SMPS

SOP – DRAFT -

MEASUREMENT AND ANALYSIS OF PARTICLE NUMBER SIZE DISTRIBUTIONS IN AMBIENT AIR USING THE SMPS

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MEASUREMENT AND ANALYSIS OF PARTICLE NUMBER SIZE DISTRIBUTIONS IN AMBIENT AIR USING THE SMPS

1. PURPOSE AND APPLICABILITY

This SOP contains the protocol for performing measurements of particle number size distribution (10 nm - 500 nm in diameter) in outdoor air for the Baltimore PM supersite study. The spectrometer consists of a Scanning Mobility Particle Sizer (SMPS, TSI). This SOP is subject to changes. Every addition to this SOP will be added as an Appendix during this study.

2. DEFINITIONS

CPC condensation particle counter

DMA differential electrical mobility particle analyzer without CPC

SMPS Scanning Mobility Particle Sizer

Gillibrator: soap-bubble flow meter

Main particle size ranges:

$NC_{0.01-0.5}$: total particle number concentration (cm^{-3}) in the size range 0.01 - 0.5 μm

$NC_{0.01-0.1}$: particle number concentration (cm^{-3}) in the size range 0.01 - 0.1 μm

$NC_{0.1-0.5}$: particle number concentration (cm^{-3}) in the size range 0.1 - 0.5 μm

Sub particle size ranges:

$NC_{0.01-0.03}$: particle number concentration (cm^{-3}) in the size range 0.01 - 0.03 μm

$NC_{0.03-0.05}$: particle number concentration (cm^{-3}) in the size range 0.03 - 0.05 μm

$NC_{0.05-0.1}$: particle number concentration (cm^{-3}) in the size range 0.05 - 0.1 μm

SOP: operating procedure

3. Data Quality Objectives

Accuracy: Daily average integral particle number concentration obtained from SMPS particle size distributions should agree within 25 % of a TSI CPC 3020 derived integral particle number concentration.

Precision: 1 sigma (Square root of counts per bin)

Lower Quantifiable Limit: 1 count cm^{-3}

Completeness: At least 80% data completeness.

3.1 DATA QUALITIY ASSURANCE

Several tests will be performed in the field to quantify the system performance before, during and after measurement campaigns. Performance checks will be scheduled during the sampling campaign. The performance tests include (but are not limited to)

b) Check of the polydisperse, monodisperse and sheath air flow
c) Visual check of the inlet impactor
d) Check of butanol level in CPC
e) Check of integral particle number concentration versus CPC 3022
f) Check of sizing properties using PSL particles

These checks and additional routine maintenance will be performed as described in the SOP below.

4. DISCUSSION

NA

5. RESPONSIBILITIES

NA

6. EQUIPMENT AND MATERIALS

6.1 Equipment

6.1.1 SMPS

a) DMA (Model 3071, TSI)
b) Kr-85 neutralizer (Model 3077, TSI)
c) CPC (Model 3010, TSI)
d) Personal computer
e) Spare parts SMPS (filters, fitting, tubing, computer cables)
f) Spare parts CPC (filters, butanol)

6.1.2 Flow meter

a) Gilian Gilibrator 2	S/N: 0044669
b) Flow cell 2-30 lpm	S/N: 003454-H
c) Flow cell 20 cc – 6 lpm	S/N: 906092-S
d) Flow cell soap	

6.2 Materials

a) Filters for SMPS: TSI P/N 1602015, Gelman 12144
b) Filter for CPC: TSI P/N 1602028, TSI P/N 1602059,
c) Filter for CPC: Balston P/N DFU-9922-05-AQ
d) 1-butanol extra pure (Merck) ACS reagent grade

6.3 Paper materials

a) Field forms to record performance parameters of SMPS in the field

b) Laboratory book for SMPS

7. PROCEDURES

7.1 Setup:

b) Setup the hardware according to the users manual.
c) Fill Butanol into the CPC.
d) Switch on CPC, pumps and classifier.
e) Adjust sheath air flow and excess air flow using the Gilibrator.
f) Adjust monodisperse air flow using the Gilibrator.
g) Repeat steps 4 and 5 until all flow rates are within their limits (limits to be determined).
h) Place absolute filter in front of the polydisperse inlet of the classifier.
i) Check for zero count rate throughout entire voltage range of the classifier.
j) Accept setup only if zero counts are less than 0.1 particles cm^{-3} over the entire range.
k) Start TSI SMPS software.
l) Check all parameters (These will be specified as soon as the SMPS is available at UMCP). Start data acquisition program.

ALL MAINTANCE PROCEDURES MUST BE RECORDED IN THE FIELD FORM

7.3 Daily maintenance of SMPS

a) Check (remotely) flows and their std of CPC, excess air and sheath air (see 8.3.1). This check needs to be recorded on a separate laboratory form.

