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New International Standard for Aerosol Particle Sizing (ISO 15900)

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Motivation and objectives

Nanoparticle measurement evolved with the introduction of electrical mobility sizers and condensation nucleus counters. The knowledge for the measurement technique broadened together with the application of these instruments for combustion control, for ambient measurements and finally for health research. Nowadays various manufacturers offer particle sizers working on the principle of electrical mobility sizing. Also legal applications for this instrument type become effective. Therefore a common language is needed to define this measuring principle and harmonise the assumptions for the calculation of the measuring results.

After almost 10 years of discussions, revisions, and editing the new ISO standard for aerosol particle sizing was accepted by the vast majority of the members of ISO TC24/SC4. The working group did a good job!

Scope

This international standard provides guidelines on the determination of aerosol particle size distribution by means of the analysis of electrical mobility of aerosol particles. The measurement is usually called “differential electrical mobility analysis for aerosol particles”. The analytical method is applicable to particle size measurements ranging from approximately 1 nm to 1 µm. The international standard does not address the specific instrument design or the specific requirements of particle size distribution measurements for different applications, but includes the calculation method of uncertainty. The complete system for carrying out differential electrical mobility analysis is referred to as DMAS (differential mobility analysing system), while the element within this system that classifies the particles according to their electrical mobility is referred to as DEMC (differential electrical mobility classifier).

General principle

The measurement of particle size distributions with a DMAS is based on particle classification by electrical mobility in a DEMC. The DEMC may be designed in many different ways; for example, coaxial cylindrical DEMC, radial DEMC, parallel plate DEMC, etc. The coaxial cylindrical DEMC shown in Figure 1 is an example of a widely used design. It consists of two coaxial, cylindrical electrodes with two inlets. One inlet (q_1) is for filtered clean sheath air. The other inlet (q_2) is for the aerosol sample air.

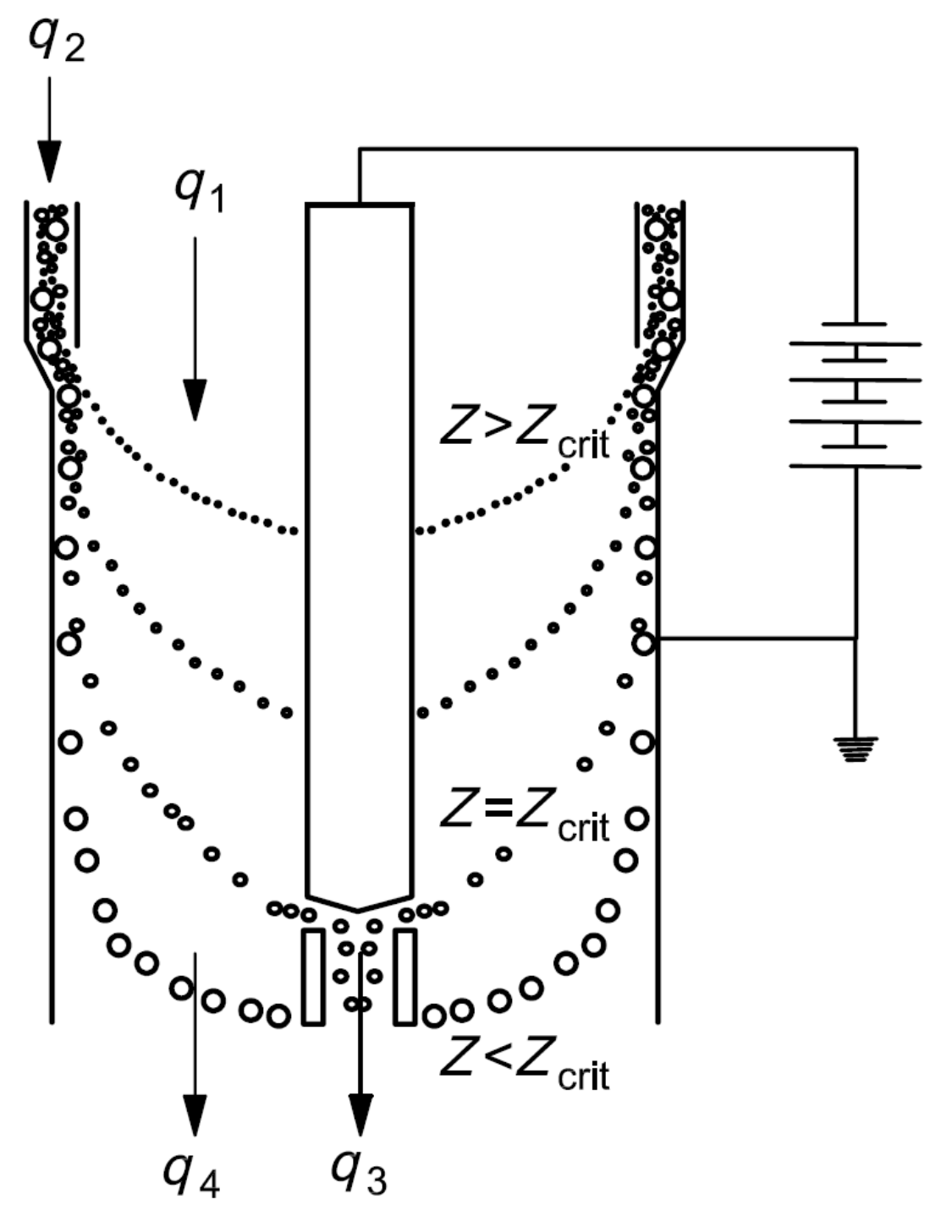

Figure 1: Schematic diagram of coaxial cylindrical DEMC.
Z_{crit}: critical mobility of particles exiting the DEMC with q_3

The aerosol sample air, some of whose particles are electrically charged, enters the DEMC in a thin annular cylinder around a core of filtered, particle-free sheath air. By applying a voltage, an electric field is created between the inner and outer electrodes. A charged particle in the presence of an electric field will migrate within the field and reach a terminal migration velocity when the fluid dynamic drag on the particle balances with the driving force of the electric field. Charged particles of the correct polarity within the sample air begin to drift across the sheath air flow towards the inner electrode. At the same time, the clean sheath air flow carries the charged airborne particles downward. A small fraction of the charged particles enters the thin circumferential slit near the bottom of the centre electrode and is carried by the air flow to the detector (q_3). By varying the voltage, particles of different electrical mobility are selected.

