Upcoming standardization for charge conditioners used in particle characterization and for the generation of calibration and test aerosols – ISO 19996

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Introduction

Charge conditioning of aerosol particles by attachment of generated airborne ions is the key process to establish a known size-dependent charge distribution in an aerosol. For some time now charge conditioners other than the traditional radioactive sources or corona chargers exist and may show different performances.

To address this a new standard [1] is currently finalized that provides guidance on performance characterization, test and calibration of charge conditioners when used for particle size classification or for generation of sub micrometer test aerosols. For a given particle size, the particles' electrical mobility is proportional to the net number of elementary charges on the particle. Therefore, the knowledge of the particle charge distribution is an essential requirement for particle size classification with differential electrical mobility analyzing systems (DMAS) [2,3].

The purpose of this International Standard is to provide a methodology to specify the performance of charge conditioners and for adequate quality control when charge conditioners are used in particle size and number concentration measurement or in particle size classification.

Types of charge conditioners treated in the standard

Bipolar charge conditioners produce ions of both polarities (i.e. positive and negative ions). Neutral particles can acquire charge while highly charged particles may discharge themselves by capturing ions of the opposite polarity. Bipolar charge conditioners differ by the way the ions are generated.

In a unipolar charge conditioner, ions of either positive or negative polarity are produced (e.g. by a corona discharge process or separation of one ion polarity in an electric field). Unipolar charging can achieve higher charging probabilities than bipolar charging. This is an advantage if small particles (d < 20 nm) are to be measured.

The following types of charge conditioners are treated in the standard:

Bipolar charge conditioners:
- Radioactive Charge Conditioner
- Soft-X-ray Charge Conditioner
- Bipolar Corona Ionizer
- Surface-Discharge Microplasma Aerosol Charger

Unipolar charge conditioners:
- Positive Unipolar Corona Discharge Charge Conditioner
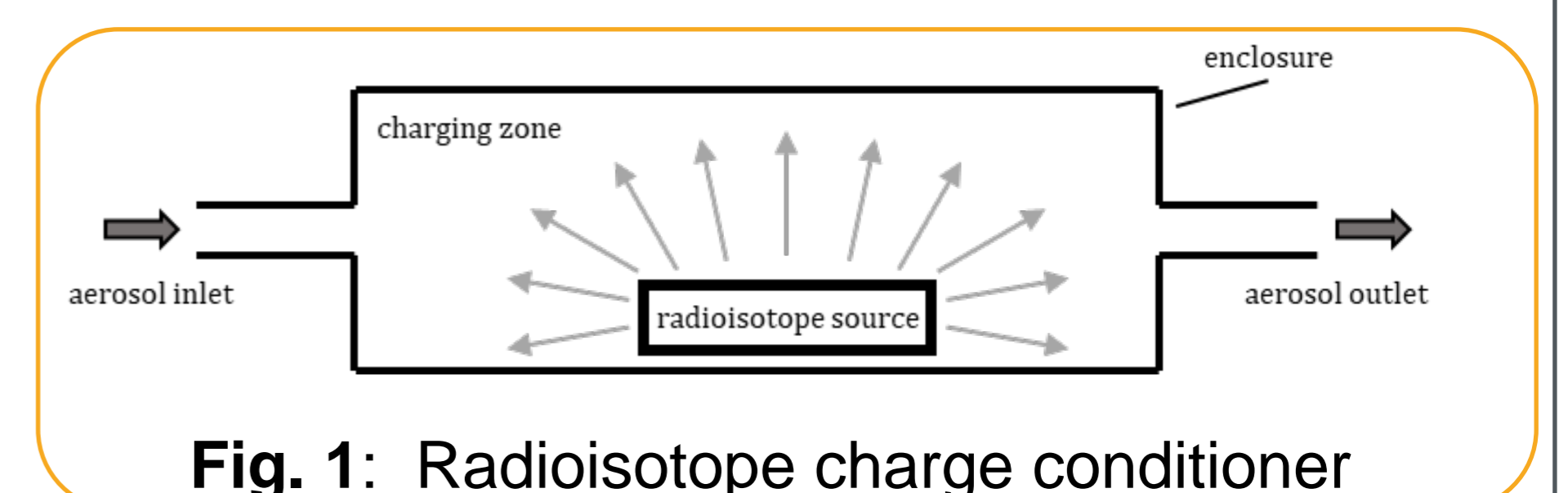- Negative Unipolar Corona Discharge Charge Conditioner