7.4 Every second day maintenance of SMPS

a) Check at least three hourly average total particle number concentrations of the SMPS measurements in comparison with the respective hourly average particle number concentrations derived from CPC measurements. If there is a contionous

discrepancy between these number concentrations call Thomas Tuch for further advice.

b) Clean impactor plate.

c) Check indicator LED on CPC front.

d) Check butanol level in CPC; fill if necessary (do not leave refill bottle connected to the CPC). Record the time of filling.

e) Check whether the voltage indicated by the program is changing synchronically with the voltage indicated on the DMA.

f) Check and record:

g) Monodisperse Flow indicated on DMA voltmeter

h) Excess Air Flow indicated on DMA voltmeter

i) Sheath Air Flow indicated on DMA voltmeter

j) Pressure Drop of impactor

k) If pressure drop differs from normal value more than 2 cm H_20: Check the sample flow. If it deviates from nominal value adjust the pressure drop. The pressure drop may change as a result of narrowing of the impactor nozzle, while the flow remains (almost) not changed.

l) Adjust flow rates if different from nominal value and indicated value is larger than 0.01 meter range 100V, nominal values should be indicated on the instrument and in the diary.

m) Repeat g) through l) until no changes in flow rates are noticeable

n) if any adjustment was necessary record old and new values

If any adjustment yields no sufficient result (i.e. normal operating conditions can not be achieved) or number concentration differences between CPC and DMPS remain larger than 30 % personal doing the routine maintenance is requested to report to an experienced operator as soon as possible.

7.5 Weekly maintenance of SMPS

a) drain CPC and refill with fresh butanol (to be done by routine personal).
b) visually check coarse filters of the DMA, replace if necessary
c) check and record sample flow rate with the Gilibrator, inform an experienced operator if the flow deviates by more than 10% from 1 l/min.
d) check null counts of the SMPS, while scanning, by placing an absolute filter in front of the sample inlet. Record the time and file name.
e) check sizing properties with monodisperse PSL aerosol of 0.2 µm. Record time and file name.

7.6 Handling of persistent instrumental deviations

If any adjustment of the operating parameters (see 7.1 - 7.3) yields no sufficient result (i.e. normal operating conditions can not be achieved, personal doing the routine maintenance is requested to report the problem and actions undertaken to solve it to an experienced operator as soon as possible.

ALL DAILY AND WEEKLY MAINTENANCE PROCEDURES MUST BE RECORDED IN THE RESPECTIVE FIELD FORM

7.7 Beginning and end of the study

Check Activity of the Kr85 neutralizer. Use an appropriate counter. Record count rate, counter model and serial number of the counter in the laboratory book. Activity may be checked at a marked point of the housing of the DMA.

8. ANALYTICAL PROCEDURES

8.1 Averaging of hourly and daily mean size distributions

Hourly average concentrations are calculated if at least 66% of the valid data (see 8.5) for one hour are available. Daily average number concentrations are valid, if at least 16 hourly averages are available for one day

Daily means will be provided for time intervals from midnight to midnight.

Strange particle size distributions must only be rejected from the data set if the unusual

size distributions are caused by an instrument failure (see 8.5).

8.2 Number concentrations and spectral data

8.2.1 Calculation of particle number concentrations per size range

The particle number concentrations, total as well as in the specified below size ranges, is done by summing up the number concentrations of hourly averaged (see 8.1) instrumental channels which fall into the specified size range. If the range boundary falls within one of the instrumental channels, only the proportional fraction of the concentration in that channel is added to the concentration in the size range, i.e. if 1/3 of the channel is in the specified size range, only one third of the concentration in that channel is attributed to that size range.

Number concentrations in the following size ranges are calculated:

Main particle size ranges:

$NC_{0.01\text{-}0.5}$: total particle number concentration (cm^{-3}) in the size range 0.01 - 0.5 μm

$NC_{0.01\text{-}0.1}$: particle number concentration (cm^{-3}) in the size range 0.01 - 0.1 μm

$NC_{0.1\text{-}0.5}$: particle number concentration (cm^{-3}) in the size range 0.01 - 0.1 μm

Sub particle size ranges:

$NC_{0.01\text{-}0.03}$: particle number concentration (cm^{-3}) in the size range 0.01 - 0.03 μm

$NC_{0.03\text{-}0.05}$: particle number concentration (cm^{-3}) in the size range 0.03 - 0.05 μm

$NC_{0.05\text{-}0.1}$: particle number concentration (cm^{-3}) in the size range 0.05 - 0.1 μm

8.3. Quality control

Quality control of the data is achieved on daily basis by:

a) checking the critical operation parameters of the instruments (flow rates etc., see 8.3.1)
b) visual checks of hourly averaged size distributions (see 8.3.2)
c) Check of the hourly average SMPS derived integral particle number concentration versus the CPC derived total particle number concentration.

