/temperature control description: passive, sample heated from atmospheric to lab temperature
251: Volume std. temperature:       273.15K
252: Volume std. pressure:          1013.25hPa
253: Detection limit:               0.1 1/Mm
254: Detection limit expl.:         Determined by instrument noise characteristics, no detection limit flag used
255: Zero/negative values:          Zero and neg. values may appear due to statistical variations at very low concentrations
256: Standard method:               Single-angle_Correction=Bond1999
259: Comment:                       Standard Bond et al. 1999 values for K1 and K2 used at all wavelengths
260: Acknowledgement:               Request acknowledgement details from data originator
261:  start_time    end_time st_y ed_y    p_int   T_int NWav        abs470        abs520        abs660    abs470pc16    abs520pc16    abs660pc16
     abs470pc84    abs520pc84    abs660pc84 numflag
301:    0.000069    0.004236 2008 2008  839.40  299.70    3      0.556600      0.319600      0.395600      0.556600      0.319600      0.395600
     0.556600      0.319600      0.395600 0.000000000000000000000000000000000000000000000
302:    0.004236    0.008472 2008 2008 9999.99 9999.99    3 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999
     999999.999999 999999.999999 999999.999999 0.990000000000000000000000000000000000000000000
```

5.3.2 Instrument Type Specific Line-by-Line Instructions

Line Nr.	Explanation of content
16	**Full titles of dependent data columns, absorption photometer specific columns** syntax: internal instrument pressure, hPa internal instrument temperature, K number of wavelengths absorption coefficient at <wavelength 1> nm, 1/Mm absorption coefficient at <wavelength 2> nm, 1/Mm absorption coefficient at <wavelength 3> nm, 1/Mm absorption coefficient at <wavelength 1> nm, 15.87 percentile, 1/Mm absorption coefficient at <wavelength 2> nm, 15.87 percentile, 1/Mm absorption coefficient at <wavelength 3> nm, 15.87 percentile, 1/Mm absorption coefficient at <wavelength 1> nm, 84.13 percentile, 1/Mm absorption coefficient at <wavelength 2> nm, 84.13 percentile, 1/Mm absorption coefficient at <wavelength 3> nm, 84.13 percentile, 1/Mm Expl.: These lines contain the titles of the dependent data columns, one each up to the total number specified in line 10. The titles of the dependent data columns (and thus the content type) are fixed for each instrument type. Except for numerical values indicating a wavelength or particle diameter, the titles should match the specification exactly to allow for column identification by string comparison. All properties referring to a volume of air (such as scattering and backscattering coefficients) are to be stated for standard conditions of temperature and pressure (273.15 K, 1013.25 hPa). The temperature and pressure stated are the ones measured inside the instrument and included to allow to calculate the concentrations back to the original measurement conditions. The number of wavelengths and the wavelength values are to be adjusted to the values provided by the instrument. The data is expected to be corrected for the dependence on particle scattering. As measure of the atmospheric variability, the format includes not only the averages (arithmetic mean) of the absorption coefficient for the hourly averaging period, but also the 15.87 and 84.13 percentiles . The hourly averages should preferably be based on at least 60 values, i.e. minute averages of raw data. Especially in case of fewer values or poor coverage, it is recommended to interpolate between adjacent percentile values to calculate the specified percentiles. These percentiles were chosen because they correspond to average value plus one standard deviation and average value minus one standard deviation in case the data has a normal (Gaussian) probability distribution.
210	**Component name identifying dataset type** syntax: Component: aerosol_absorption_coefficient Expl.: Component names are fixed for and identify the type of the reported data. For filter absorption photometer data however, this line always needs to have the content as stated here.
211	Unit of reported main variable syntax: Unit: 1/Mm Expl.: The unit of the reported main variable is determined by the component name. For absorption coefficient data measured by filter absorption photometer, the unit always needs to be 1/Mm. The unit stated here doesn't rule out that the file contains auxiliary variables that are given in other units as specified in the respective column headers.
217	Instrument type syntax: Instrument type: <instrument type> Expl.: The instrument type refers to the measurement principle. For filter-based in situ observations of the local aerosol absorption coefficient, the instrument type is always "filter_absorption_photometer".

<table>
<tr><th>Line Nr.</th><th>Explanation of content</th></tr>
<tr><td>218</td><td>Instrument name
syntax: Instrument name: <manufacturer>_<model>_<additional ID>
Expl.: The instrument name field serves 3 purposes:
• identify instrument manufacturer
• identify instrument model
• logically identify instrument uniquely within the network
A change in the instrument name will be registered as start of a new time series, even if the same parameter has been measured before at the station. This is meant to ensure that a time series is internally comparable. The instrument name must not contain spaces. Its manufacturer and model parts need to be selected from the list of allowed combinations below. The "additional ID" is supposed to make the ID unique within the GAW network and the WDCA database. Please choose a logical ID, e.g. the style "BIR_dry" identifying the instrument sampling the dry-state aerosol at Birkenes Observatory (Norway). That way, the instrument name won't need to change if you swap the instrument with one having a different serial number which is otherwise identical. The additional ID also allows to distinguish several instruments of the same type and model that may be run in parallel at a station for different purposes (e.g. dry-state vs. increased relative humidity) or intercomparison. If you are using an instrument not listed in the table below, please send an e- mail to ebas@nilu.no.

<table>
<tr><td><manufacturer></td><td><model></td><td><manufacturer></td><td><model></td></tr>
<tr><td>Magee</td><td>AE22</td><td>Radiance-Research</td><td>PSAP-1W</td></tr>
<tr><td>Magee</td><td>AE30</td><td>Radiance-Research</td><td>PSAP-3W</td></tr>
<tr><td>Magee</td><td>AE31</td><td>Thermo</td><td>5012</td></tr>
</table></td></tr>
<tr><td>256</td><td>Standard method
syntax: Standard method: <standard method tag>
Expl.: The standard method refers to one of the standard operating procedures (SOPs) for filter absorption photometers recognised by the GAW Scientific Advisory Group for aerosol. Please use one of the keywords for recognised SOPs listed below only if your observations are in fact conducted following this SOP. If not, you may and should still report your observations, and fill in this field with "None".
Single-angle_Correction=none
The absorption coefficient is simply calculated from the filter transmittance at begin and end of the averaging period using Lambert-Beer's law (e.g. Bond et al., 1999, equation 2). No other corrections (e.g. filter loading, scattering, ...) are applied except for applying the correct flow calibration and potential sample spot size corrections.