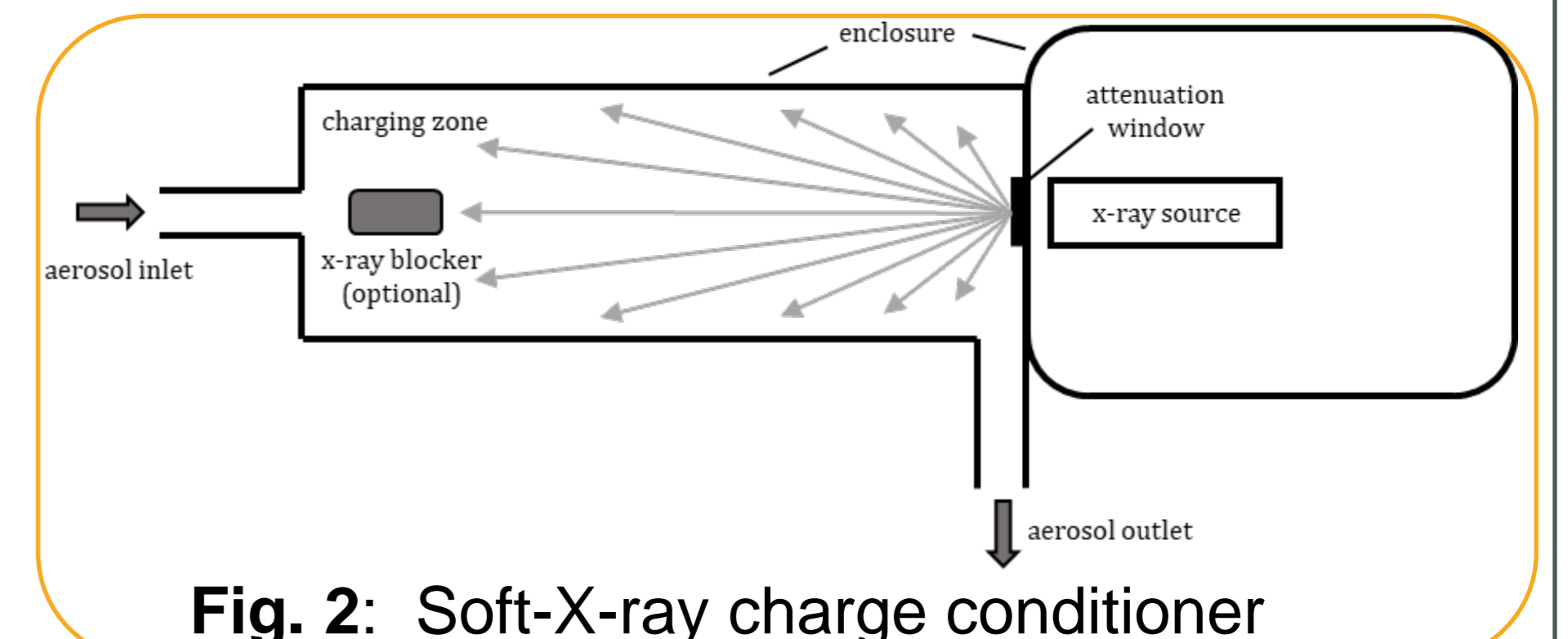**Fig. 1**: Radioisotope charge conditioner