Structure of the standard

Section: General principle

For improved agreement of particle sizing the standardisation of the relationship between electrical mobility, particle size, and the charge distribution function is fundamental (recommended values see below). Furthermore the relevance of data inversion and the transfer function are explained.

Section: System and apparatus

Description of the components (see Figure 2)

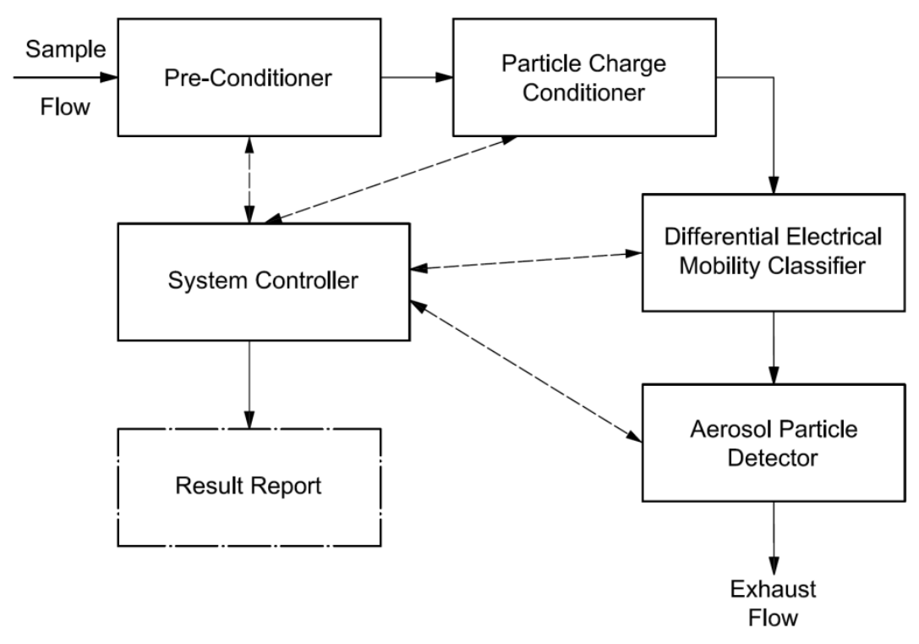

Figure 2: Fundamental components of the DMAS

Section: Measurement procedures

This section illustrate a good measurement practice step by step: Setup and preparation of the instrument, pre-measurement checks, measurement methods, maintenance.

Section: Periodic tests and calibrations

Very often the instrument maintenance and calibration is neglected. Here the maintenance matrix is introduced (see Figure 3).

	Preconditioner	Particle charge conditioner	DEMC	Aerosol particle detector	System controller
Leak test	X	X	X	X	
Zero tests	X	X	X	X	
Flow meter calibration			X	X	X
Voltmeter calibration			X		X
Particle charge conditioner integrity test		X			
Calibration for size measurement	X	X	X	X	X
Size resolution test	X	X	X	X	X
Number concentration calibration				X	

Figure 3: Matrix for sensitive components of a DMAS

Section: Reporting of results

Measurement results shall be accompanied with the relevant data for the instrument setting and the measuring setup.

Informative Annexes for detailed information

Annex A: Particle charge conditioners and charge distributions
Annex B: Particle detectors
Annex C: Slip correction factor
Annex D: Data inversion
Annex E: Cylindrical DEMC
Annex F: Size calibration of a DMAS with using particle size standards
Annex G: Uncertainty

Recommended values for S_c, η and l

The electrical mobility Z of a particle depends on its size d and its electric charge p. The relationship between electrical mobility and particle size for spherical particles is a function of the slip correction S_c, the dynamic viscosity η and the mean free path l of gas molecules according the following equations:

$$Z(d,p) = \frac{pe}{3\pi \eta d} S_{\mathrm{c}} \qquad S_{\mathrm{c}} = 1 + Kn\left[A + B\exp\left(-\frac{C}{Kn}\right)\right] \qquad Kn = \frac{2l}{d}$$

$$l = l_0 \times \left(\frac{T}{T_0}\right)^2 \times \left(\frac{P_0}{P}\right) \times \left(\frac{T_0 + S}{T + S}\right) \qquad \eta = \eta_0 \times \left(\frac{T}{T_0}\right)^{3/2} \times \left(\frac{T_0 + S}{T + S}\right)$$

Parameter	Value	Remarks
η_0	1,832 45 10^{-5} kg·m^{-1}·s^{-1}	For dry air at T_0 = 296,15 K; P_0 = 101,3 kPa. All values from: J.H. Kim, G.W. Mulholland, S.R. Kukuck and D.Y.H. Pui (2005).
l_0	6,730 × 10^{-8} m	
S	110,4 K	
A	1,165	
B	0,483	
C	0,997	

Acknowledgement

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