Single-angle_Correction=Weiss
This method applies to the PSAP. The absorption coefficient calculated by Lambert-Beer's law and corrected for sample flow calibration and sample spot size is corrected for filter loading effects using the correction by Weiss that is included in the PSAP firmware as quoted by Bond et al., 1999, equation 3. This essentially means the values reported by the instrument, and corrected for sample flow calibration and sample spot size.
Single-angle_Correction=Bond1999_Ogren2010
This method applies to the Radiance Research PSAP. The absorption coefficient calculated by Lambert-Beer's law and corrected for sample flow calibration and sample spot size is corrected for filter loading effects using the correction by Weiss that is included in the PSAP firmware as quoted by Bond et al., 1999, equation 3. In addition, the correction with respect to particle scattering as defined by Bond et al., 1999 is applied, which requires a collocated measurement of the aerosol scattering coefficient. When using this method, please also consider the subsequent correction described in Ogren 2010 (see Chapter 4 for details). Please describe any deviations from this procedure as comment in line 259.
Single-angle_Correction=Weingartner2003
This method applies to the Magee Aethalometer. The data reported by the instrument are converted to aerosol absorption coefficients using the method described by Weingartner et al., 2003. When there are different options for constants possible that are used in the method, or when you use constants different from those described in the article, please state them as comment in line 259.</td></tr>
</table>

Line Nr.	Explanation of content
256 cont.	**Single-angle_Correction=Arnott2005** This method applies to the Magee Aethalometer. The data reported by the instrument are converted to aerosol absorption coefficients using the method described by Arnott et al., 2005. When there are different options for constants possible that are used in the method, or when you use constants different from those described in the article, please state them as comment in line 259. **Single-angle_Correction=Schmid2006** This method applies to the Magee Aethalometer. The data reported by the instrument are converted to aerosol absorption coefficients using the method described by Schmid et al., 2006. When there are different options for constants possible that are used in the method, or when you use constants different from those described in the article, please state them as comment in line 259. **Single-angle_Correction=Virkkula2007** This method applies to the Magee Aethalometer. The data reported by the instrument are converted to aerosol absorption coefficients using the method described by Virkkula et al., 2007. When there are different options for constants possible that are used in the method, or when you use constants different from those described in the article, please state them as comment in line 259. **Single-angle_Correction=Collaud2010eq14a** This method applies to the Magee Aethalometer. The data reported by the instrument are converted to aerosol absorption coefficients using the method described by Collaud Coen et al., 2010 and its equation 14a. When there are different options for constants possible that are used in the method, or when you use constants different from those described in the article, please state them as comment in line 259. **Single-angle_Correction=Collaud2010eq14b** This method applies to the Magee Aethalometer. The data reported by the instrument are converted to aerosol absorption coefficients using the method described by Collaud Coen et al., 2010 and its equation 14b. When there are different options for constants possible that are used in the method, or when you use constants different from those described in the article, please state them as comment in line 259. **Single-angle_Correction=Collaud2010eq14b+noscattering** This method applies to the Magee Aethalometer. The data reported by the instrument are converted to aerosol absorption coefficients using the method described by Collaud Coen et al., 2010 and its equation 14b, but disregarding the correction depending on single scattering albedo / aerosol scattering coefficient. When there are different options for constants possible that are used in the method, or when you use constants different from those described in the article, please state them as comment in line 259. **Multi-angle_Correction=Petzold2004** This method applies to the Thermo 5012 Multi-Angle Absorption Photometer. Already the firmware corrects the data for filter loading and multi-scattering between aerosol load and filter (Petzold and Schönlinner, 2004). The data, which is reported by the instrument as black carbon mass concentration, is converted to aerosol absorption coefficient using a mass absorption cross-section of 6.6 m^2/g. This value is also used internally by the instrument to convert the actually measured aerosol absorption coefficient to BC mass concentration. **None** None of the above standard operating procedures is used. Please use a few keywords to describe your method as comment in line 259.
259	**Comment** syntax: Comment: <freetext comment> Expl.: This line allows to convey any additional information on how the data was processed, e.g. parameters used for processing the data according to the stated "Standard method" (e.g.: "Comment: Standard Bond et al. 1999 values for K1 and K2 used at all wavelengths"). Freetext.

5.4 Light Scattering Coefficient Obtained by Integrating Nephelometer (e.g. Ecotech M9003 or TSI 3563)

5.4.1 Example and Template

```
 1: 93 1001
 2: Fiebig, Markus; Someone, Else
 3: NO01L, Norwegian Institute for Air Research, NILU,, Instituttveien 18,, N-2027, Kjeller, Norway
 4: Fiebig, Markus
 5: GAW-WDCA
 6: 1 1
 7: 2008 01 01 2008 06 24
 8: 0.041667
 9: Days from the file reference point (start_time)
10: 25
11: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
12: 9999.999999 9999 9999 9999.99 9999.99 9999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999
     999999.999999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999
     999999.999999 999999.999999 999999.999999 999999.999999 999999.999999 9.999999999999999999999999999999999999999999999
13: end_time of measurement, days from the file reference point
14: start_time of measurement, year
15: end_time of measurement, year
16: internal instrument pressure, hPa
16: internal instrument temperature, K
16: number of wavelengths
16: recalibrated, truncation corrected scattering coefficient at 450 nm, 1/Mm
16: recalibrated, truncation corrected scattering coefficient at 550 nm, 1/Mm
16: recalibrated, truncation corrected scattering coefficient at 700 nm, 1/Mm
16: recalibrated, truncation corrected backscattering coefficient at 450 nm, 1/Mm
16: recalibrated, truncation corrected backscattering coefficient at 550 nm, 1/Mm
16: recalibrated, truncation corrected backscattering coefficient at 700 nm, 1/Mm
16: scattering coefficient 15.87 percentile at 450 nm, 1/Mm
```

```
 16:  scattering coefficient 15.87 percentile at 550 nm, 1/Mm
 16:  scattering coefficient 15.87 percentile at 700 nm, 1/Mm
 16:  backscattering coefficient 15.87 percentile at 450 nm, 1/Mm
 16:  backscattering coefficient 15.87 percentile at 550 nm, 1/Mm
 16:  backscattering coefficient 15.87 percentile at 700 nm, 1/Mm
 16:  scattering coefficient 84.13 percentile at 450 nm, 1/Mm
 16:  scattering coefficient 84.13 percentile at 550 nm, 1/Mm
 16:  scattering coefficient 84.13 percentile at 700 nm, 1/Mm
 16:  backscattering coefficient 84.13 percentile at 450 nm, 1/Mm
 16:  backscattering coefficient 84.13 percentile at 550 nm, 1/Mm
 16:  backscattering coefficient 84.13 percentile at 700 nm, 1/Mm
100:  numflag, no unit
101:  0
102:  54
201:  Data definition:              EBAS_1.1
