INTERCOMPARISON OF PARTICLE NUMBER SIZE SPECTROMETERS

Massling[1], A., Löndahl[1], J., Ketzel[2], M., Jensen[2], B., Wåhlin[2], P., Bilde[3], M., Rosenbohm[3], E., Hansson[4], H.-C., Hallquist[5], M., Lunder[6], C. and Swietlicki[1], E.

[1]Lund University, Department of Physics, Division of Nuclear Physics, Lund, Sweden
[2]National Environmenal Research Institute, Department of Atmospheric Environment, Roskilde, Denmark
[3]Copenhagen University, Department of Chemistry, Copenhagen, Denmark
[4]University of Stockholm, Institute for Applied Environmental Research, Stockholm, Sweden
[5]Göteborg University, Göteborg, Sweden
[6]Norwegian Institute for Air Research, Oslo, Norway

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INTRODUCTION

The measurement of particle number size distributions is one of the most important tasks describing the physical properties of aerosol particles. Particles show large variation in number and size depending on their location of occurrence. In the last decade, a number of groups has started to measure particle number size distributions at various locations over the world by operating measurement devices continuously.
A typical measurement device for providing particle number size distributions in the submicrometer size range is the Differential/Scanning Mobility Particle Sizer (DMPS/SMPS) including a Differential Mobility Analyzer (DMA) to select a narrow particle size followed by a Condensation Particle Counter (CPC) to count individual particles. Figure 1 shows a schematic sketch of this measurement device.

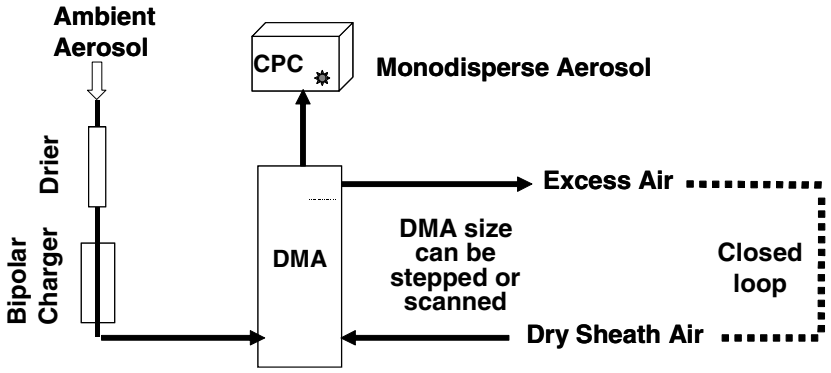

Figure 1: Schematic sketch of a DMPS/SMPS system.

Up to now there is no standard to compare those systems for particle sizing and counting efficiency. The only comparisons made are based on efficiency for counting for different CPCs in calibration workshops or on one CPC operated at different parameters (Banse et al., 2001; Mertes et al., 1995; Wiedensohler et al., 1997). A comparison of DMPS/SMPS systems is very difficult since most of the systems are home-made and based on different types of DMAs, CPCs, and programming languages. In Table 1, system dependent properties that may have an impact on particle sizing are listed.

SIZING	SYSTEM	Low impact	Large impact
Sheath flow stability	DMPS/SMPS	X	
Ambient pressure in the DMA (at ground)	DMPS/SMPS	X	
Ambient temperature in the DMA	DMPS/SMPS	X	
Relative humidity in the DMA	DMPS/SMPS		X
Voltage calibration	DMPS/SMPS, especially for ultrafine particles		X
Residence time of particles in the system (CPC desmearing)	Only SMPS	X	

Table 1: List of properties that may have an impact on particle sizing using DMPS/SMPS systems.

Apart from the sizing also a comparison in measured total particle number is important when evaluating results obtained from different measurement devices. In Table 2, system dependent properties that may have an impact on measured total particle number are listed.

COUNTING EFFICIENCY		Low impact	Large impact
Aerosol flow stability	DMPS/SMPS	X	
Penetration losses in the inlet and the DMA	DMPS/SMPS	X	
DMA transfer function	DMPS/SMPS	X	
Probability of bipolar charging	DMPS/SMPS		X
CPC efficiency	DMPS/SMPS, especially for ultrafine particles		X

Table 2: List of properties that may have an impact on measured total particle number using DMPS/SMPS systems.