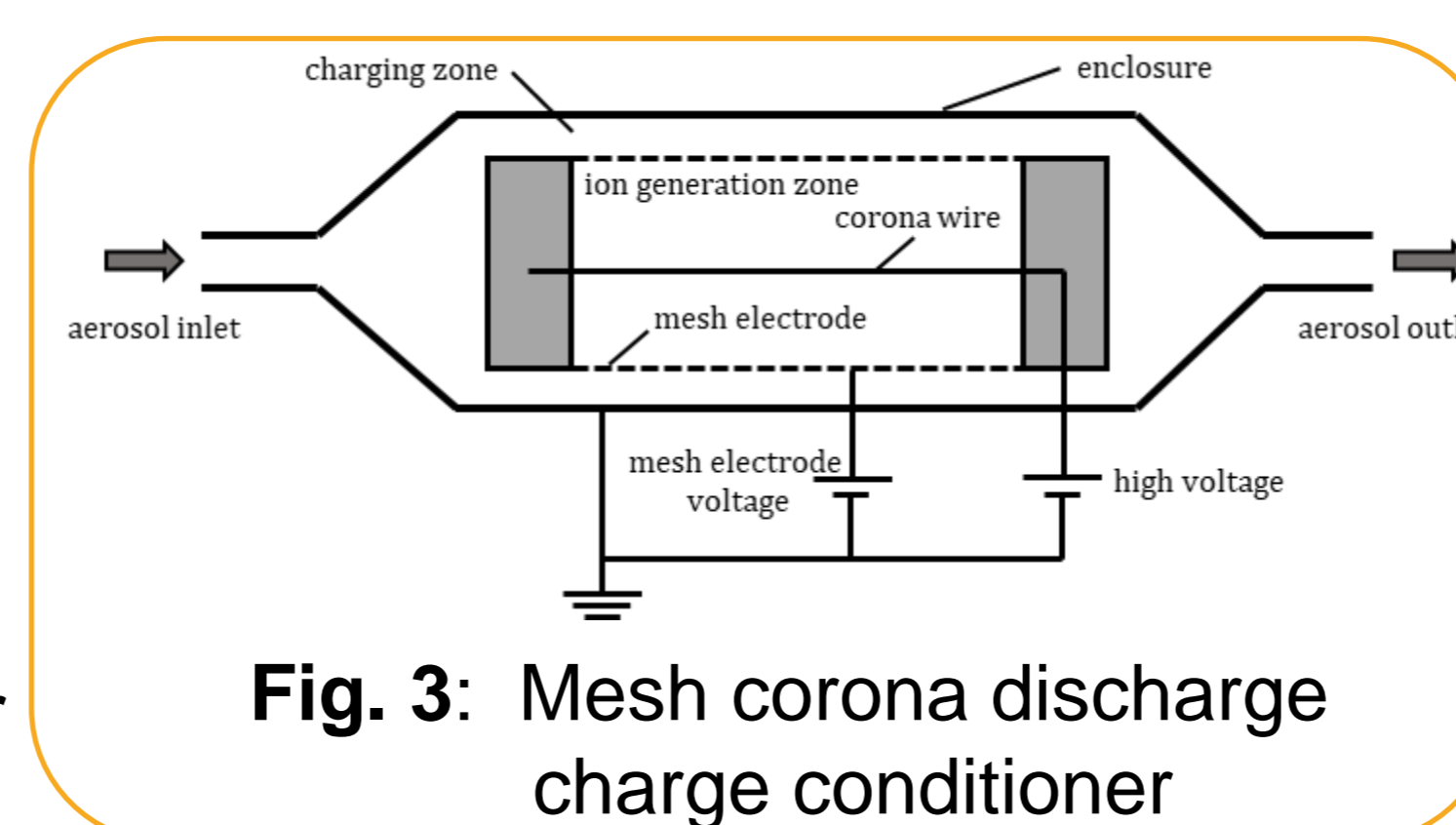**Fig. 2**: Soft-X-ray charge conditioner

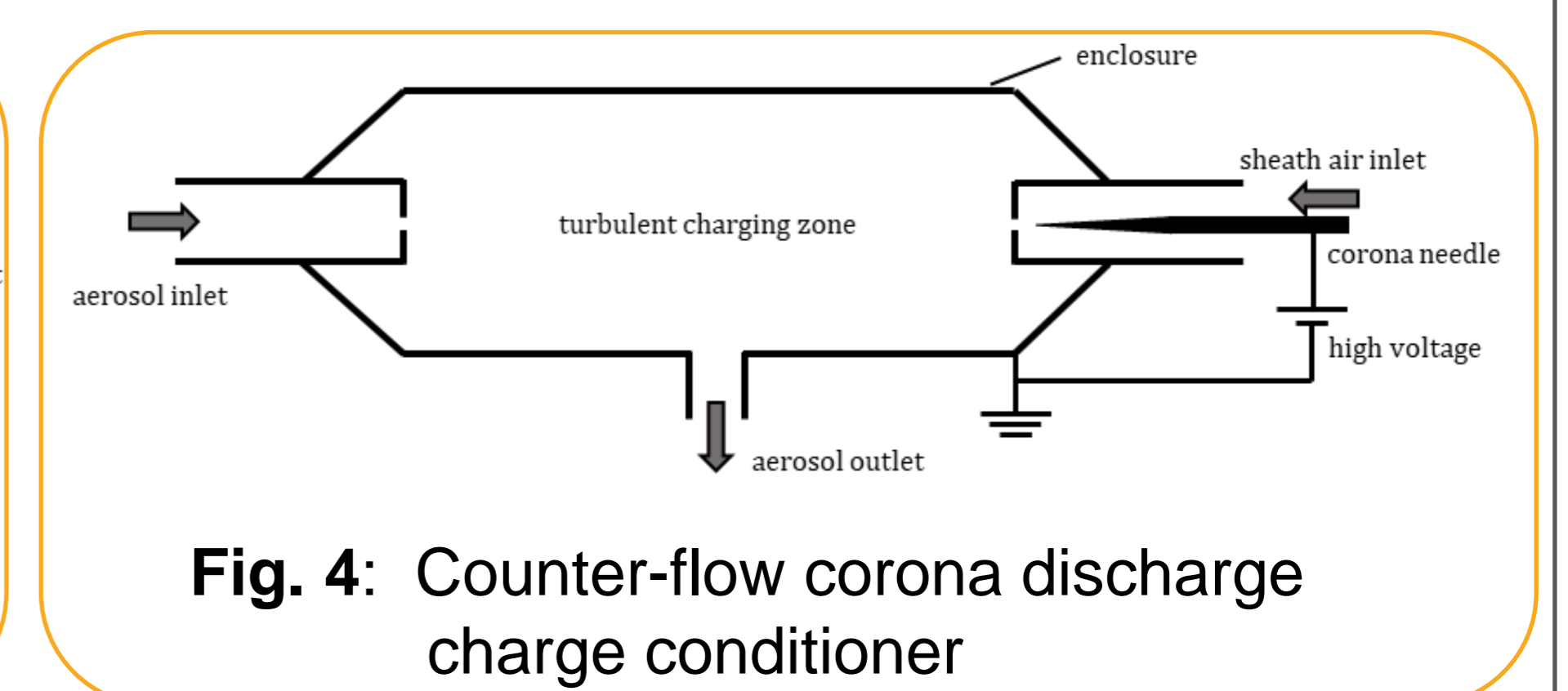**Fig. 3**: Mesh corona discharge charge conditioner