202:  Set type code:                TU
203:  Station code:                 NO0001R
204:  Platform code:                NO0001S
205:  Timezone:                     UTC
206:  Startdate:                    20080101000000
207:  Timeref:                      00_00
208:  Revision date:                20080624000000
210:  Component:                    aerosol_light_scattering_coefficient
211:  Unit:                         1/Mm
212:  Matrix:                       pm10
213:  Period code:                  1y
214:  Resolution code:              1h
215:  Sample duration:              1h
216:  Laboratory code:              NO01L
217:  Instrument type:              nephelometer
```

```
218: Instrument name:              TSI_3563_BIR_dry
219: Instrument serial number:     70810508
220: Method ref:                   NO01L_scat_coef
223: Add. qualifier:               6mn
224: File name:                    NO0042R.20080101000000.20080624000000.aerosol_light_scattering_coefficient.pm10.1y.1h.nas
226: Station WDCA-ID:              GAWANO__BIR
227: Station WDCA-Name:            Birkenes Atmospheric Observatory
228: Station GAW-ID:               BIR
229: Station AIRS-ID:                             [this line is optional]
230: Station other IDs:            201(NILUDB)
231: Station state/province:                      [this is line optional]
232: Station latitude:             58.380
233: Station longitude:            8.250
234: Station altitude:             220m
235: Station land use:             Forest
236: Station setting:              Rural
237: Station GAW type:             R
238: Station WMO region:           6
239: Originator:                   Fiebig, Markus, Markus.Fiebig@nilu.no, Norwegian Institute for Air Research, NILU, Atmosphere and Climate Department,
                                     Instituttveien 18,, N-2027, Kjeller, Norway
239: Originator:                   Someone, Else, Someone@somewhere.no, Some nice Institute, WOW, Super interesting division, Street 18,, X-9999,
                                     Paradise, Noway
240: Submitter:                    Fiebig, Markus, Markus.Fiebig@nilu.no, Norwegian Institute for Air Research, NILU, Atmosphere and Climate Department,
                                     Instituttveien 18,, N-2027, Kjeller, Norway
241: Data level:                   2
242: Version:                      1
243: Version description:          initial revision, Adis_EUSAAR_NRT_neph_lev0_2_lev1 v.0.0_2, Adis_EUSAAR_NRT_neph_lev1_2_lev2 v.0.0.3
244: Height AGL:                   4m
247: Inlet type:                   Impactor--direct
248: Inlet description:            PM10 at ambient humidity inlet, Digitel, flow 140 l/min
249: Humidity/temperature control: None
250: Humidity/temperature control description: passive, sample heated from atmospheric to lab temperature
251: Volume std. temperature:      273.15K
```

```
252: Volume std. pressure:         1013.25hPa
253: Detection limit:              0.3 1/Mm
254: Detection limit expl.:        Determined by instrument counting statistics, no detection limit flag used
255: Zero/negative values:         Zero and neg. values may appear due to statistical variations at very low concentrations
256: Standard method:              cal-gas=CO2+AIR_truncation-correction=Anderson1998
259: Comment:                      Standard Anderson & Ogren 1998 values used for truncation correction
260: Acknowledgement:              Request acknowledgement details from data originator
261:  start_time    end_time st_y ed_y   p_int   T_int nWav         sc450        sc550         sc700         bsc450        bsc550
            bsc700     sc450pc16      sc550pc16    sc700pc16    bsc450pc16    bsc550pc16    bsc700pc16      sc450pc84     sc550pc84
         sc700pc84    bsc450pc84    bsc550pc84    bsc700pc84 numflag
301:    0.000000    0.041667 2008 2008  839.40  299.80    3      0.932200      0.222400      0.122400      0.631200      0.122400
          0.082400      0.932200      0.222400      0.222400      0.631200      0.285300      0.285300      0.932200      0.222400
          0.222400      0.631200      0.285300      0.285300 0.000000000000000000000000000000000000000000000
302:    0.041667    0.083333 2008 2008 9999.99 9999.99    3 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999
      999999.999999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999 999999.999999  999999.999999 999999.999999
      999999.999999 999999.999999 999999.999999 999999.999999 0.999000000000000000000000000000000000000000000
```

5.4.2 Instrument Type Specific Line-by-Line Instructions

Line Nr.	Explanation of content
16	**Full titles of dependent data columns, nephelometer specific columns** syntax: internal instrument pressure, hPa internal instrument temperature, K number of wavelengths recalibrated, truncation corrected scattering coefficient at <wavelength 1> nm, 1/Mm recalibrated, truncation corrected scattering coefficient at <wavelength 2> nm, 1/Mm recalibrated, truncation corrected scattering coefficient at <wavelength 3> nm, 1/Mm recalibrated, truncation corrected backscattering coefficient at <wavelength 1> nm, 1/Mm recalibrated, truncation corrected backscattering coefficient at <wavelength 2> nm, 1/Mm recalibrated, truncation corrected backscattering coefficient at <wavelength 3> nm, 1/Mm scattering coefficient 15.87 percentile at <wavelength 1> nm, 1/Mm scattering coefficient 15.87 percentile at <wavelength 2> nm, 1/Mm scattering coefficient 15.87 percentile at <wavelength 3> nm, 1/Mm backscattering coefficient 15.87 percentile at <wavelength 1> nm, 1/Mm backscattering coefficient 15.87 percentile at <wavelength 2> nm, 1/Mm backscattering coefficient 15.87 percentile at <wavelength 3> nm, 1/Mm scattering coefficient 84.13 percentile at <wavelength 1> nm, 1/Mm scattering coefficient 84.13 percentile at <wavelength 2> nm, 1/Mm scattering coefficient 84.13 percentile at <wavelength 3> nm, 1/Mm backscattering coefficient 84.13 percentile at <wavelength 1> nm, 1/Mm backscattering coefficient 84.13 percentile at <wavelength 2> nm, 1/Mm backscattering coefficient 84.13 percentile at <wavelength 3> nm, 1/Mm Expl.: These lines contain the titles of the dependent data columns, one each up to the total number specified in line 10. The titles of the dependent data columns (and thus the content type) are fixed for each instrument type. Except for numerical values indicating a wavelength or particle diameter, the titles should match the specification exactly to allow for column identification by string comparison. All properties referring to a volume of air (such as scattering and backscattering coefficients) are to be stated for standard conditions of temperature and pressure (273.15 K, 1013.25 hPa). The temperature and pressure stated are the ones measured inside the instrument and included to allow to calculate the concentrations back to the original measurement conditions. The number of wavelengths and the wavelength values are to be adjusted to the values provided by the instrument. The data is expected to be corrected to compensate for angular truncation. As measure of the atmospheric variability, the format includes not only the averages (arithmetic mean) of scattering and hemispheric backscattering coefficient for the hourly averaging period, but also the 15.87 and 84.13 percentiles . The hourly averages should preferably be based on about 60 values, i.e. minute averages of raw data. Especially in case of fewer values or poor coverage, it is recommended to interpolate between adjacent percentile values to calculate the specified percentiles. These percentiles were chosen because they correspond to average value plus one standard deviation and average value minus one standard deviation in case the data has a normal (Gaussian) probability distribution.