For intercomparison of continuously operated ground based DMPS/SMPS systems within the Nordic countries, an intercomparison unit has been constructed that will be distributed within participating groups to calibrate and to compare those measurement devices. The comparison will take into account the sizing and the counting efficiency of the DMPS/SMPS systems that are built by various components differing in the used DMA, CPC and programming language.

METHODS

The basic demand on the intercomparison unit is the following: it should be simple to use, easy to transport and possible to be operated at various measurement sites. The constructed unit consists of an aerosol nebulizer, a dilution chamber and a dilution unit. Polystyrene spheres of known size can be nebulized and conducted into the dilution chamber, where the total number concentration of the generated monodisperse particle number size distribution can be adjusted by a dilution unit. The intercomparison unit has been tested up to now for one system continuously operated at a roof top station in central Malmö, Sweden. Figure 2 shows a simple sketch of the intercomparison unit.

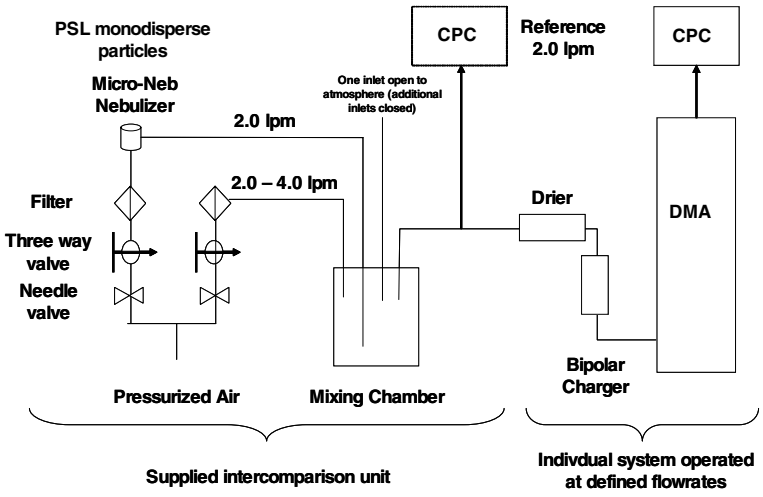

Figure 2: Schematic sketch of the intercomparison unit for calibration in sizing of particle number size spectrometers.

This set up provides the possibility to compare system properties without moving those systems since the unit can be distributed and sent to the laboratories where the individual systems are operated. Within an intercomparison of DMPS/SMPS systems of the Nordic countries (NORPAC, 2004), a calibration will be performed for dry sizes of Dp = 101, 277 and 420 nm covering the submicrometer size range.

An intercomparison in measured total number concentration is as important as a calibration in sizing. Therfore a CPC has been added to the intercalibration unit to compare the calculated total particle number of the ambient aerosol measured by the DMPS/SMPS systems to the total particle number measured by this CPC which has been calibrated for size dependent counting efficiency. The set up for this test is shown in Figure 3.

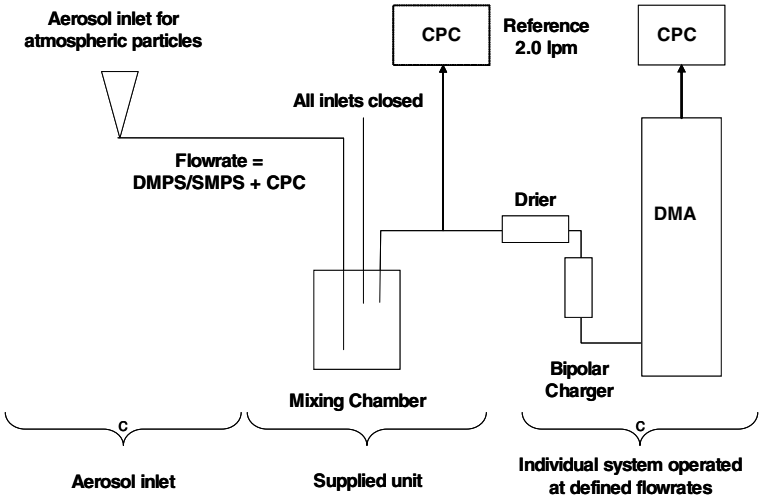

Figure 3: Schematic sketch of the set up for calibration in counting efficiency of particle number size spectrometers.

Also, this unit will be added to be sent around within the participating groups in order to compare the counting efficiency of the different measurement devices. A describing manual will support the participating groups to make the set up as detailed as shown in the figure and to guarantee that results from calibrations of different systems are comparable.

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