Fig. 4: Counter-flow corona discharge charge conditioner

Charge distribution functions

The particle size-dependent charge distribution function, $f_p(d)$ of the charge conditioner is required in data inversion routines of DMAS measurements. While the charge distribution function for <u>radioactive bipolar charge conditioners</u> are sufficiently described by the Wiedensohler approximation [4] in combination with Gunn [5], for nonradioactive bipolar charge conditioners the calculation is complicated and requires careful experimental verification.

Annex A in the standard describes the theoretical concepts to enable users to calculate a charge distribution function for a <u>given bipolar charge conditioner</u>.

It includes an example for the charge distribution function for a charge conditioner based on X-ray ionization.

It is important to note that the charging of particles in <u>unipolar charge conditioners</u> is very much dependent on individual designs and operating parameters. Therefore, no general approximation should be used.

Annex E describes an experimental method to approximate the charge distribution of a given unipolar charge conditioner [6].

Test methods and performance parameters

The standard describes test methods that are intended to be performed by manufacturers for parameters that should be listed in the charge conditioners datasheets as well as test procedures for the assessment of the suitability of a charge conditioner for a particular measurement. Other methods in Table 1 can be used for characterizing a new design or periodic quality control of a charge conditioner.

Annex	Performance parameter	Test procedure in section
B	Particle generation rate	B.2
	Particle transmission efficiency	B.3
	Charging probability f_0	B.4
	Charging probabilities f_i $(i \neq 0)$	B.5
E	Charge distribution from unipolar charge conditioners	E.2
F	Maximum permissible particle number concentration	F.2
G	Ratio of +1 charged particles to -1 charged particles	G.2.4
	Charging probability f_{+1} (or f_{-1})	G.2.5
H	Adequate performance of charge conditioner	H.3

Table 1: ISO 19996 Annexes with test procedures

Conclusions

This standard provides an overview of the main ionization sources for DMAS and details their different charging performances along with several influencing factors, such as for example particle size and surface area and carrier gas characteristics. The standard provides several quantitative metrics for the performance of charge conditioners along with relatively fast performance procedures. These were successfully used to establish individual differences in performance among several radioactive and Soft-X-ray charge conditioners [7].

References

[1] ISO 19996 "Charge conditioning of aerosol particles for particle characterization and the generation of calibration and test aerosols", in preparation, anticipated publication in July 2024
[2] ISO 15900 "Determination of particle size distribution — Differential electrical mobility analysis for aerosol particles"
[3] ISO 27891 "Aerosol particle number concentration — Calibration of condensation particle counters"
[4] WIEDENSOHLER, A. (1988). An approximation of the bipolar charge distribution for particles in the submicron range. J. Aerosol Sci.,19(3), pp. 387-389
[5] GUNN, R. (1956). The hyperelectrification of raindrops by atmospheric electric fields. J. Meteor., 13, pp. 283-288
[6] KAMINSKI, H. et al, Mathematical Description of Experimentally Determined Charge Distributions of a Unipolar Diffusion Charger. Aerosol Science and Technology, 46:6, 708-716
[7] EMPIR 19ENV08 AEROMET II, Advanced Aerosol Metrology for Atmospheric Science and Air Quality, https://www.aerometprojectii.com/