210	**Component name identifying dataset type** syntax: Component: aerosol_light_scattering_coefficient Expl.: Component names are fixed for and identify the type of the reported data. For nephelometer data, this line always needs to have the content as stated above.
211	**Unit of reported main variable** syntax: Unit: 1/Mm Expl.: The unit of the reported main variable is determined by the component name. For scattering coefficient data measured by nephelometer, the unit always needs to be 1/Mm. The unit stated here doesn't rule out that the file contains auxiliary variables that are given in other units as specified in the respective column headers.
217	**Instrument type** syntax: Instrument type: <instrument type> Expl.: The instrument type refers to the measurement principle. For in situ observations of the local aerosol scattering coefficient, the instrument type is always "nephelometer".

Line Nr.	Explanation of content
218	**Instrument name** syntax: Instrument name: <manufacturer>_<model>_<additional ID> Expl.: The instrument name field serves 3 purposes: • identify instrument manufacturer • identify instrument model • logically identify instrument uniquely within the network A change in the instrument name will be registered as start of a new time series, even if the same parameter has been measured before at the station. This is meant to ensure that a time series is internally comparable. The instrument name must not contain spaces. Its manufacturer and model parts need to be selected from the list of allowed combinations below. The "additional ID" is supposed to make the ID unique within the GAW network and the WDCA database. Please choose a logical ID, e.g. the style "BIR_dry" identifying the instrument sampling the dry-state aerosol at Birkenes Observatory (Norway). That way, the instrument name won't need to change if you swap the instrument with one having a different serial number which is otherwise identical. The additional ID also allows to distinguish several instruments of the same type and model that may be run in parallel at a station for different purposes (e.g. dry-state vs. increased relative humidity) or intercomparison. If you are using an instrument not listed in the table below, please send an e- mail to ebas@nilu.no. <manufacturer> <model> <manufacturer> <model> Ecotech M9003 Radiance-Research M903 Ecotech Aurora3000 TSI 3563
256	**Standard method** syntax: Standard method: <standard method tag> Expl.: The standard method refers to one of the standard operating procedures (SOPs) for nephelometers recognised by the GAW Scientific Advisory Group for aerosol. Please use one of the keywords for recognised SOPs listed below only if your observations are in fact conducted following this SOP. If not, you may and should still report your observations, and fill in this field with "None". **cal-gas=CO2+AIR_truncation-correction=none** The instrument is calibrated regularly with carbon dioxide as span gas and particle free air as zero gas as described by Anderson et al. (1996). The instrument inherent angular truncation in the forward and backward direction is not corrected. **cal-gas=CO2+AIR_truncation-correction=Anderson1998** This method applies to the TSI 3563 nephelometer. The instrument is calibrated regularly with carbon dioxide as span gas and particle free air as zero gas as described by Anderson et al. (1996). The instrument inherent angular truncation in the forward and backward direction is corrected following Anderson and Ogren (1998). If you are using the same general concept for truncation correction as Anderson and Ogren (1998), but different coefficients than indicated there, please use the comment line 259 to specify the details. **cal-gas=FM-200+AIR_truncation-correction=none** The instrument is calibrated regularly with the hydrofluorocarbon FM-200 as span gas, and particle free air as zero gas. The instrument inherent angular truncation in the forward and backward direction is not corrected. **None** None of the above standard operating procedures is used. Please use the comment line 259 to specify the details.
259	**Comment** syntax: Comment: <freetext comment> Expl.: This line allows to convey any additional information on how the data was processed, e.g. parameters used for processing the data according to the stated "Standard method" (e.g. "Comment: Standard Anderson & Ogren 1998 values used for truncation correction"). Freetext.

5.5 Line-by-Line Instructions Common to All Instrument Types

Line Nr.	Explanation of content
1	**Total number of header lines and format number** syntax: <total number of header lines> 1001 Expl.: Total number of lines in header and NASA-Ames format number (for our use always 1001), separated by a space. Since the number of data columns and associated header lines varies between instruments, the number of header lines varies between instruments / observed variables. If optional header lines are left out, the number of header lines needs adjustment.
2	**Data originator / principal investigator name(s)** syntax: <last name 1>, <first name1>; <last name 2>, <first name2> Expl.: Last name(s) and first name(s) are separated by a comma. If more than one PI, use same syntax for all PIs, and separate PI names by a semi-colon.
3	**Details of the sponsoring organisation** syntax: <lab code>, <organisation name>, <organisation acronym>, <organisation unit>, <organisation address 1>, <organisation address 2>, <organisation ZIP>, <organisation town>, <organisation country> Expl.: The sponsoring organization host and /or pays for the measurement. Fields are comma separated. All commas have to be present. Fields may be left empty if not needed. If a comma is part of field content, enclose field content in "". On initial submission, please contact ebas@nilu.no for obtaining a lab code.
4	**Data submitter(s) name(s)** syntax: <last name 1>, <first name 1>; <last name 2>, <first name 2> Expl.: Last name(s) and first name(s) are separated by a comma. If more than one person is responsible for submitting the data, use the same syntax for all, and separate the names by a semi-colon.