8.3.1. Check for critical operation parameters

The following operation parameters are checked on daily basis:

a) sheath and excess flow rates of SMPS should be within 1% of the set points of the flow controllers
b) the standard deviation of both sheath and excess flows of SMPS during one scan is within 2%
c) sample flow rate of SMPS should be within 10% from 1 l/min
d) sizing accuracy of SMPS as determined with PSL is within 10%

If one or more operating parameters are deviating from the nominal, the instrument should be checked and adjusted to the nominal parameters as soon as possible. Data collected with that instrument during the period of malfunction should be corrected, if possible, for the observed deviations (see 8.4).

8.3.2. Visual checks of hourly averaged size distributions

Hourly-averaged size distributions should be checked visually by an experienced operator for persistent (for more than 3 hours in a row) “gaps” i.e. whether the spectra appear to be missing particles at some sizes.

If such persistent gaps are found the instruments should be checked as soon as possible by an experienced operator. If instrument is found to be malfunctioning, it should be adjusted to normal operation. Data collected with that instrument during the period of malfunction should be corrected, if possible, for the observed deviations from nominal operating parameters (see 8.4). If no malfunctioning is found, data from the instruments is accepted as is and is not rejected.

8.4. Correction of data for recoverable instrumental malfunction

If an instrumental malfunction was found, the data can be corrected for the observed deviation, in the following cases:

a) Sample flow of SMPS deviates by less than 50% from 1 l/min
b) Sheath /excess flows of SMPS deviate by less than 50% from 10 l/min
c) Std. deviation of sheath and excess flows in SMPS during one scan is less than 10%

Corrected data should be marked, the reason and the procedure of correction should be described.

8.5. Data validation

The data are considered invalid, if it is discovered that the instrument was operated outside the nominal operating conditions, for which no correction can be applied (see 8.4), or if one or more critical parts of the instrument (i.e. laser of CPC or LAS, pumps, empty butanol reservoir of CPC, etc.) were not functioning or were out of order.

8.6. Calculation of particle volume concentrations

8.6.1. Convolution to particle volume distributions

The number concentration distribution data will be convoluted into particle volume distributions assuming spherical particles of the nominal particle diameter of the given size intervals using the TSI SMPS software version 3.
Particle volume concentrations will be calculated for the following size ranges:

Main size ranges:

$VC_{0.01\text{-}0.5}$: total volume concentration ($\mu m^3\ m^{-3}$) in the size range between 0.01 - 0.5 µm

$VC_{0.01\text{-}0.1}$: volume concentration ($\mu m^3\ m^{-3}$) in the size range between 0.01 - 0.1 µm

$VC_{0.1\text{-}0.5}$: volume concentration ($\mu m^3\ m^{-3}$) in the size range between 0.1 – 0.5 µm

Sub particle size ranges:

$VC_{0.01-0.03}$: mass concentration ($\mu m^3 m^{-3}$) in the size range between 0.01 - 0.03 µm

$VC_{0.03-0.1}$: mass concentration ($\mu m^3 m^{-3}$) in the size range between 0.03 - 0.1 µm

$VC_{0.1-0.5}$: mass concentration ($\mu m^3 m^{-3}$) in the size range between 0.1 - 0.5 µm

8.7. Data storage

Time and date stamped size distribution data will be stored initially as comma delimited ASCII in a continous append file on the harddisk of the data acquisition computer. These raw data will be merged every other day into a continuous EXCEL spreadsheet. Missing data, suspicious data and calibration data will be flagged in this spreadsheet along with a written plain language explanation for the reason of the flagging. Raw Data and Spreadsheet data will be copied every other day to the hard disk of the main computer of the super site. All data raw data files and spreadsheet files collected on the harddisk of the main computer will be copied every other day (daily during intensives) to two CD-Rs labeled with the date of the copy. One CD-R will remain at the supersite, the other copy will be transported to the UMCP campus in College Park.

All original lab books with information on the performance will be kept at the supersite during the measurement period. A scanned version of each page will be stored along with the data set in a separate file. These scanned pages will be stored along with the data files in a separate subdirectory of the Data CDs.

Further evaluation and manipulation of the data will follow the procedures defined in the Data Management/Storage SOP.

9. References

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Brand, P., Gebhart, J., Below, M., Georgi, B., Heyder, J. (1991), Characterisation of Environmental Aerosol on Helgoland Island, *Atmospheric Environment*, **25A**, 581-585.

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Tuch, Th., Brand, P., Wichmann, H.E., Heyder, J. (1997) , Variation of Particle Number and Mass

Concentration in Various Size Ranges of Ambient Aerosols in Eastern Germany., *Atmospheric Environment*, **31**,4193-4197.

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SMPS

		Check:							Remarks:
						clean	visible	green	<---nominal values, o primary
Day	**Date**	**Pressure drop**	**Mono**	**Poly**	**Sheath**	**Impact Plate**	**Butanol**	**LEDs**	**e.g. flow adjuste operat**
Monday									
Tuesday									
Wednesday									
Thursday									
Friday									
Saturday									
Sunday									

Butanol Change: date/time:	Sheath air filter:	Zero measurement: