INTERNATIONAL STANDARD

ISO 27891

First edition
2015-03-01

Aerosol particle number concentration — Calibration of condensation particle counters

Densité de particules d'aérosol — Étalonnage de compteurs de particules d'aérosol à condensation

Reference number
ISO 27891:2015(E)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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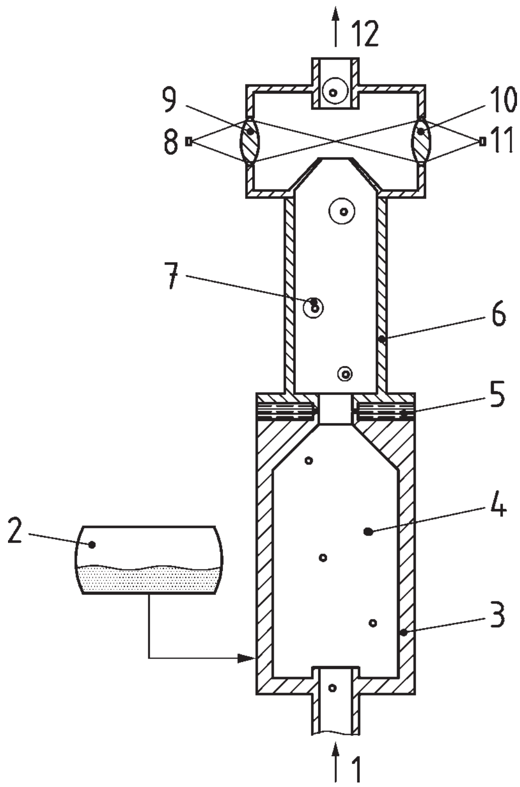
For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 24, *Particle characterization including sieving*, Subcommittee SC 4, *Particle characterization*.

Introduction

A condensation particle counter (CPC) is a measuring device for the number concentration of small aerosol particles. The common principle of all different CPC types is that condensation of supersaturated vapours is used to grow ultra-fine and nanoparticles to droplets of sizes that can be detected optically.[44] The counting of the droplets is performed via optical light scattering. The droplet passes through a detection area where it is illuminated by a focused light beam and a portion of the scattered light is detected with a photodetector. The frequency of this event leads, with the known volume of sampled air, to the particle number concentration. At low concentrations, the CPC counts individual particles and allows an absolute determination of particle number concentration.

Commercially available CPCs employ different working fluids to generate the vapour, e.g. 1-butanol, 2-propanol, or water. Moreover, different principles are in use to achieve the needed supersaturation in the sample air. The most common CPC uses laminar flow and diffusional heat transfer. The diffusion constant of the working fluid determines the needed heating or cooling steps to initiate condensation and hence, the principle design of a laminar flow CPC. Less common are turbulent mixing CPCs: in these CPCs, the supersaturation is achieved by turbulently mixing the sample air with a particle free gas flow saturated with the working fluid. Figure 1 shows a schematic of the probably most common CPC type with a laminar flow through a heated saturator and a cooled condenser.



Key

1	aerosol inlet	7	droplet
2	working fluid reservoir	8	light source
3	heated saturator	9	illumination optics
4	nanoparticle	10	receiving optics
5	thermoelectric cooling and heating device	11	photodetector
6	condenser	12	aerosol outlet

Figure 1 — Principle of a laminar flow CPC

The accuracy of CPC measurements, however, depends on various influences. For example, if the flow rate had an error, the concentration would have an error. Coincidence error at very high concentration, inefficient activation of particle growth at very small sizes, and losses of particles during transport from the inlet to the detection section are other possible sources of errors. For accurate measurement, the CPC shall be calibrated.

“Calibration” of the CPC is usually done using a Faraday-cup aerosol electrometer (FCAE) as reference instrument.[33][36] In many cases, the purpose of the “calibration” is to determine the limit of particle detection at very small size. The FCAE has been used as the reference since the detection efficiency of the FCAE was considered to be unity at any size. The detection efficiency of a CPC is determined as the ratio of the concentration indicated by the CPC under calibration to that by the FCAE, while aerosols of singly charged, size-classified particles of the same number concentration are supplied simultaneously to both instruments.

This International Standard sets out two distinct methods of CPC calibration: the characterization of a CPC by comparison with an FCAE, which is the same as the traditional approach described above; and by comparison with a reference CPC. An FCAE that has a reputable calibration certificate, covering the relevant particle number concentrations, sizes, and composition, can be used. In the latter case, the reference CPC is one that has a reputable calibration certificate, again covering the relevant particle number concentrations, sizes, and composition. A reputable calibration certificate shall mean either one that has been produced by a laboratory accredited to ISO/IEC 17025 or an equivalent standard, where the type and range of calibration is within the laboratory’s accredited scope, or a European Designated Institute or a National Metrology Institute that offers the relevant calibration service and whose measurements fulfil the requirements of ISO/IEC 17025.

Two major sources of errors are known in CPC calibration: the presence of multiply charged particles and the bias of the particle concentrations between the inlet of the CPC under calibration and that of the reference instrument. Evaluation of these factors and corrections for them shall be included in the calibration procedure, the methods of which are specified in this International Standard.

This International Standard is aimed at

— users of CPCs (e.g. for environmental or vehicle emissions purposes) who have internal calibration programmes,

— CPC manufacturers who certify and recertify the performance of their instruments, and

— technical laboratories who offer the calibration of CPCs as a service, which can include National Metrology Institutes who are setting up national facilities to support number concentration measurements.