5	**Project association(s)** syntax: <project acronym 1> <project acronym 2> Expl.: Space separated list of project acronyms indicating the projects the data is associated with. For WDCA data, the GAW-WDCA project always has to be included. Additional project associations can be found at http://ebas.nilu.no.
6	**Volume number and total number of volumes** syntax: 1 1 Expl.: In the original NASA-Ames specification, is it possible to spread a dataset over several files to reduce the size of each individual file. The numbers in line 6 indicate the total number of volumes for the present dataset and the volume number of this file, separated by a space. Both numbers are not used here, fixed to 1, but kept for being backwards compatible and conforming with the NASA-Ames specification.
7	**File reference date and revision date** syntax: <reference date year> <reference date month> <reference date day> <revision date year> <revision date month> <revision date day> Expl.: The file reference date indicates the start point of the time axis in the file. The time axis is always stated in days and begins at 00 UTC on the file reference date. For example, a time stamp for 5 January 2008, 0 UTC may be stated with a reference date of 2008 01 05 in line 7 and a day of 0 in the data section, or with a reference date of 2008 01 01 in line 7 and a day of 4 in the data section. The revision date is the date when the file was created or last updated. Both dates are space separated, and stated in the format YYYY MM DD.
8	**Time interval between measurement start points.** syntax: 0.041667 Expl.: The interval between consecutive measurement start points is stated in the same units as the file time axis, (fractional) days. For hourly averaged data (default for regular submissions), it is 1/24 = 0.041667, for daily averaged data, it is 1 (common in gravimetric measurements of PM mass). Stating this interval implies that it applies for the whole data section of the file. Shifts in time need to be corrected, holes in the time series need to be filled with missing data tags, and the data needs to be aggregated to averages as required by the observation type. Please use a precision of at least 6 digits right of the decimal point.

Line Nr.	Explanation of content
9	**Description of time unit** syntax: Days from the file reference point (start_time) Expl.: Even though the unit of the time variable is flexible in the original NASA-Ames format specification, the EBAS NASA-Ames format fixes the time unit to days from the file reference point. The time unit description in this line is fixed to the stated wording, but kept in the header for being backwards compatible. The time axis starts with 0.0 at 00 UTC on the file reference date stated in header line 7.
10	**Number of dependent data columns** syntax: <number of dependent data columns> Expl.: According to the original NASA-Ames 1001 definition, a file contains only one independent variable in the leftmost data column, usually the time variable. All other data columns consist of dependent variables. EBAS NASA-Ames contains two additional fixed columns, the end time of the averaging period (second from left) and a flag column (rightmost). These are accommodated as dependent columns. The number of other dependent columns depends on instrument type and data level. Line 10 states the total number of dependent variables / columns, including the two EBAS NASA-Ames required columns (end_time of measurement, numflag). This number varies between instruments, please check respective example.
11	**Multiplication factors, one per dependent variable, space separated** syntax: <scaling factor 1> <scaling factor 2> <scaling factor 3> ... Expl.: This line contains one multiplication (scaling) factor for each dependent variable. The multiplication (scaling) factor is applied to the dependent variable for converting the reported number to the true value. This NASA-Ames feature is not used any longer, i.e. the factor is set to 1 for all dependent variables, but kept for being backwards compatible. Please check the instrument specific example.
12	**Missing value tags** syntax: <missing value tag 1> <missing value tag 2> ... Expl.: This line contains one missing value code for each dependent variable in the file. The number format of the missing value code (number of digits left and right of the decimal point, use of exponential notation or not) specifies the number format of the corresponding data column in the data section. The missing value code is usually generated by filling all digits with a 9. This applies also for numbers in exponential notation. In any case, the absolute value of the missing values code needs to be 1 to 2 orders of magnitude larger than the largest valid value ever expected. Files containing data entries exceeding the number format stated by the missing value code will cause an error message. Please refer to the instrument specific headers for a correct example.
13	**Full titles of dependent data columns, 1st dependent column** syntax: end_time of measurement, days from the file reference point Expl.: The first dependent data column (second column from left in data section) is the end time of the averaging period reported in the line, and is constant for all instrument types. This line and the following lines contain the titles of the dependent data columns, one each up to the total number specified in line 10. The titles of the dependent data columns (and thus the content type) are fixed for each instrument type. Except for numerical values indicating a wavelength or particle diameter, the titles should match exactly to allow for column identification by string comparison.
14	**Full titles of dependent data columns, 2nd dependent column** syntax: start_time of measurement, year Expl.: The 2nd dependent data column (3rd column from left in data section) is the year of the start time of the averaging period reported in the line, and is constant for all instrument types. This line and the following lines contain the titles of the dependent data columns, one each up to the total number specified in line 10. The titles of the dependent data columns (and thus the content type) are fixed for each instrument type. Except for numerical values indicating a wavelength or particle diameter, the titles should match exactly to allow for column identification by string comparison.[1]

[1] Observant readers will have noticed that this column contains information that is repeated in several lines, and that is already contained in the header of the file. These columns were nevertheless included in the

Line Nr.	Explanation of content
15	Full titles of dependent data columns, 3rd dependent column syntax: end_time of measurement, year Expl.: The 3rd dependent data column (3rd column from left in data section) is the year of the end time of the averaging period reported in the line, and is constant for all instrument types. This line and the following lines contain the titles of the dependent data columns, one each up to the total number specified in line 10. The titles of the dependent data columns (and thus the content type) are fixed for each instrument type. Except for numerical values indicating a wavelength or particle diameter, the titles should match exactly to allow for column identification by string comparison.
100	**Full titles of dependent data columns, last dependent column** syntax header: numflag syntax data: 0.<3 digit flag #1><3 digit flag #2><3 digit flag #3>... Expl.: Title of a dependent data column, one each up to the total number specified in line 10. The titles of the dependent data columns (and thus the content type) are fixed generally or per instrument type. Except for numerical values indicating a wavelength or particle diameter, the titles should match the specification exactly to allow for column identification by string comparison. The last (rightmost) column holds flags that convey additional, time dependent information to the data user. The flags are 3 digit integer numbers. A list of available flags can be found at http://tarantula.nilu.no/projects/ccc/flags/index.html. Since The NASA-Ames format definition accepts only floating point numbers in the data section, the flags are coded as digits right of the decimal point of a leading "0.". In the examples, the number format defined by the missing value code specifies 15 flags, i.e. 45 digits right of the decimal point for the floating point number in the "numflag" column. If fewer flags are used, the remaining digits should be filled with 0. The length of the number in the numflag column may be adjusted, but must be constant throughout one file, and number formats between missing value code and data section have to match. The number of digits right of the decimal point always has to be an integer multiple of 3. Further Examples: 0.999 This number format has room for only one 3-digit flag. The corresponding missing value code in line 12, last number, would be 9.999. The flag in the example, 999, means that the data are missing, i.e. the data values in the line contain missing value codes except for the time columns and columns indicating number of wavelengths or number of size bins. 0.394189000 This number format has room for three 3-digit flags. The corresponding missing value code in line 12, last number, would be 9.999999999. The flags in the example, 394 and 189, indicate temporal coverage of less than 90% in the averaging period, and possible local contamination indicated by wind direction.
101	**Number of special comment lines** syntax: 0 Expl: Special comment lines (as defined by NASA-Ames specs) are used for data centre internal purposes. The number of special comment lines for data reporting is therefore 0.
102	**Number of normal (auxiliary) comment lines** syntax: <number of auxiliary comment lines> Expl: All the following header lines contain information for classifying the dataset in the database. With respect to the original NASA-Ames specification, these are "normal comment lines", or auxiliary comment lines. This line gives the total number of these lines. Since some of these "EBAS" lines are optional, and some instruments require special ones, this number (and also the total number of header lines in header line 1) needs to be adapted in each case. Please refer to the instrument specific sections for examples.

EBAS NASA-Ames format on user request. Some users like to concatenate several annual data files to one large file. Including the year in every line keeps the time stamp in every line unique in this application.

Line Nr.	Explanation of content
201	**Metadata format definition** syntax: Data definition: EBAS_1.1 Expl.: This line states the version of the header format. For files submitted to WDCA, this is always "EBAS_1.1".
202	**Dataset type code** syntax: Set type code: TU Expl.: The dataset type code describes whether the time spacing of the dataset is strictly homogeneous (code "TU", meaning time-series, uniform), or whether the user has to expect gaps and shifts in the timesamp (code "TI", meaning time-series, irregular). For all data types covered in this SOP, it is required during the processing and quality assurance process to aggregate the data to hourly averages, and to pad holes with missing value codes. The type code is therefore always TU for a regular data submission of the instruments covered here.
203	**Station code** syntax: Station code: <station code> Expl.: The station code is a unique identifier of your station in the EBAS database that hosts the WDCA. After registration with GAWSIS, new stations should write an e-mail to ebas@nilu.no for requesting their station code.
204	**Platform code** syntax: Platform code: <platform code> Expl.: Some stations use several platforms, i.e. a ground station and a boundary layer tower. The platform code is used to distinguish these if present. The "S" in the example stands for "surface", which applies to most stations. After registration with GAWSIS, new stations should write an e-mail to ebas@nilu.no for requesting their platform code.
205	**Timezone specification** syntax: Timezone: UTC Expl.: All times in WDCA data files have to be stated in UTC. Even though the content of this line may not be changed, it is repeated here for completeness and as a reminder.
206	**Start date and time of data in file** syntax: Startdate: <4 digit year><2 digit month><2 digit day><2 digit hour><2 digit minute><2 digit second> Expl.: Independently of the reference date used as origin of the time axis in the file (see header line 7), the start date and time states the time of the first data point in the file.
207	**Reference time for sample changes** syntax: Timeref: <UTC hour>_<UTC minute> Expl.: This line contains a feature usable for measurements on a fixed schedule with sample change intervals of a day or longer, e.g. filter samples. For all other observations, or if you are in a hurry and don't want to use this feature, set this field to "00_00".[2]
208	**Revision date and time of data in file** syntax: Revision date: <4 digit year><2 digit month><2 digit day><2 digit hour><2 digit minute><2 digit second> Expl.: This line states date and time when the file was created or changed last. The date needs to be the same as the one stated in line 7. In the present line however, not only the revision date, but also the revision time is given, which is important for larger, almost simultaneously generated file collections or near-real-time applications.

[2] *The "Timeref" field can be used for observations where a sample interval always, i.e. for the whole time series in the file without any exception, starts and ends at a fixed time of the day. The "Timeref" field may then contain the UTC hour and the UTC minute of the sample change in the format stated in the syntax line. In this case, the start time and end time of the sampling interval in the data section of the file must be stated only with the integer day part, i.e. without any decimal places indicating when on that day the sample started or ended. The decimal places of sample start and end time will be set on import into the database according to the "Timeref" stated.*

Line Nr.	Explanation of content
212	**Matrix (atmospheric compartment sampled)** syntax: Matrix: <matrix identifier> Expl.: The matrix identifies the atmospheric compartment sampled by the reported measurement. For aerosol, the allowed values include: aerosol: Measurements refer to a chemical or physical property of the total aerosol particle phase. The term "aerosol" is used here as often done in the air quality community, i.e. refers to the particle phase only. pm1: Measurements refer to a chemical or physical property of the total aerosol particle phase in the size fraction less than 1 micrometer median aerodynamic diameter. pm25: Measurements refer to a chemical or physical property of the total aerosol particle phase in the size fraction less than 2.5 micrometer median aerodynamic diameter. pm10: Measurements refer to a chemical or physical property of the total aerosol particle phase in the size fraction less than 10 micrometer median aerodynamic diameter. The size cuts are commonly achieved by an impactor or cyclone in the inlet system. For PM mass data, the matrix must correspond to the size fraction reported.
213	**Period code for time span covered in file** syntax: Period code: <period code tag> Expl.: The period code describes the time span covered by the time series contained in the file. Common options for regular reporting, that may be analogously adapted, include: 1y: 1 year 6mo: 6 months, half a year 1mo: 1 month
214	**Resolution code** syntax: Resolution code: <resolution code tag> Expl.: Interval between start times of samples. For regularly reported data, it is expected that this interval is valid throughout the file, i.e. that holes in the time series are padded with missing data lines. Unless noted otherwise, regularly reported data are aggregated to hourly averages, in which case the resolution code in "1h" for 1 hour.
215	**Sample duration** syntax: Sample duration: <Sample duration tag> Expl.: Time between start and end of a sample. Since regularly reported data are aggregated to hourly averages, this tag is fixed to "1h" for one hour.
216	**Laboratory code** syntax: Laboratory code: <lab code> Expl.: Code of the laboratory / institution responsible for processing the data or analysing the sample. If your lab / institution has never before submitted data to WDCA, please write an e-mail to ebas@nilu.no for obtaining a lab code.
219	**Instrument serial number** syntax: Instrument serial number: <serial number> Expl.: Serial number of the instrument used. If the instrument was replaced within the reporting period, please submit two different files, one covering the time before, and one after the replacement.
220	**Method reference** syntax: Method ref: <lab code>_<unique reference to lab internal SOP (no spaces)> Expl.: The method reference is managed by the reporting lab and identifies the standard operating procedure used for generating the reported dataset. The standard operating procedure is a document that describes setup and steps necessary to make a comparable measurement, e.g. inlet design, sample flow, sample conditioning, calibration procedures, data processing steps, ... Since the method reference is managed by the reporting lab, it needs to begin with the lab code. Any change in instrument setup or data handling that could make the time series incomparable needs to result in use of a new method reference (will register as new time series in database).

Line Nr.	Explanation of content
221	**External laboratory code** syntax: Ext. lab. code: <lab code> Expl.: Code of the laboratory / institution responsible for processing the data or analysing the sample. This line needs to be used for the analysing lab if it is different from the lab responsible for collecting the sample stated in line 216. If that lab / institution has never before submitted data to WDCA, please write an e-mail to ebas@nilu.no for obtaining a lab code. If you don't use this line, please make sure to decrease the total number of header lines in line 1 and the number of auxiliary comment lines in line 102 by 1.
222	**External method reference** syntax: Ext. meth. ref: <lab code>_<unique reference to lab internal SOP (no spaces)> Expl.: The external method reference is managed by the external reporting lab and identifies the standard operating procedure used for generating the reported dataset. The standard operating procedure is a document that describes setup and steps necessary to make a comparable measurement, e.g. inlet design, sample flow, sample conditioning, calibration procedures, data processing steps, ... Since the external method reference is managed by the reporting lab, it needs to begin with the external lab code. Any change in instrument setup or data handling that could make the time series incomparable needs to result in use of a new method reference (will register as new time series in database). This line needs to be used for the analysing lab if it is different from the lab responsible for collecting the sample stated in line 216. If that lab / institution has never before submitted data to WDCA, please write an e-mail to ebas@nilu.no for obtaining a lab code. If you don't use this line, please make sure to decrease the total number of header lines in line 1 and the number of auxiliary comment lines in line 102 by 1.
223	**Additional qualifier** syntax: Add. qualifier: <original time resolution> Expl.: For WDCA, the "additional qualifier" is used to state the original time resolution of the data that was used to compute the aggregated, hourly average. Common options, that may be analogously adapted, include: 1s: 1 second 1mn: 1 minute 6mn: 6 minutes
224	**File name** syntax: File name: <station code>.<start date / time>.<revision date / time>.<component>.<matrix>.<period code>.<resolution code>.nas Expl.: This line contains the name of the file itself. The file name is composed of the content of several previous header items as specified in the syntax line above.
226	**WDCA station ID** syntax: Station WDCA-ID: <WDCA station ID> Expl.: The WDCA has previously used another set of station IDs in addition to the ones issued by the GAW Station Information System (GAWSIS). This ID is included in the header to allow connecting older and newer datasets from the same station. Established GAW stations have this ID issued already. New stations will receive it when initially contacting WDCA for their first submission.
227	**Official station name in GAW network** syntax: Station WDCA-Name: <GAWSIS registered station name> Expl.: This line contains the station name as registered with GAWSIS.
228	**GAWSIS station ID** syntax: Station GAW-ID: <3 letter GAWSIS station ID> Expl.: Three letter station ID issued by GAWSIS
229	**AIRS station ID** syntax: Station AIRS-ID: <AIRS station ID> Expl.: For North-American stations, this line contains the station ID issued by the Alliance of Information and Referral Systems (AIRS) if such an ID has been issued. If such an ID hasn't been issued, e.g. for all non-North American stations, this line may be left out. If you leave out this line, please make sure to decrease the total number of header lines in line 1 and the number of auxiliary comment lines in line 102 by 1.

Line Nr.	Explanation of content
230	**Other stations IDs** syntax: Station other IDs: <ID 1>(<database acronym 1>) <ID 2>(<database acronym 2>) ... Expl.: This line contains a space separated list of IDs the station has with other networks or databases. The ID is immediately followed by the acronym of the issuing network or database in parenthesis. If the station doesn't have any other IDs, this line may be left out. If you leave out this line, please make sure to decrease the total number of header lines in line 1 and the number of auxiliary comment lines in line line 102 by 1.
231	**Station state or province** syntax: Station state/province: <state or province name> Expl.: For U.S. and Canadian stations, this line contains the non-abbreviated name of the state or province. For all other stations, this line may be left out. If you leave out this line, please make sure to decrease the total number of header lines in line 1 and the number of auxiliary comment lines in line line 102 by 1.
232	**Station Latitude** syntax: Station latitude: <station WGS 84 latitude> Expl.: This line contains the station latitude given in decimal degrees following WGS84. Please use 6 digit accuracy right of the decimal point. Positive values for northern latitudes.
233	**Station Longitude** syntax: Station longitude: <station WGS 84 longitude> Expl.: This line contains the station longitude given in decimal degrees following WGS84. Please use 6 digit accuracy right of the decimal point. Positive values for eastern longitudes.
234	**Station altitude** syntax: Station altitude: <station altitude in meters> Expl.: Ground level altitude above sea mean level at station in meters (m).
235	**Station land use** syntax: Station land use: <land use keyword> Expl.: WMO has defined a list of accepted land use keywords to describe land use at stations. Please choose the option most applicable to your station from: Agricultural, Airport, Blighted area, Commercial Desert, Forest, Industrial, Military reservation Mobile, Remote Park, Residential, Single point source area Snowfield, Urban park, Other, Not available
236	**Station setting** syntax: Station setting: <setting keyword> Expl.: WMO has defined a list of accepted keywords to describe the setting of a stations. Please choose the option most applicable to your station from: Mountain, Polar, Coastal, Rural Suburban, Urban and center city, Other, Not available
237	**GAW type of station** syntax: Station GAW type: <station GAW type letter> Expl.: GAW has defined 3 station types with corresponding key letters: G (for global), R (for regional), and C (for contributing). Please choose the letter applicable to your station as registered in GAWSIS.
238	**WMO region of station** syntax: Station WMO region: <region key number> Expl.: WMO has defined 7 regions on the globe, together with corresponding key numbers: 1 (Africa), 2 (Asia), 3 (South America), 4 (North and Central America), 5, (South-West Pacific), 6 (Europe), 7 (Antarctica). Please choose the region where your station is located. This may be different from the region where the institution operating the station is located.

Line Nr.	Explanation of content
239	**Data originator affiliation and contact information** syntax: Originator: <last name>, <first name>, <e-mail address>, <affiliation name>, <affiliation acronym>, <affiliation unit>, <affiliation address 1>, <affiliation address 2>, <affiliation ZIP>, <affiliation town>, <affiliation country> Expl.: For each data originator named in header line 2, one line of contact and affiliation information has to be present. The order needs to correspond to the order of names in header line 2. Fields are comma separated. All commas have to be present. Fields may be left empty if not needed. If a comma is part of field content, enclose field content in "". If you include more or fewer originator names than in the example, please make sure to adjust the total number of header lines in line 1 and the number of auxiliary comment lines in line 102.
240	**Data submitter affiliation and contact information** syntax: Submitter: <last name>, <first name>, <e-mail address>, <affiliation name>, <affiliation acronym>, <affiliation unit>, <affiliation address 1>, <affiliation address 2>, <affiliation ZIP>, <affiliation town>, <affiliation country> Expl.: For each data submitter named in header line 4, one line of contact and affiliation information has to be present. The order needs to correspond to the order of names in header line 4. Fields are comma separated. All commas have to be present. Fields may be left empty if not needed. If a comma is part of field content, enclose field content in "". If you include more or fewer submitter names than in the example, please make sure to adjust the total number of header lines in line 1 and the number of auxiliary comment lines in line 102.
241	**Data level** syntax: Data level: <data level number> Expl.: For regular data submissions, the data level is always 2.
242	**Data version** syntax: Version: <version number> Expl.: In case the data contained in the file has been processed several times into the same format, the versions receive a unique, sequential number.
243	**Data version description** syntax: Version description: <version description> Expl.: This line (freetext) contains a few key words on how this version was processed, e.g. as opposed to the previous version.
244	**Sampling height above ground level** syntax: Height AGL: <sampling height above ground level in meters> Expl.: Height of inlet tip or instrument location above ground level at station.
247	**Inlet type** syntax: Inlet type: <inlet type keyword> Expl.: A set of inlet type keywords has been defined. Please choose the most appropriate from: Cyclone; Diffuser cone; Elutriator; Hat or hood Impactor--direct; Impactor--virtual/concentrator; Impactor--elutriator combination Isokinetic; None--open-face filter; Open conductive tubing Selective filtration
248	**Inlet description** syntax: Inlet description: <freetext keywords describing inlet> Expl.: Since the values for the previous field are limited and may not convey all necessary information, this line (freetext) may contain the essential key words (size cut, brand, flow, diameter, ...) describing the inlet system used.

Line Nr.	Explanation of content
249	**Sample humidity and temperature control keyphrase** syntax: Humidity/temperature control: <hum. / temp. control keyphrase> Expl.: A set of keywords for describing commonly used methods of sample temperature and humidity conditioning has been defined. Please choose the most appropriate from: Diffusion dryer Humidification Humidification with temperature condition at ambient Humidification with temperature conditioning at 50 deg. C Heating to 40% RH, limit 40 deg. C Manual control (see metadata) Nafion dryer Nafion dryer with temperature conditioning at 30 deg. C Temperature conditioning at 20 deg. C Temperature conditioning at 25 deg. C Temperature conditioning at 30 deg. C Temperature conditioning at 40 deg. C Temperature conditioning at 50 deg. C Temperature conditioning at ambient Temperature controlled Other (see metadata) None
250	**Sample humidity and temperature control description** syntax: Humidity/temperature control description: <freetext keywords describing temperature and humidity conditioning> Expl.: Due to the limited selection of options in the previous line, this field (freetext) uses key words to describe the temperature / humidity control implemented.
251	**Standard temperature for volume concentrations** syntax: Volume std. temperature: 273.15K Expl.: For regular data reporting, all volume concentrations always need to be normalised to a temperature of 273.15 K and a pressure of 1013.25 hPa. Though fixed, the standard temperature is repeated here as a reminder and to complete the self-documentation of the data.
252	**Standard pressure for volume concentrations** syntax: Volume std. pressure: 1013.25hPa Expl.: For regular data reporting, all volume concentrations always need to be normalised to a temperature of 273.15 K and a pressure of 1013.25 hPa. Though fixed, the standard pressure is repeated here as a reminder and to complete the self-documentation of the data.
253	**Detection limit of main variable** syntax: Detection limit: <detection limit> Expl.: State the detection limit of the main variable reported in the file. Please use the same unit as stated in line 211
254	**Explanation of detection limit** syntax: Detection limit expl.: <freetext keywords explaining detection limit> Expl.: Short key word statement how the detection limit was determined.
255	**Explanation for zero and negative values** syntax: Zero/negative values: <freetext keywords explaining zero / neg. values> Expl.: Short statement whether 0 or negative values may occur, and why so.
260	**Acknowledgement information** syntax: Acknowledgement: <acknowledgement information> Expl.: Information on whom to contact in terms of acknowledgement for using the data in any form of publication. Freetext.
261	**Column short headers** syntax: start_time end_time st_y ed_y <short header> <short header> <...> numflag Expl.: This line is intended to increase the readability for a human user. Please align the short headers with the values in the data columns right below.

Line Nr.	Explanation of content
301	**First data section example line** syntax: <DOY start time> <DOY end time> <1st data value> <2nd data value> ... <flags column> Expl.: Example of first line of data section. The data values in the line have constant width and are space separated. The first value in the line, the independent variable according to NASA-Ames terminology, is the start time (stated as DOY) of the averaging period reported in the line. Its long header is given in line 9. It is followed by the end time of the averaging period, which is the first dependent variable, its header given in line 13. The following data values are identified by the column long headers in line 14 ff, the last column being the one containing the flags. Please take a look at the comments for line 100 on how to assemble this column. The number format of the data values (notation, number of digits and significant places) has to correspond to the format of the columns missing value code specified in line 12.
302	**Second data section example line** syntax: <DOY start time> <DOY end time> <1st data value> <2nd data value> ... <flags column> Expl.: This line exemplifies the use of missing value codes. Please observe that for columns stating a number of wavelengths or size bins to follow, the missing value code may not be used even though it is defined.

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